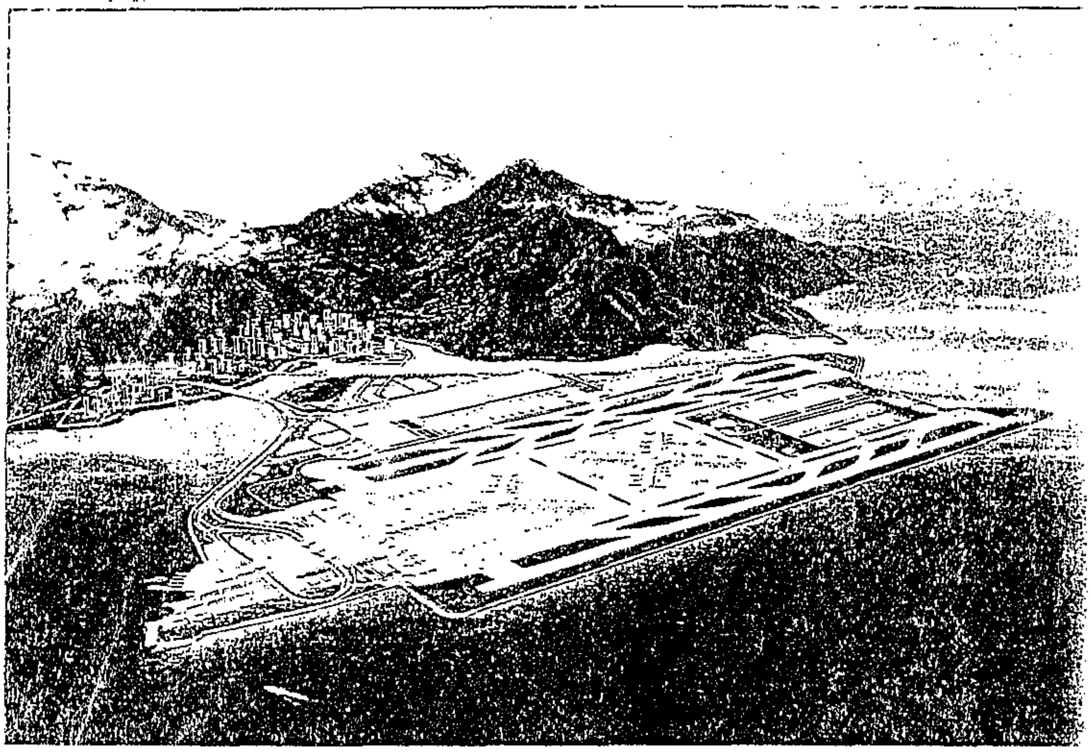
Provisional Airport Authority - Hong Kong

# New Airport Master Plan

## Environmental Impact Assessment



Greiner - Maunsell

## 8.1 Assessment Methodology

A marine ecological survey was carried out in November 1990 and covered areas to be reclaimed for airport construction and associated marine areas likely to suffer environmental impact. The objectives of the field survey were;

(a) To characterise the littoral and sublittoral marine flora and fauna in areas directly affected by reclamation and borrow activities, and to identify any rare or unique habitats/assemblages.

(b) To characterise the littoral and sublittoral marine flora and fauna in areas which may be indirectly affected by the construction (e.g. dredging plumes) and operation (e.g. storm and any foul water discharges) of the airport.

(c) To provide baseline biological data against which future impacts could be assessed, and on the basis of which recommendations for future monitoring programmes could be made.

The field survey was divided into two sections. The first section investigated the sublittoral marine biota, i.e. the biota below the impact of the tides and therefore permanently submerged, by means of trawl (collecting epifauna on or just above the bottom) and grab samples (collecting infauna, buried in the sediment of the bottom). The second section investigated the littoral biota on local shores experiencing regular immersion and emersion as a result of tidal rhythms.

The sublittoral survey samples were taken in the immediate vicinity of Tung Chung Bay and Chek Lap Kok, and in the borrow area north of The Brothers. Thirteen double replicate trawls were made during the survey and grab samples were taken at 16 sites as depicted on Exhibits 8.1 and 8.2. In addition to sampling biota, the grab sampling allowed additional baseline data to be collected on the grain size distributions of sublittoral sediments and the heavy metal concentrations in these sediments.

The littoral survey was carried out on foot on the North Lantau shores in the vicinity of Tung Chung and by sampan to survey the shores of Chek Lap Kok. Detailed species lists were drawn up and placed within the category of hard shores (which included rocky cliffs, jetty and boulder shores), Zoysia beds, sandy shores or mangrove swamps. Additional baseline data were collected on the heavy metal concentrations using local biota as pollutant metal biomonitors.

A full description of the methodology and results of the marine ecological survey with detailed species lists and numbers of specimens observed, was reported during the course of the Study and is presented here in summary form.

In addition to the survey, an assessment was made of potential impacts on cetaceans, since concern has been expressed over potential adverse effects on the Chinese White Dolphin (*Sousa chinensis*) of the reclamation and borrow operations. Data on live and dead sightings of *Sousa chinensis* were obtained from the Agriculture and Fisheries Department and the World Wide Fund for Nature, and supplemented by records of incidental sightings during fieldwork for other aspects of this study.

Impacts of suspended sediment dispersion resulting from dredging, dumping and borrow operations have also been addressed in Section 7 (Water Quality).

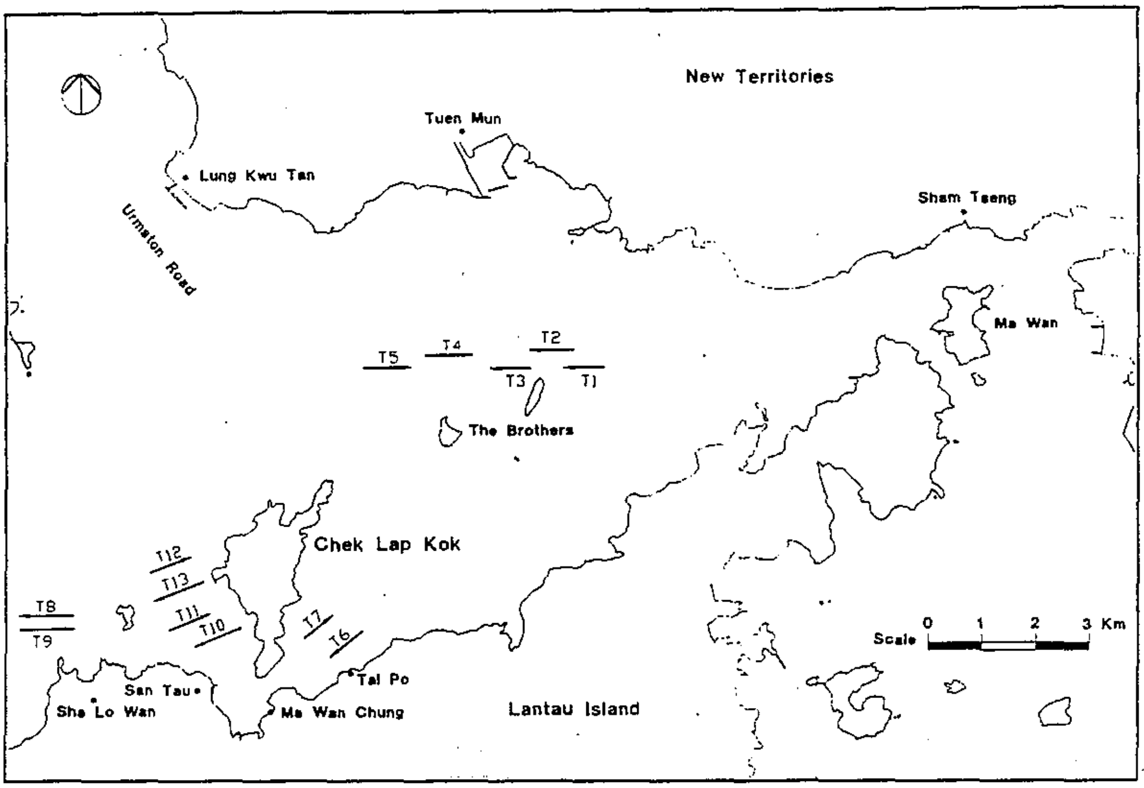



*Exhibit* **8.1**

***Location of Trawls Made North of Lantau between 6th and 8th of November 1990***

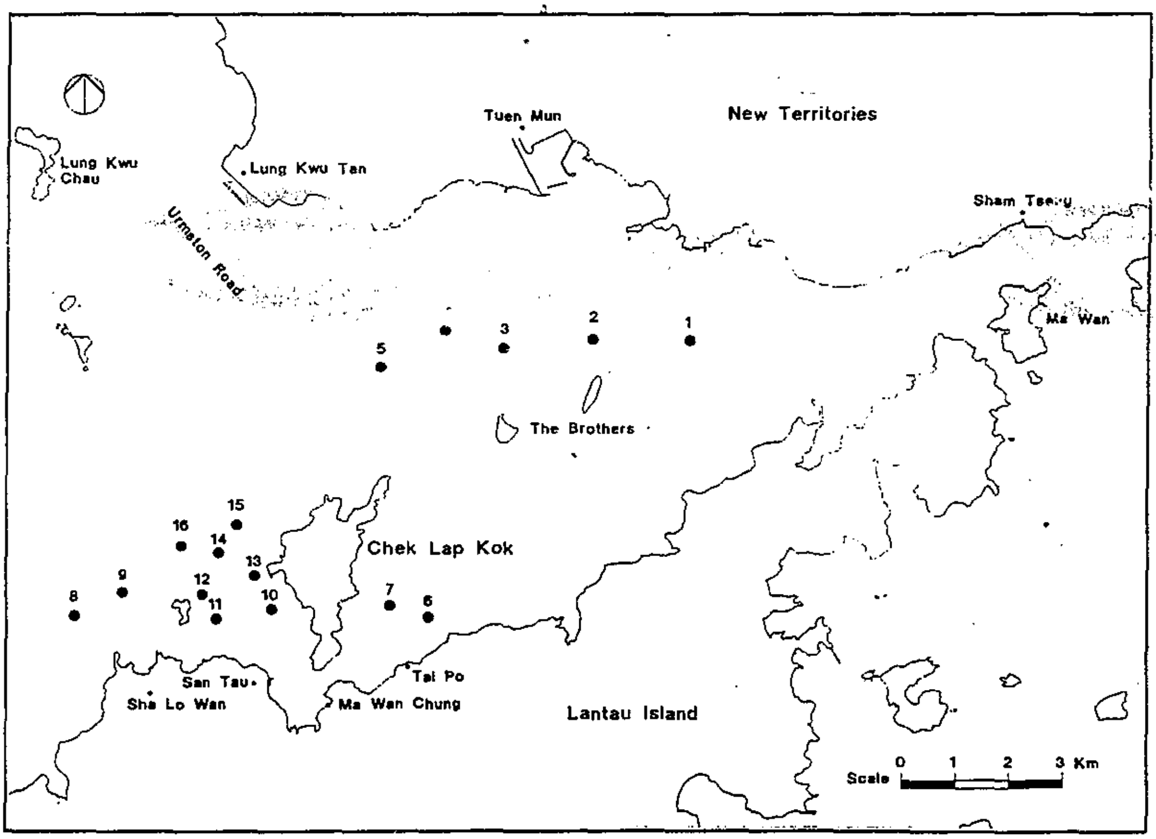



*Exhibit* **8.2**

***Location of Grab Sites 1 to 16 Made North of Lantau between 5th and 7th of November 1990***

## 8.2 Existing Environment

### 8.2.1 Sublittoral

Sublittoral sediments taken by grab sampling north of Lantau showed a variety of types, ranging from those dominated by coarse material under the influence of strong tidal currents (to the northeast of The Brothers) to those dominated by mud, silt and clay. The baseline concentrations of heavy metals were measured in whole sediment samples from 16 grab sites as depicted in Table 8.1. The 1990 concentrations are not atypical of metal concentrations in Hong Kong sublittoral sediments, and indicate a lack of any substantial local source of heavy metal pollution.

The heterogeneity of sediment type and depth promotes a high diversity of burrowing infauna, as was found to be present in the sublittoral sediments, with the exception of echinoderms. A complete list of fauna collected by grab sample is given in Table 8.2. Species new to science were collected including the pycnogonid *Neopallene* sp. and the gastropod *Pseudoliotia* sp. This is probably a feature of the paucity of existing systematic knowledge and investigation of Hong Kong sublittoral sediments in general, rather than an indication of particularly special local sublittoral marine habitats.

The bottom invertebrate community as sampled by trawl was considered to be a good example of that expected in Hong Kong coastal waters. Most organisms were identified down to species level although the time available and an inadequate systematic knowledge of Hong Kong fauna (not restricted to this study) did result in several incomplete identifications. A complete list of fauna collected by trawl is given in Table 8.3. The species list is long with considerable faunal diversity although a reduced echinoderm diversity was again revealed. This absence is expected given the relatively low salinity of the waters north of Lantau during the high summer flow of the adjacent Pearl River (Morton and Wu, 1975). Echinoderms are susceptible to low salinity and this is particularly evident in surface waters due to the lower density of low salinity water. The greatest abundance of echinoderms was found in trawls in deeper water. Those species notable due to their relative abundance in the trawl survey include several species of mollusc including the predatory gastropod *Murex trapa* and the turret shell *Turritella bacillum*. Faunal associations were experienced notably amongst mollusc shells with hermit crabs, barnacles and corals.

*Table 8.1*
*Metal Concentrations in Bulk Sediment Samples Collected by Van Veen Grab (Sites 1A-16A)*

| | Metal Concentration (mg/kg dry wgt) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Copper | Cadmium | Chromium | Nickel | Lead | Zinc | Cobalt | Silver |
| Mean | 16 | 0.23 | 42 | 19 | 34 | 97 | 8.2 | 0.3 |
| Range | 5.4-73 | 0.1-0.57 | 4-73 | 1.2-27 | 6.8-50 | 16-150 | 0.8-11 | 0.1-1.1 |

*Source : Greiner-Maunsell, 1991*

*Table 8.2*
*Complete List of Fauna Collected by Grab North of Lantau, 5th to 7th November 1990*

| | | |
|---|---|---|
| **PORIFERA** | unidentified sponge sp. | |
| | | |
| **CNIDARIA** | | |
| - **Hydrozoa** | hydrozoan actinula (? *Tubularia*) | |
| | unidentified athecate hydrozoan | |
| - **Anthozoa** | unidentified Pennatulacean | |
| | unidentified cerianthid | |
| **ANNELIDA** | | |
| - **Polychaeta** (coarse fractions only) | | |
| AMPHINOMIDAE | *Linopherus* sp. | [*Pseudeurythoe* sp. in Shin and Thompson (1982)] |
| POLYNOIDAE | *Halosydnopsis pilosa* | |
| ACOETIDAE | *Acoetes melanonota* | [*Polyodontes melanonotus* in Shin and Thompson (1982)] |
| SIGALIONIDAE | *Sthenolepis* sp. | |
| PHYLLODOCIDAE | *Eteone* sp. | |
| PILARGIIDAE | *Synelmis* sp. | |
| " | *Sigambra* sp. | |
| NEREIDIDAE | *Gymnonereis* sp. | |
| NEPHTYIDAE | *Aglaophamus* sp. A | |
| " | *Aglaophamus* sp. B | |
| " | *Aglaophamus* sp. C | |
| GLYCERIDAE | *Glycera chirori* | |
| " | *Glycera* sp. | |
| LUMBRINERIDAE | *Augeneria shiinoi* | [*Lumbrineris shiinoi* in Shin and Thompson (1982)] |
| ARABELLIDAE | *Drilonereis logani* | |
| " | Arabellidae sp. indeterminable | [possibly *D. logani*] |
| ONUPHIDAE | *Diopatra* sp. | |
| EUNICIDAE | *Eunice indica* | |
| PARAONIDAE | *Paradoneis* sp. | [Possibly *Paraonides lyra* in Shin and Thompson (1982)] |
| SPIONIDAE | *Aonides* sp. | |
| " | *Prionospio (Minuspio)* sp. | |
| " | *Prionospio (Prionospio)* sp. A | |
| " | *Prionospio (Prionospio)* sp. B | |
| " | *Paraprionospio* sp. A | |
| " | *Paraprionospio* sp. B | |
| " | *Laonice* sp. | |
| CIRRATULIDAE | *Tharyx* sp. | |
| COSSURIDAE | *Cossurella aciculata* | |
| CAPITELLIDAE | *Mediomastus* sp. | |
| " | *Notomastus* sp. | |
| | *Heteromastus* sp. | |
| | *Paraleiocapitella* sp. | |
| MALDANIDAE | Maldanidae indeterminable | |
| TEREBELLIDAE | *Amaeana* sp. | |
| TRICHOBRANCHIDAE | *Trichobranchus* sp. | |
| - **Oligochaeta** | unidentified oligochaete spp. | |
| - **Archiannelida** | unidentified archiannelid sp. | |
| | | |
| **NEMERTEA** | unidentified nemertean spp. | |

*Table 8.2 (Continued)*

| | |
|---|---|
| **SIPUNCULA** | unidentified sipunculan spp. |
| | *Phascolosoma* sp. |
| **MOLLUSCA** | |
| **- Bivalves** | *Cardita* sp. |
| | *Carditella* cf. *hanzawi* |
| | *Veremolpa* sp. |
| | *Tapes* sp. |
| | *Corbula* sp. |
| | *Gadila* sp. |
| | *Nucula* sp. |
| | *Macoma gubernaculum* |
| | *Costanuculana* sp. |
| | *Circe scripta* |
| | *Verilarca sinensis* |
| | *Bassina calophylla* |
| | *Bellucina* sp. |
| | *Bellucina seminula* |
| | indeterminable Leptonacean sp. |
| | indeterminable Tellinacean sp. |
| | indeterminable Venerid sp. |
| **- Gastropods** | *Eulima* sp. |
| | *Cylichna* sp. |
| | *Adamnestia tosaensis* |
| | *Iravadia (Pseudonoba)* sp. |
| | *Iravadia (Fairbankia)* sp. |
| | *Nassarius succinatus* |
| | *Nassarius siquijorensis* |
| | *Umbonium* sp. |
| | *Pseudoliotia* nov. sp. |
| | *Pseudoliotia* sp. B |
| | *Stenothyra* sp. |
| | *Tormida* sp. |
| | *Natica hilaris* |
| | *Odostomia* sp. |
| | *Turritella bacillum* |
| | *Duplicaria spectabilis* |
| | *Chemnitzia* sp. |
| | *Murex trapan* |
| | *Paramormula* sp. |
| | indeterminable Tornidae sp. |
| | indeterminable Vitrinellidae sp. |
| | indeterminable Pyramidellidae sp. |
| | indeterminable nudibranch |
| **- Solenogastres** | unidentified solenogastre |
| **- Scaphopods** | *Graptacme aciculum* |
| | *Fissidentalium* sp. |
| **CRUSTACEA** | |
| **- Amphipoda** | *Corophium* sp. |
| | ? *Maera* sp. |
| | *Ampelisca* sp. |
| | *Idunella* sp. |
| | *Elasmopus* sp. |

Table 8.2 (Continued)

| | |
|---|---|
| | Oedicerotid (? *Synchelidium*) sp. A |
| | Oedicerotid sp. B |
| | Ischyrocerid sp. |
| | Ischyrocerid/Photid sp. |
| | ? Ischyrocerid sp. |
| | Jassid sp. |
| | Stenothoid/Metopid sp. |
| | Lysianassid sp. A |
| | Lysianassid sp. B |
| | Melitid sp. A |
| | Melitid sp. B |
| | Melitid sp. C |
| | ? Dogielinotid sp. |
| | ? Amphilochid sp. |
| | Corophioid sp. A |
| | Corophioid sp. B |
| | Corophioid sp. C |
| | Corophioid sp. D |
| | Caprellid spp. |
| **- Cumacea** | Cumacean sp. A (Bodotriidae ?) |
| | Cumacean sp. B (? *Campylaspis*) |
| | Cumacean sp. C |
| | Cumacean sp. D |
| **- Tanaidae** | unidentified tanaid sp. A |
| | unidentified tanaid sp. B |
| **- Isopoda** | unidentified isopod A |
| **- Stomatopoda** | ? *Oratosquilla oratoria* |
| **- Decapoda** | unidentified postlarval decapod sp./spp. |
| | unidentified postlarval penaeid sp./spp. |
| | Processidae (? *Nikoides*) sp. |
| | Processidae (? *Processa*) sp. |
| | Pasiphaeidae *Leptochela* sp. A |
| | Pasiphaeidae *Leptochela* sp. B |
| | Paguridae hermit crab juvenile |
| **- Decapoda** | |
| - Brachyura | *Eucrate crenata* |
| | Pinnotheridae (cf *Xenophthalmus*) |
| **PYCNOGONIDA** | *Neopallene* sp. nov. |
| **MEROSTOMATA** | Limulid postlarva (? *Tachypleus tridentatus*) |
| **ECHINODERMATA** | |
| **- Ophiuroids** | *Amphipholis squamata* ? |
| | unidentified ophiuroid sp./spp. |
| **- Echinoids** | postlarval echinoid |
| **FISH** | *Odontamblyopus rubicundus* |

*Source : Greiner-Maunsell, 1991*

*Table 8.3*
*Complete List of Fauna Collected by Trawl North of Lantau, 5th to 8th November 1990*

| | | |
|---|---|---|
| Porifera | unidentified sponge sp. | |
| Cnidaria | - Hydrozoa | unidentified hydroid sp. |
| | - Anthozoa | *Oulangia stokesiana* Milne-Edwards & Haime |
| | | *Muricella abnormalis* Nutting |
| | | *Echinogorgia sassapo reticulata* (Esper) |
| | | *Echinomuricea indomalaccensis* Ridley |
| | | *Cavernularia obesa* |
| | | *Virgularia* sp. |
| | | *Pteroeides sparmanni* |
| | | *Cancrosocia expansa* |
| | | *Calliactis parasitica* |
| Annelida | - Polychaeta | *Glycera* sp. |
| | | *Hesione* sp. |
| Sipuncula | | *Phascolosoma* sp. |
| Mollusca | - Bivalves | *Perna viridis* |
| | | *Musculista senhausia* |
| | | *Pinctada martensi* |
| | | *Anomia sinensis* |
| | | *Alectryonella plicatula* |
| | | *Bassina calophylla* |
| | | *Tapes philippinarum* |
| | | *Paphia undulata* |
| | | *Anadara granosa* |
| | - Gastropods | *Murex trapa* |
| | | *Turricula nelliae* |
| | | *Turritella bacillum* |
| | | *Gemmula deshayesi* |
| | | *Crepidula walshi* |
| | | *Crepidula onyx* |
| | | *Nassarius siquijorensis* |
| | | *Nassarius succinatus* |
| | | *Lophiotoma leucotropis* |
| | | *Inquisitor flavidula* |
| | | *Inquisitor latisinuata* |
| | | *Capulus* sp. |
| | | *Linatella caudata* |
| | | *Thais mutabilis* |
| | | *Bursa rana* |
| | | *Lataxiena fimbriata* |
| | | *Armina* sp. |
| | - Cephalopods | *Octopus membranaceus* |
| Crustacea | - Cirripedia | *Balanus amphitrite* |
| | | *Balanus variegatus* |
| | | *Chirona amaryllis* |

Table 8.3 (Continued)

| | | |
|---|---|---|
| | | *Conopea calceolus* |
| | - Isopoda | *Nerocila sundaica* |
| | | *Orbione halipora* |
| | - Stomatopoda | *Oratosquilla oratoria* |
| | - Decapoda | |
| | - Penaeidae | *Penaeus merguiensis* |
| | | *Penaeus penicillatus* |
| | | *Penaeus monodon* |
| | | *Metapenaeus ensis* |
| | | *Metapenaeus* cf *ensis* |
| | | *Metapenaeus affinis* |
| | | *Trachypenaeus longipes* |
| | | *Trachypenaeus pescadoreensis* |
| | | *Trachypenaeus curvirostris* |
| | | *Metapenaeopsis barbata* |
| | | *Parapenaeopsis tenella* |
| | | *Parapenaeopsis hardwickii* |
| | | *Solenocera crassicornis* |
| | - Brachyura | *Charybdis (Charybdis) helleri* (A. Milne Edwards) |
| | | *Charybdis (Charybdis) granulata* De Haan |
| | | *Charybdis (Goniohellenus) truncata* (Fabricius) |
| | | *Charybdis (Goniohellenus)* cf *truncata* |
| | | *Thalamita* cf *admete* |
| | | *Portunus pelagicus* |
| | | *Portunus gracilimanus* (Stimpson) |
| | | *Portunus hastatoides* Fabricius |
| | | *Doclea ovis* (Herbst) |
| | | *Doclea* sp. A |
| | | *Doclea* sp. B |
| | | *Galene bispinosa* (Herbst) |
| | | *Halimede ochtodes* (Herbst) |
| | | unidentified Xanthid (cf *Halimede*) |
| | | *Parthenope (Platylambrus) validus* De Haan |
| | | *Parthenope* sp. A |
| | | *Eucrate crenata* |
| | | unidentified Gonoplacid |
| | | *Macrophthalmus (Venitus) latreillei* (Desmarest) |
| | | *Dorippe quadridens* (Fabricius) |
| | | *Dorippe (Paradorippe) faustinho* (previously *D. granulata*) |
| | | *Neodorippe japonica* |
| | | *Leucosia vittata* Stimpson |

Source : Greiner Maunsell [illegible]

*Table 8.3 (Continued)*

| | | |
|---|---|---|
| | - Others | *Nursia plicata* (Herbst) |
| | | unidentified Leucosiid |
| | | *Lysmata* cf *kukenthali* |
| | | *Alpheus distinguendus* |
| | | *Alpheus* sp. |
| | | *Dardanus arrosor* |
| | | *Porcellana picta* |
| Bryozoa | | unidentified bryozoan |
| Echinodermata | - Echinoids | *Temnopleura toreumaticus* |
| | - Holothuroids | *Holothuria* sp. |
| | | *Stichopus* cf *oshimae* |
| | | *Pseudocolochirus violaceus* |
| | | *Acaudina malpadiodes* |
| | - Ophiuroids | unidentified ophiuroid |
| Tunicata | | *Styela* sp. |

| Fish | Common name(if known) |
|---|---|
| *Sillago sihama* (Forskal) | Silver whiting |
| *Polynemus sextarius* Block and Schneider | Thread fin |
| *Argyrosomus pawak* Lin | |
| *Johnius belengrii* (Cuvier and Valenciennes) | |
| *Pleuronichthys cornutus* (Temminck and Schlegel) | |
| *Apogon doederleini* (Jordan and Snyder) | Cardinal Fish |
| *Platycephalus indicus* (Linnaeus) | Bar tailed Flathead |
| *Acentrogobius caninus* (Cuvier and Valenciennes) | |
| *Oxyurichthys tentacularis* (Cuvier and Valenciennes) | Goby |
| *Leiognathus brevirostris* (Cuvier and Valenciennes) | Ponyfish |
| *Leiognathus ruconius* (Hamilton-Buchanan) | Ponyfish |
| *Cynoglossus melampetalus* (Richardson) | Tongue sole |
| *Trypauchen taenis* Koumans | |
| *Clupanodon thrissa* (Linnaeus) | |
| *Callionymus kaianus* Gunther | Dragonet |
| *Takifugu oblongus* (Bloch) | Puffer fish |
| *Vespicula sinensis* (Bleeker) | |
| *Odontamblyopus rubicundus* (Hamilton-Buchanan) | |
| *Siganus fuscessens* (Houttuyn) | |
| *Gerres* sp. | Silver biddy |
| *Dasyatis akajei* (Muller and Henle) | Ray |
| *Anchoviella chinensis* (Gunther) | Anchovy |
| *Chiloscyllium plagiosum* (Bennett) | |
| *Conger cinereus* Ruppell | |
| *Ophichthus cephalozona* Bleeker | |
| *Anguilla japonica* | Eel |

*Source : Greiner-Maunsell, 1991*

Changes in species composition were expected when comparing earlier work of ten years ago due to a deterioration in coastal waters. However many similarities were found amongst the dominant species although several benthic species were now found to be absent. Data for 1979 (Wu and Richards, 1981) are not reported as fully as the data collected in 1990, so a general comparison is not possible. The 1979 abundance of echinoderms may be a reflection of sampling further east in 1979 than in 1990, with associated reduction of any low salinity effect.

The fish community sampled by trawl was of high diversity and in line with previous investigations in 1978/79 (Richards and Wu, 1985). Data from work by earlier researchers showed great seasonal variation so there are expected absences in this November study. A high fish species diversity found in 1978/79 was also true for 1990. Fish resource records from the Agriculture and Fisheries Department for 1990/91 indicate that species of most commercial value in the area are Grey Mullet (*Mugil affinis*), Yellow-finned Seabream (*Mylio latus*), Yellow Croaker (*Pseudosciaena crocea*), Yellowtail (*Seriola* spp.) and other species of seabream (Sparidae). Important species collected as fry for sale or for raising in fish culture zones inlcude Red Pargo (*Chrysophrys major*), Gold-lined Seabream (*Rhabdosargus sarba*) and other seabream, Yellowtail, Russell's Snapper (*Lutjanus russelli*) and Japanese Sea Perch (*Lateolabrax japonicus*). The Japanese Sea Perch is also the predominant species caught by stick-net fishing in the Tung Chung/Chek Lap Kok area, together with Grey Mullet, Emperor (*Lethrinus* spp.) and seabream. Shellfish and crustaceans of commercial value include clams (*Tapes* spp.), prawns (Penaeidae) and swimming crabs (Portunidae). Several species of commercially exploited penaeid prawns were observed in the trawl survey.

Records of dolphins in the North Lantau, Deep Bay and Pearl River Estuary area between July 1980 and October 1991 show 30 sightings of the Chinese White Dolphin, *Sousa chinensis* as listed in Table 8.4. Of these, 21 were live sightings and 9 were floating or, more commonly, beached carcasses. In addition to *Sousa chinensis*, carcasses of *Stenella coeruleoalba*, *Carcharhincus leucas* and *Delphinus delphis* were observed in 1988/89. The frequency of dolphin sightings has increased over the last two years, but this could be due to increased interest in the area because of the PADS projects, rather than an inherent increase in numbers of animals. Agriculture and Fisheries Department reported only one immature specimen of approximately 1m length out of the total number of sightings, which suggests that the area may be used as a feeding range for adults rather than as a breeding ground.

### 8.2.2 Littoral

Baseline data on littoral communities were reported with respect to seven designated community types comprising rocky cliff, jetty, boulder, *Zoysia* bed, sandy shore, mangrove swamp, and open shore communities. The locations of these communities are shown on Exhibit 8.3, while associated flora and fauna are listed in Tables 8.5-11.

The littoral fauna and flora of the Tung Chung and Chek Lap Kok areas are diverse and compare favourably with those of other Hong Kong shores. There was no evidence for detrimental pollution effects locally but North Lantau shores lack echinoderms, chitons (*Liolophura japonica*) and the predatory gastropod *Morula musiva* - perhaps as a result of periodic low salinity challenge from the Pearl River. Limpets were also in low abundance, possibly as a result of low salinity but also possibly because of high summer 1990 temperatures (perhaps in synergistic action with low salinity).

*Table 8.4*
*Reported Sightings of Chinese White Dolphin* Sousa chinensis *in North Lantau, Deep Bay and Pearl River Estuary Area Between July 1980 and October 1991*

| Date | Location | State |
|---|---|---|
| 2.7.80 | Castle Peak Bay | floating carcass |
| 24.6.86 | Butterfly Beach | live sighting |
| 22.7.86 | Lung Kwu Sheung Tan | stranded carcass |
| 31.1.87 | Sha Lo Wan | live sighting |
| 5.8.88 | off Brothers Island | live sighting |
| 21.1.89 | Tuen Mun Pier | live sighting |
| 5.2.89 | Tuen Mun Pier | live sighting |
| 3.7.89 | Castle Peak | stranded carcass |
| 5.8.89 | Tsing Lung Tau | stranded carcass |
| 23.3.90 | Lung Kwu Sheung Tan | stranded carcass |
| 1.5.90 | Pearl Island | live sighting |
| 13.6.90 | Tuen Mun Pier | stranded carcass |
| 24.6.90 | North of Lantau | live sighting |
| 1.7.90 | Tai Lam Marine Base | stranded carcass |
| 20.7.90 | Siu Lan Shui, Tuen Mun | stranded carcass |
| 1.11.90 | off Yung Long | live sighting |
| 7.11.90 | off Tuen Mun | live sighting |
| 18.11.90 | off Yung Long | live sighting |
| 22.11.90 | off Brothers Island | live sighting |
| 24.11.90 | off Macau | live sighting |
| 25.11.90 | off Lung Kwu Chau | live sighting |
| 26.11.90 | off Black Point | live sighting |
| 27.11.90 | Sha Chau | live sighting |
| 26.12.90 | north of Brothers | live sighting |
| 28.12.90 | between Tap Shek Kok and Sha Chau | live sighting |
| 23.12.90 | between Tuen Mun and Tung Chung | live sighting |
| 2.2.91 | between Lantau and Tuen Mun | live sighting |
| 14.2.91 | off Macau | live sighting |
| 3.3.91 | Chek Lap Kok | stranded carcass |
| 10.3.91 | off Sham Chek Tsuen | live sighting |
| 11.3.91 | north of Lantau, off Tai O | live sighting |
| 16.5.91 | Sham Shui Kok | live sighting |
| 28.5.91 | between Chep Lap Kok and Lok On Pai | live sighting |
| 2.6.91 | East Brother | live sighting |
| 3.6.91 | Urmston Road, off Tap Shek Kok | live sighting |
| 6.6.91 | between Chep Lap Kok and Big Brother | live sighting |
| 23.6.91 | North Lantau | live sighting |
| 10.7.91 | North Lantau | live sighting |
| 17.7.91 | North Lantau | live sighting |
| 1.8.91 | off Sham Wat, Lantau | live sighting |
| 11.8.91 | North Lantau | live sighting |

*Table 8.4 (Continued)*

| Date | Location | State |
|---|---|---|
| 11.8.91 | north west of Po Chu Tam, Lantau | live sighitng |
| 20.8.91 | west of Sham Wat | live sighting |
| 28.8.91 | Tung Chung Wan | live sighting |
| 1.9.91 | south of Brothers | live sighting |
| 9.9.91 | off Tap Sek Kok | live sighting |
| 23.9.91 | north of Chek Lap Kok | live sighitng |
| 23.9.91 | north of Lantau | live sighting |
| 24.9.91 | west of Tai Mo To in Tung Chung Wan | live sighting |
| 31.9.91 | Chek Lap Kok | live sighting |
| 9.10.91 | north west Chek Lap Kok | live sighting |

*Sources : AFD, World Wide Fund for Nature Hong Kong and Greiner-Maunsell, 1991*

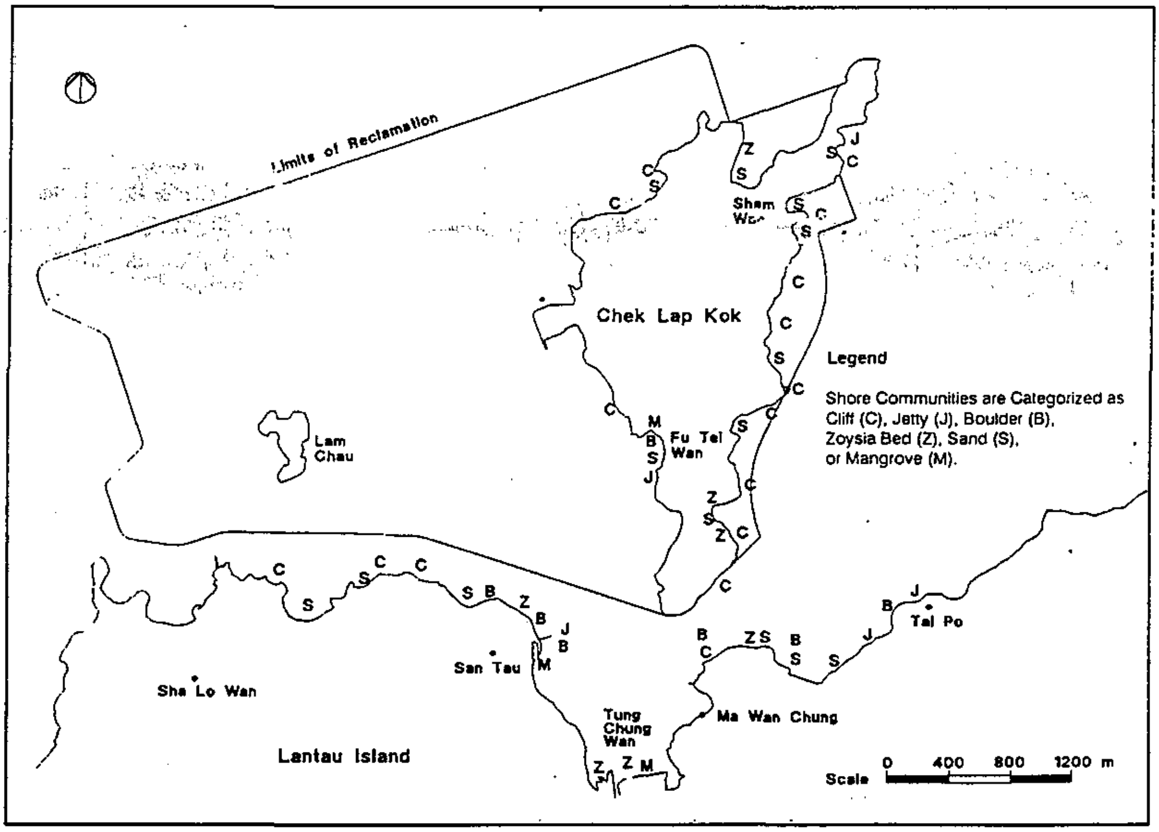



***Exhibit 8.3***
***Shore Survey of Littoral Communities, 9th to 11th of November 1990***

*Table 8.5*
*Fauna and Flora List for Typical Rocky Cliff Community (Relatively Wave Exposed) in Region of Tung Chung, North Lantau (November 1990)*

| Type | Species Name | [Previously reported as] |
|---|---|---|
| Lichen | *Caloplaca* spp. | |
| " | *Lecanora* spp. | |
| " | *Verrucaria* spp. | |
| Littorinid gastropod | *Nodilittorina trochoides* | [*Littorina pyramidalis*] |
| " | *Nodilittorina radiata* | [*Littorina exigua*] |
| " | *Littoraria articulata* | [*Littorina articulata*] |
| Other gastropod | *Nerita squamulata* | [*Nerita chamaeleon*] |
| " | *Monodonta labio* | |
| " | *Thais clavigera* | |
| Blue Green Alga | *Brachytrichia maculans* | |
| Red Alga | *Bangia* sp. | |
| " | *Hildenbrandia* sp. | |
| Bivalve (oyster) | *Saccostrea cucullata* (in shelter) | |
| Bivalve | *Barbatia virescens* (in crevices) | |
| Isopod crustacean | *Ligia exotica* | |
| Barnacle | *Capitulum mitella* | [*Pollicipes mitella*] |
| " | *Tetraclita squamosa* (not split into subspecies) | |
| Grapsid crab | *Grapsus albolineatus* | |
| Gastropod limpet | *Cellana toreuma* (few) | |
| " | *Siphonaria sirius* (few) | |
| " | *Patelloida* sp. (few) | |
| Crevice anemone | *Heliplanella luciae* | |

*Source : Greiner-Maunsell, 1991*

*Table 8.6*
*Fauna and Flora List for Typical Jetty Community in Region of Tung Chung, North Lantau (November 1990)*

| Type | Species Name | [Previously reported as] |
|---|---|---|
| Alga | *Brachytrichia maculans* | |
| Isopod | *Ligia exotica* | |
| Littorinid gastropod | *Nodilittorina trochoides* | [*Littorina pyramidalis*] |
| " | *Nodilittorina radiata* | [*Littorina exigua*] |
| " | *Littoraria articulata* | [*Littorina articulata*] |
| Limpet gastropod | *Patelloida* sp. (few) | |
| " | *Cellana toreuma* (few) | |
| Gastropod | *Nerita squamulata* | [*Nerita chamaeleon*] |
| " | *Monodonta labio* | |
| " | *Thais clavigera* | |
| Barnacle | *Tetraclita squamosa* | |
| Bivalve | *Barbatia virescens* (crevices) | |
| " | *Saccostrea cucullata* | |
| Hermit crab | *Clibanarius* sp. (in *Batillaria* shell) | |

*Source : Greiner-Maunsell, 1991*

*Table 8.7*
*Fauna and Flora List for Typical Lower Shore Boulder Community in Region of Tung Chung, North Lantau (November 1990)*

| Type | Species name | [Previously reported as] |
|---|---|---|
| Alga | *Brachytrichia maculans* | |
| " | *Hildenbrandia* sp. | |
| " | *Gomontia* sp. | |
| Barnacle | *Tetraclita squamosa* (wave exposed) | |
| " | *Balanus amphitrite* (sheltered) | |
| Gastropod (limpet) | *Cellana toreuma* | |
| Gastropod | *Nerita squamulata* | [*Nerita chamaeleon*] |
| " | *Nerita albicilla* | |
| " | *Monodonta labio* | |
| " | *Thais clavigera* | |
| " | *Lunella coronata* | |
| " | *Euchelus asper* | |
| " | *Chlorostoma rustica* | |
| Cephalopod | *Octopus membranaceus* | |
| Bivalve (oyster) | *Saccostrea cucullata* (shelter) | |
| Bivalve | *Barbatia virescens* | |
| " | *Perna viridis* | |
| " | *Trapezium sublaevigatum* | |
| Grapsid crab | *Hemigrapsus sanguineus* | |
| " | *Gaetice depressa* | |
| Xanthid crab | *Sphaerozius nitidus* | |
| Porcelain crab | *Porcellana japonicus* | |
| Pistol shrimp | *Alpheus bisincisus* | |
| Hermit crab | *Clibanarius* sp. | |
| Serpulid polychaete | *Pomatoleios kraussi* | |
| Fish (blenny) | *Tridentiger trigonocephalus* | |
| Sipunculan | *Phascolosoma scolops* | |

*Source : Greiner-Maunsell, 1991*

*Table 8.8*
*Fauna and Flora List for Typical Upper Shore Zoysia Community Near Tung Chung, North Lantau (November 1990)*

| Type | Species name | [Previously reported as] |
|---|---|---|
| Grass | *Zoysia sinica* | |
| Littorinid gastropod | *Littoraria ardouiniana* (on grass) | [*Littorina ardouiniana*] |
| " | *Littoraria melanostoma* (on grass) | [*Littorina melanostoma*] |
| " | *Littoraria articulata* (on rocks) | [*Littorina articulata*] |
| Gastropod | *Clithon oulaniensis* | |
| " | *Clithon faba* | |
| Bivalve mussel | *Xenostrabus atrata* (under rocks) | [*Brachidontes atrata*] |
| Grapsid crab | *Metopograpsus messor* | |
| " | *Parasesarma plicatum* (in *L. melanostoma* shell) | |
| Hermit crab | *Clibanarius longitarsus* | |
| " | *Pagurus trigonocheirus* | |
| Sipunculan | *Sipunculus nudus* | |
| Oligochaete | *Pontodrilus litoralis* | |

*Source : Greiner-Maunsell, 1991*

*Table 8.9*
*Fauna and Flora List for Typical Sandy Shore Communities (Varying with Wave Exposure and Beach Particle Size) in Region of Tung Chung, North Lantau (November 1990)*

| Type | Species Name |
|---|---|
| Fringing vegetation | |
| screw pine | *Pandanus tectorius* |
| scrambling shrub | *Scaevola frutescens* |
| convolvulus | *Ipomoea pes-caprae* |
| prickly pear | *Opuntia dilleni* |
| grass | *Zoysia sinica* |
| yellow hibiscus | *Hibiscus tilianus* |
| horsetail tree | *Casuarina equisetifolia* |
| Ghost crab | *Ocypode ceratophthalma* |
| Ghost crab | *Ocypode mortoni* |
| Talitrid amphipod | *Talorchestia* sp. |
| Fiddler crab | *Uca lactea* |
| Bubbler crab | *Scopimera intermedia* |
| Soldier crab | *Mictyris longicarpus* |
| Bivalve | *Mesodesma striata* |
| Bivalve (wedge shell) | *Donax faba* |
| Bivalve | *Meretrix meretrix* |
| Bivalve | *Tapes philipinnarum* |
| Innkeeper worm (Echiuroid) | *Ochetostoma erythrogrammon* |

*Source : Greiner-Maunsell, 1991*

*Table 8.10*
*Fauna and Flora List for Typical Mangrove Swamp Community in Region of Tung Chung, North Lantau (November 1990)*

| Type | Species Name |
|---|---|
| Mangrove tree | *Kandelia candel* |
| " | *Aegiceras corniculatus* |
| " | *Avicennia marina* |
| " | *Lumnitzera racemosa* |
| " | *Bruguiera gymnorrhiza* |
| " | *Excoecaria agallocha* |
| " | *Acanthus ilicifolius* |
| Gastopods - Littorinids | *Littoraria melanostoma* |
| | *Littoraria ardouiniana* |
| | *Littoraria pallescens* |
| Other gastropods | *Terebralia sulcata* |
| | *Cerithidea rhizophorarum* |
| | *Cerithidea cingulata* |
| | *Clithon retropictus* |
| | *Cerithidiopsilla djadjariensis* |
| | *Monodonta labio* |
| Oyster | *Saccostrea cucullata* |
| Barnacle | *Euraphia withersi* |
| " | *Balanus albicostatus* |
| Fiddler crab | *Uca lactea* |
| " | *Uca arcuata* |
| " | *Uca acuta* |
| Grapsid crab | *Chiromanthes bidens* |
| " | *Helice tridens* |
| Portunid crab | *Scylla serrata* |
| Hermit crab | *Clibanarius sp.* |
| Fish (mudskipper) | *Periophthalmus cantonensis* |

*Source : Greiner-Maunsell, 1991*

*Table 8.11*
*Fauna and Flora List for Typical Open Shore Communities Directly Adjacent to Mangrove Swamps in Region of Tung Chung, North Lantau (November, 1990)*

| Type | Species name |
|---|---|
| a) Open mud/sand | |
| grass | *Zoysia sinica* |
| gastropod | *Cerithidea rhizophorarum* |
| " | *Cerithidiopsilla djadjariensis* |
| " | *Batillaria zonalis* |
| " | *Terebralia sulcata* |
| " | *Laemodonta* sp. (Ellobiid) |
| " | *Clithon faba* |
| " | *Clithon oulaniensis* |
| bivalve | *Cyclina orientalis* |
| " | *Polymesoda erosa* |
| fiddler crab | *Uca lactea* |
| hermit crab | *Clibanarius longitarsus* (in *Batillaria* shells) |
| " | *Pagurus trigonocheirus* (in *Batillaria* shells) |
| sipunculan | *Sipunculus nudus* |
| fish (mudskipper) | *Periophthalmus cantonensis* |
| b) Oyster clumps | |
| bivalve (oyster) | *Saccostrea cucullata* |
| bivalve | *Barbatia virescens* |
| bivalve | *Trapezium sublaevigatum* |
| bivalve | *Brachidontes variabilis* |
| bivalve (oyster) | *Inus* sp. |
| barnacle | *Balanus amphitrite* |
| gastropod | *Nerita squamulata* |
| " | *Thais clavigera* |
| " | *Cymia trigona* (Thaid) |
| " | *Mondonta labio* |
| " | *Nerita squamulata* |
| " | *Littoraria articulata* |
| " | *Laemodonta* sp. (Ellobiid) |
| sipunculan | *Phascolosoma scolops* |
| grapsid crab | *Metopograpsus messor* |

*Source : Greiner-Maunsell, 1991*

Shores in the Tung Chung area have very good examples of Hong Kong mangrove swamps, particularly for densities of the mangrove tree *Bruguiera gymnorrhiza*. A predatory gastropod (*Cymia trigona*) associated with littoral freshwater runoff over oyster clumps was recorded for the first time on Hong Kong shores. The mangrove swamp and associated foreshore with seagrass beds containing the eel grass *Zostera nana* south of Tin Sam jetty is of international conservation significance. There is one other *Zostera* bed in Hong Kong at Lai Chi Wo beach, which together with the beds at Tin Sam form the most southerly beds in China; the nearest sites elsewhere are in Shandong and Hebei Provinces, about 1,500km to the north (Hodgkiss and Morton 1978; Melville, 1989). This site is therefore worthy of protection.

Baseline concentrations of copper, zinc and cadmium were established in the barnacle *Tetraclita squamosa* from four sites in the region of Tung Chung and Chek Lap Kok as shown on Exhibit 8.4. The concentrations were low by local standards as indicated in Table 8.12. Table 8.13 indicates that levels of nickel, chromium and cobalt were undetectable.

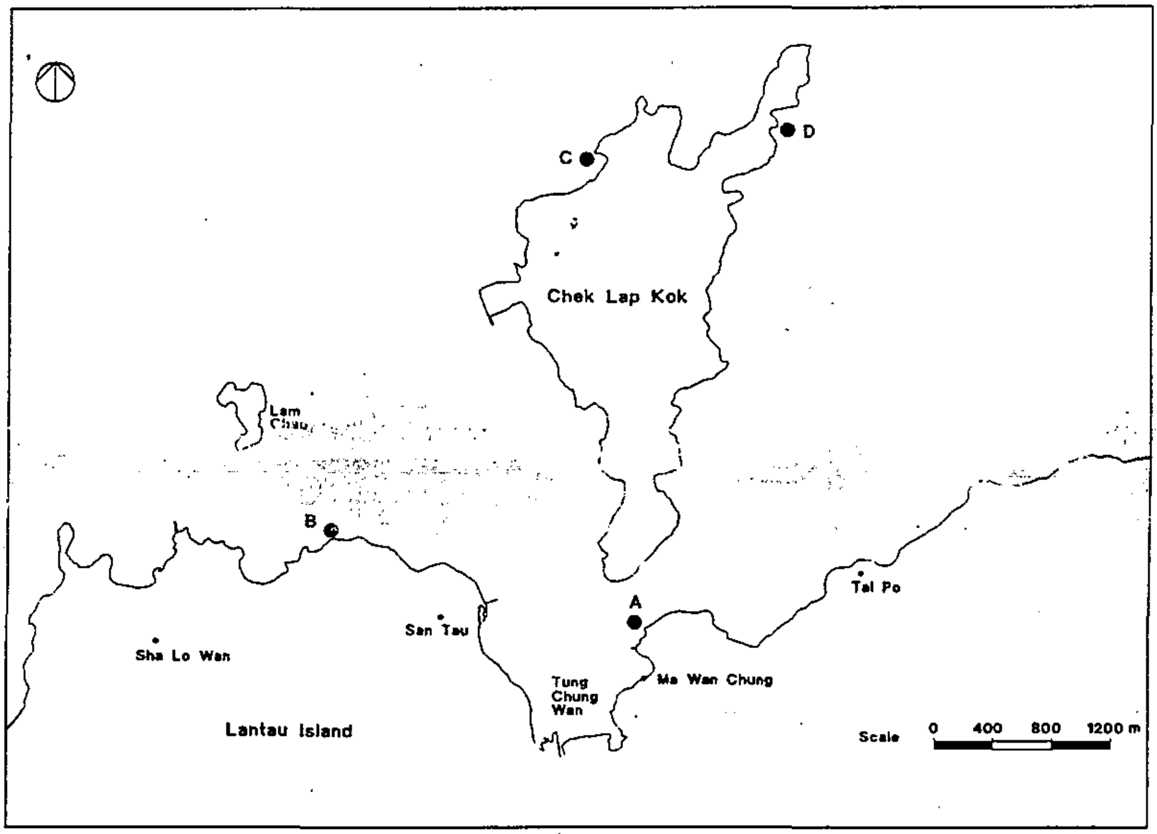



*Exhibit 8.4*
***Sample Sites (A,B,C,D) for Collection of the Barnacle***
**Tetraclita squamosa *for Biomonitoring of Heavy Metals***

*Table 8.12*
*Biomonitoring data : Estimated metal concentrations (mg/kg dry wgt with 95% confidence limits) in standard weight bodies (0.02 g dry wgt) of Tetraclita squamosa collected from 4 sites in the immediate area of Tung Chung and Chek Lap Kok, North Lantau on 10 and 11 November 1990, as estimated from best-fit double log regressions of body metal concentration against body dry weight. Sites (A-D as shown on Exhibit 8.4) showing a common letter in the ANCOVA column for one metal are not significantly different at the P=0.05 probability level. Also shown are equivalent data for Tung Chung (equivalent to site A) and Reef Island*

| | Copper | | | Zinc | | | Cadmium | | |
|---|---|---|---|---|---|---|---|---|---|
| Site | Cu conc. | 95% CL | ANCOVA | Zn conc. | 95% CL | ANCOVA | Cd conc. | 95% CL | ANCOVA |
| | | 21.8 | | | 5297 | | | 12.9 | |
| A | 16.5 | 12.4 | X | 4472 | 3776 | X | 10.6 | 8.7 | X |
| | | 20.1 | | 5925 | 7080 | | | 14.6 | |
| B | 16.7 | 13.9 | X | | 4958 | Y | 12.8 | 11.2 | X |
| | | 24.9 | | | 5806 | | | 17.4 | |
| C | 19.3 | 15.0 | X | 4043 | 2815 | X | 13.7 | 10.7 | X |
| | | 20.8 | | | 7030 | | | 21.1 | |
| D | 18.8 | 17.0 | X | 6017 | 5150 | Y | 16.2 | 12.5 | X |
| Tung Chung | | | | | | | | | |
| April 1986* | | 24.3 | | | 3555 | | | 6.5 | |
| | 14.9 | 9.1 | | 2245 | 1414 | | 4.2 | 2.7 | |
| Reef Island | | 41.3 | | | 6677 | | | 12.6 | |
| April 1986* | 30.9 | 23.2 | | 4207 | 2651 | | 7.7 | 4.7 | |

*Sources : Greiner-Maunsell, 1991 and *Chan et al., 1990*

*Table 8.13*
*Range of maximum concentrations of nickel, chromium and cobalt in bodies of the barnacle Tetraclita squamosa collected from four sites in North Lantau (see Exhibit 8.4) in November, 1990. Also presented are nickel data for T. squamosa collected in April, 1986 and chromium and cobalt data for the same barnacles expressed as maximum ranges*

| | Metal Concentrations (mg/kg dry wgt) | | |
|---|---|---|---|
| Site | Nickel | Chromium | Cobalt |
| A | <23.1-<53.2 | <11.6-<26.6 | <11.6-<26.6 |
| B | <17.4-<29.4 | <8.7-<14.7 | <8.7-<14.7 |
| C | <13.2-<29.6 | <6.6-<14.8 | <6.6-<14.8 |
| D | <24.8-<43.9 | <12.4-<21.9 | <12.4-<21.9 |
| * Tung Chung April 1986 | 2.0-4.7 | <1.2-<2.5 | <1.2-<2.5 |
| * Reef Island April 1986 | 1.7-5.0 | <1.5-<2.8 | <1.3-<2.8 |

*Sources : Greiner-Maunsell, 1991 and *Chan et al., 1990*

## 8.3 Marine Ecological Impacts

The main impacts of airport construction on marine biota will be the destruction of benthic fauna in the immediate vicinity of dredging, reclamation and dumping operations, and disturbance to fauna in the surrounding area through dispersal of suspended sediments. The effects of dispersed sediments on biota outside the immediate dredging/dumping sites, although extensive, would be expected to be less significant than for example in eastern Territorial waters, since the faunal communities of the North Lantau area are to an extent acclimatised and adapted to periods of high suspended solids in the water column and irregular sediment deposition events as a result of the Pearl River discharge. The dredging and dumping operations will in effect exacerbate this "natural" impact, with suspended solids concentrations increasing typically by between 1 and 10 mg/l over a large spatial area. Since the material to be dredged has been shown to be uncontaminated and levels of metals in bioindicator species are low, the dredging will not involve the introduction of toxic substances into the marine environment (as would, for example, a new sewage outfall) but will rather involve disturbance and redistribution of largely inert material already contained within the ecosystem. This aspect is recognised in the *US Code of Federal Regulations* (1990), where dredged material that is substantially the same as the substrate at the disposal site, and that is taken from sites far removed from known existing and historical sources of pollution, is considered to be environmentally acceptable for disposal.

### 8.3.1 Sublittoral Biota

It is a feature of Hong Kong coastal sediments that they receive much natural disturbance (Shin, 1989), being washed out and recolonised irregularly. Thus benthic sediment recolonization of naturally depopulated areas is ongoing and effective.

At Chek Lap Kok, the shallow sublittoral habitats to the west of the island will clearly be permanently lost beneath the reclamation for the new airport. Sublittoral habitats outside the airport footprint will also be destroyed or disturbed during dredging of e.g. access channels and the flushing channel to the south of the airport. In the long term, however, after construction is completed, areas no longer being disturbed will be recolonized by benthic invertebrates and fish. If the sediment is of the same type as at present then a similar fauna will return. In some areas around Chek Lap Kok, sediment types will be different than at present because of the changed tidal flow. This may result in greater scouring of some sublittoral areas, such as at the northeast corner of the reclamation, thereby leading to coarser sediment, whilst more sheltered areas such as East Tung Chung Bay may accumulate more fine sediment fractions. Infauna will colonise these new sediments but such fauna will be different to those currently present.

Away from Chek Lap Kok, baseline data have been collected for the borrow areas/dumping grounds north of The Brothers. Again, great heterogeneity in sediment types was evident (possibly partly as a result of previous anthropogenic disturbance) and a high diversity of benthic fauna was observed. Fauna at borrow areas will be destroyed when marine mud overburden is removed and the surrounding areas will be affected by sediment deposition during dredging of mud and sand, particularly if overflowing of barges during sand loading occurs. However, providing that the pits are backfilled to restore the original bathymetry and substrate type, a similar community of benthic invertebrates and fish would be expected to return and recolonise the area. Although no baseline data were collected in this survey for other borrow areas, since these had not been defined in detail at the time the survey was carried out, the conclusions made above can be expected to hold for areas such as Urmston Road.

Thus, it can be expected that the sublittoral fauna of any area disturbed by airport construction will be affected in the short term, but they will recolonize in the long term after anthropogenic disturbance has ceased. If the sediment type is unchanged, existing faunal assemblages have the potential to return by such mechanisms as larval recolonization and immigration. If the sediment type is changed by dumping, dredging or change of tidal flow regime, then a different faunal assemblage will colonize the new sediment. Given the heterogeneity of sediments already present in the North Lantau area, however, such changes are unlikely to be of significant long term detrimental effect to the sublittoral marine ecosystem as a whole to the north of Lantau.

Fish will be frightened away during construction operations but will likely return to the area once disturbance has ceased, providing that there are no adverse operational impacts from the airport. Some detrital feeders may be attracted by disturbed sediments. It is possible that specific fish breeding and nursery grounds will be permanently lost, although Agriculture and Fisheries Department has little information on fish breeding grounds in the area. It is known that the Japanese Sea Perch (*Lateolabrax japonicus*) breeds in a broad range from Castle Peak to Stonecutters Island from November onwards, migrating from the Pearl River to the shallow inshore waters around North Lantau. It is thought that other local fish species spawn offshore and the planktonic larval stages drift inshore to shallow bays to feed. A number of the bays on North Lantau, including Hau Hok Wan, San Tau and Tai Ho Wan, and Fu Tei Wan and A Ma Wan on Chek Lap Kok, have been identified in previous surveys as being important sites for the collection of fish fry for subsequent cultivation in fish culture zones. The impact on local species which are of commercial value, and others is unknown but will depend on the density of other suitable breeding and nursery grounds in the area unaffected by the airport and New Town development.

Effects on cetaceans such as the Chinese White Dolphin would not be expected to be great; as air-breathing mammals they will be less affected by high suspended solids concentrations than fish. The sighting records show that their range includes the waters around Macau which are typically subject to equivalent or higher solids loadings from the Pearl River than the North Lantau area, and suggests that the white dolphin is reasonably tolerant of waters with a high silt content. There may, however, be an indirect effect in terms of food availability, since fish stocks and breeding grounds may be adversely affected. The significance of this potential impact is dependent upon the size of the feeding range of the white dolphin and the proportion of its range which would be affected by the airport construction works. There is very little published information on the range or behaviour patterns of *Sousa chinensis*, but observations of other humpback dolphins (*Sousa plumbea*/*Sousa lentiginosa*) suggests that they have a fairly limited range and, unlike bottlenose dolphins which may be found over 30 km offshore, tend to restrict their movements to inshore waters (Saayman and Tayler, 1979). The northwestern waters may thus form an important part of the normal range of the white dolphin. As intelligent mammals, they will be capable of avoiding works areas, but in order to reduce the degree of sterilisation of their range, it would be preferable to work borrow/dumping areas individually rather than simultaneously, thus minimising the geographical extent of disturbance at any one time.

### 8.3.2 Littoral Communities

The major effect of the airport development on the littoral communities of the local North Lantau area will be the complete destruction of many shores under reclaimed land. Thus most of the shores on the west and north coasts of Chek Lap Kok will be destroyed as will most on the east coast of the island. The seawall edges of reclaimed land at Chek Lap Kok will be sloped rock rubble with a high (40%) void space, and will therefore offer some scope for recolonization by hard shore epifauna, but in comparatively low diversity as a result of the reduced local microhabitat variation, for example with respect to wave exposure, aspect, insolation etc. Such seawalls will not support the existing biota of, for example, local rocky cliffs.

Shoreline communities on North Lantau would also have been destroyed under the full reclamation scenario. In view of the inevitable loss of these communities on Chep Lap Kok, it was strongly recommended that the flushing channel option be adopted. This will permit the stretch of the North Lantau coastline south of the airport to be retained, even if in a reduced condition in comparison to its present rich diversity. These littoral communities will be affected during reclamation of the airport by the increased suspended solids concentrations generated by dredging for the southern seawall, and to a greater extent when the flushing channel is dredged. Greatly increased sediment loads will be lethal to many shore organisms. Although mangroves commonly occur in areas of rapid sedimentation, they cannot survive heavy loads of fine flocculent material, as this can coat and clog the aerial roots, thus effectively suffocating the plants. Increased turbidity also impairs photosynthesis of submerged aquatic plants by reducing light penetration. Dredging activities could therefore damage the mangrove/eel grass association near Tin Sam jetty, which is of conservation importance. An application has been made by the World Wide Fund for Nature to have the site of this association designated as an SSSI.

Once the southern seawall is completed, the hydraulic regime along the shoreline will be altered. Although it is the intention that flushing rates along the channel are maintained, wave action will be considerably reduced, and the nature and extent of wave exposure and localised tidal flushing will change permanently. The shores will be more sheltered than at present even if they suffer no further anthropogenic interference. Biota of exposed rocky cliffs or sandy shores are likely to be lost and replaced by sheltered rocky communities dominated by oysters or by sedimentary shores of smaller particle size e.g. muds. The littoral communities that survive the construction impacts would thus be expected to deteriorate and be replaced by comparatively depauperate muddy shore communities

Although the temporary dredging impacts from the airport can be mitigated, the permanent changes in the localised hydraulic conditions near the mangrove/eel grass community, and possible impacts from the adjacent New Town development, could adversely affect this association in the longer term. For the proposed Maplin Airport in the UK, an experimental programme of transplanting *Zostera* was carried out using turfs taken from Maplin Sands (Boorman and Ranwell, 1977). The trials were of limited sucess due mainly to the lack of a suitable stable mudflat, but it was concluded that it would be possible to establish eel grass beds on a suitably engineered mudflat. The possibility of transplanting part of the existing eel grass bed to any areas created for mangrove establishment could therefore be considered, if monitoring suggests that the state of the existing beds is deteriorating.

## 8.4 Mitigation Measures

Several mitigation measures, in addition to those already specified for the protection of water quality in Section 7, are recommended relating to works at Chek Lap Kok and at the borrow areas. The feasibility of the latter is dependent upon policy relating to dedication of specific borrow areas to one project, and the practical and economic viability of working out and restoring individual areas in the context of managing the total fill resource.

*Chek Lap Kok*

- The southern seawall of the airport reclamation should be progressively constructed in advance of the dredging works to contain sediment dispersion as far as possible and to protect the North Lantau shoreline.

- Water quality monitoring stations should be established by PAA within the proposed channel, one north of Tin Sam jetty between the dredging area and the mangrove/eel grass community and one at its western end off the sandy shore, to provide data on turbidity generation in this area. Remedial measures should be implemented by the Contractor if suspended solids levels become unacceptably high in relation to measured background concentrations.

- Disturbance of the sea bed outside the airport footprint, channel excavation, marine borrow areas and marine mud disposal areas should be avoided wherever possible.

- Should surveys of the existing *Zostera* beds indicate deterioration, consideration should be given by Government to the possibility of transplanting *Zostera* turfs from Tung Chung Bay to any new mudflats engineered for mangrove replanting adjacent to PADS developments along the North Lantau coastline.

*Borrow Areas*

- Where practicable, marine borrow areas should be worked individually and backfilled while the next area is being worked. This will reduce the extent of disturbance at any one time to marine communities. Recolonisation of affected areas depends on a supply of animals from unaffected areas and may be significantly slower and less successful if large surface areas of seabed are destroyed simultaneously.

- Where practicable, worked out borrow areas should be backfilled to the original level, with at least 5m of uncontaminated marine mud at the surface, to permit recolonisation to begin within as short a time as possible.

- Contractors should be advised of the possible presence of dolphins in the area and of the need for their protection.

## 8.5 Monitoring

The monitoring requirements for water quality, which are also applicable to marine ecology, are detailed in Section 7.

It is recommended that repeat surveys of the sublittoral community are carried out by Government following construction of the airport. Fish and invertebrate macrofauna should be sampled by grab and trawl at sites immediately adjacent to the airport, particularly in East Tung Chung Bay and at sites such as borrow/dump areas disturbed anthropogenically as a result of airport construction. Monitoring at borrow/dump sites can be discontinued once a baseline community is re-established.

Surveying after completion of the construction phase will permit an assessment of the effects of the airport reclamation on local marine communities in the longer term, once they have stabilised in response to the new conditions of substratum and flow patterns. Since the monitoring would be carried out during the operational stage rather than the construction stage *per se*, it is recommended that one series of marine ecological surveys, carried out biannually over the first six years of airport operation, is undertaken to assess the combined effects of the airport construction and operation. The monitoring requirements are addressed further in Section 20.

Inspection of the eel grass beds south of Tin Sam jetty should be made on a quarterly basis to assess whether degradation is occuring as a result of sediment deposition from dredging. If construction activities are considered to be causing a serious risk to its survival, transplanting of part of the bed to another site should be instigated, with the assistance of the World Wide Fund for Nature Hong Kong.

## 9.1 Assessment Methodology

### 9.1.1 Terrestrial Flora and Fauna

Assessment of the terrestrial flora and associated fauna on Chek Lap Kok has focused on the identification of habitat types rather than on the production of species lists, for three reasons. Firstly, in view of the limited time available, only partial species lists could be produced and only for the best known and most conspicuous taxonomic groups. Such partial sampling is, by definition, likely to miss the rare or restricted species which are of major conservation interest. Secondly, even if it were possible to produce complete species lists for all taxonomic groups, too little is known about the rarity and conservation status of the vast majority of local species for such a list to be of much value. Thirdly, many species are either not identifiable (e.g. many orchids, insects such as Coleoptera and Diptera) or not present for much of the year (e.g. migratory birds) so a reliable inventory would require at least one year's work.

The flora and fauna studies have therefore focused upon habitats, highlighting individual species only where there was sufficient information or where the species were of known conservation value. Habitat types have been ranked on the basis of their rarity in the local and regional context and on their relative contribution to local biological diversity. An additional criterion which, in practice, usually correlates with the other two, is whether or not a habitat could be "recreated" elsewhere. Application of these criteria to the Territory as a whole gives highest conservation priority to remnants of Hong Kong's original forest cover. These habitats are rare, exceptionally diverse and essentially "unrecreatable". Other hillside habitats can be ranked in terms of the height, density and area of tree and shrub cover, since these factors correlate with their rarity, botanical diversity and value as animal habitat. The extensive fire-maintained grasslands, with or without scattered shrubs, are, in comparison, ecological deserts, supporting only a depauperate flora and fauna.

The other major group of ecologically important habitats in the Territory are the streams and wetlands. Perennial water supply is a major limiting factor for many organisms in Hong Kong and wet areas provide islands of diversity in the landscape. Moreover, stream communities integrate changes in land use within their drainage basins and so can be used as powerful indicators of environmental quality. Freshwater wetlands are especially threatened locally since they are mostly associated with flat land outside Country Parks and hence tend to be prime development sites. Mangroves are noted for their faunal diversity and are of additional importance for their contribution to marine diversity and their role as a nursery area for many species of fish and crustaceans.

The baseline survey of terrestrial flora and fauna on Chek Lap Kok was carried out over the period July-November 1990. The small size of the island allowed all parts to be visited on foot and made reliance on interpretation of aerial photographs unnecessary. After an initial general survey, attention was concentrated on the habitats of greatest ecological significance. Plant species were mostly identified in the field, and systematic searches were made for traces of mammals, such as burrows, droppings and food remains. Collections of animals from ponds and small streams were preserved for later identification in the laboratory. Extensive enquiries were also made among professional and amateur field biologists in Hong Kong concerning the flora and fauna of Chek Lap Kok.

Limited habitat surveys were also carried out in May and November 1991 of a number of the remote sites identified for possible terrain cuts on northeast Lantau and in Tai Lam Country Park (CP); for installation of electronic equipment on East and West Brother Islands, Lung Kwu Chau, Sha Chau, Tai Lam Kok (Brothers Point) and two small hillside areas on northeast Lantau; and for installation of obstruction lights on Sunset and Lantau Peaks and three peaks in south Tai Lam CP.

### 9.1.2 Avifauna

The avifauna study involved a monthly visit to Chek Lap Kok (August 1990 to July 1991) to determine species composition of the avifauna and habitat use. All major habitat types on the island were visited each month and bird species presence/absence recorded. Although the avifauna species composition was determined, due to the limited time available it was not possible to study the number of birds present on the island or the population turnover. Field surveys of the remote sites were made in May 1991 and November 1991 to assess their importance as bird habitats.

## 9.2 Existing Environment

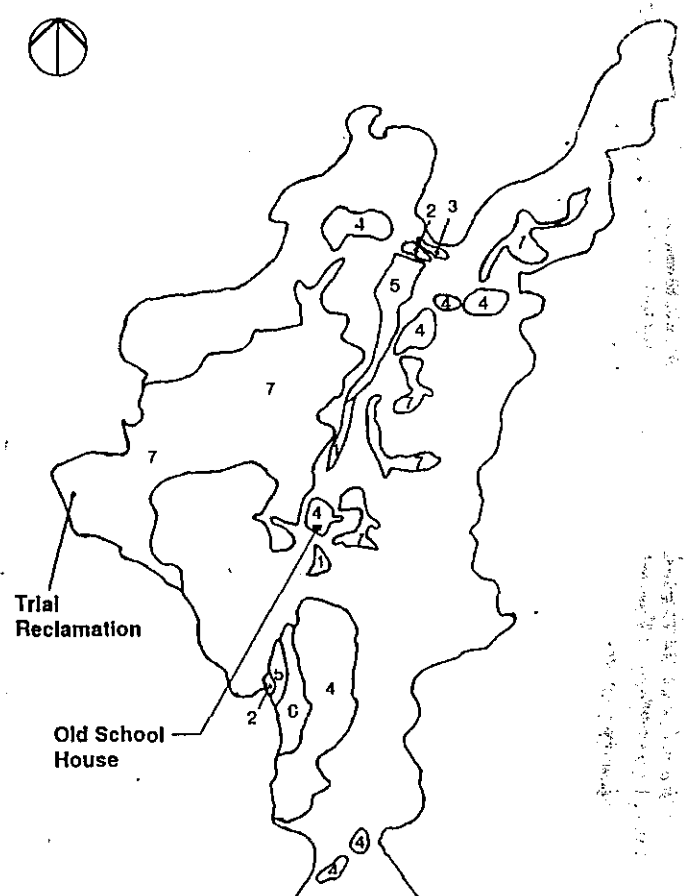
### 9.2.1 Terrestrial Flora and Fauna

**Chek Lap Kok**

A schematic vegetation map of Chek Lap Kok is shown on Exhibit 9.1 and plant species observed on the island during the survey period are listed in Table 9.1.

Chek Lap Kok must once have been covered in forest and is large enough to have supported much of Hong Kong's terrestrial vertebrate fauna. However, centuries of cutting and burning have removed all the forest and the exposed granitic slopes have been subject to massive erosion. As a result, the vegetation of most of the island is relatively uniform and poor in plant species. The absence of native woodland, or even extensive areas of closed shrubland, provides poor habitat for the majority of Hong Kong's vertebrate fauna.

The most interesting and valuable habitats on the island are the wetlands (Exhibit 9.1). The mangroves, although not extensive, contain most of Hong Kong's mangrove plant species, including many large specimens of the relatively rare *Bruguiera gymnorrhiza*. The freshwater wetlands are home to a rare Hong Kong endemic, Romer's Tree Frog (*Philautus romeri*), which is known from only three sites in the world : Chek Lap Kok, part of Lantau Island, and a small area on Lamma Island. However, although the lowland wetlands on Chek Lap Kok are of conservation importance because of the presence of *P. romeri*, they have already been severely disturbed by agricultural activities. In addition, livestock wastes flow into many of the lowland marshy areas. Apart from *P. romeri*, no evidence was found of rare or endangered freshwater animals on the island. No invertebrate or fish species of any conservation significance were recovered.




Key: Notes On Vegetation Type

1. *Nepenthes mirabilis* patches : these do not represent the only plants on the island but include the major stands; isolated plants can be found in small, permanently wet valleys. The northern stand is the larger of the two.

2. Mangrove : these small patches include all of the major mangrove species in Hong Kong including well-developed specimens of *Bruguiera gymnorrhiza.* This habitat intergrades into typical back-of-beach vegetation (*Hibiscus tiliaceus, Scaevola sericea,* etc.). Although there are only two small mangrove stands on Chek Lap Kok, their loss must be considered in the context of the proposed destruction of North Lantau mangrove as a consequency of PADS. In mitigation, attempts should be made to recreate equivalent mangrove habitat on Lantau.

3. Salt meadow behind barrier beach comprising a rich community of strand-line herbs and creepers (including *Suaeda australis*).

4. Open secondary woodland, exotic trees and tall shrubs : including local species typical of regenerating secondary forest such as *Schefflera octophylla, Macaranga tanarius, Rhus chinensis, R. succedanea* and *Sterculia lanceolata.* Larger trees in the neighbourhood of settlements are mostly fruit trees or other exotics (e.g. *Cassia* sp., *Casaurina equisetifolia, Acacia confusa, Tristania conferta, Pinus* spp.). These areas of the terrestrial habitat on Chek Lap Kok add to the diversity of the landscape but probably have limited conservation value in the local context. They do, however, provide shelter for migrant birds and their loss should be compensated by planting native species in North Lantau.

5. Freshwater wetlands : these low-lying areas have been profoundly influenced by man and are intimately mixed with agricultural land. Some are polluted by animal wastes while the moisture in other areas is probably a direct consequence of diversion of natural drainage patterns to promote irrigation. Thus the extent of these wetlands has probably been increased by human actions. Despite the pervasive anthropogenic impacts, these areas provide habitat for *Philautus romeri.* However, other elements of the freshwater fauna (dragonflies, damselfies, aquatic beetles, etc.) comprise species which are widely-distributed in the Territory.

6. Actively cultivated agricultural land intergrading into wetland.

7. Badlands : no conservation value.

Unmarked regions on the map comprise grassland and low scrub, shading into grass with patches of bare soil on steep slopes and hill tops. Extensive areas in the south of the island have been burnt recently. This habitat comprises much of Chek Lap Kok. The grassland is dominated by *Ischaemum* spp., *Arundinella setosa, Eulalia speciosa,* and *Cymbopogon tortilis,* with a varying admixture of *Rhodomyrtus tomentosa, Eurya japonica* and *Rhaphiolepis indica,* which are widespread in the territory. The shrubland in valley bottoms, lower slopes, and along the margins of mixed exotic and secondary woodland (see 4 above) is more varied. The commonest species - in addition to *Rhodomyrtus, Eurya* and *Rhaphiolepis* - are *Baeckia frutescens, Embelia laeta, Litsea rotundifolia* and *Melastoma sanguineum,* with the climbers *Alyxia sinensis* and *Gnetum montanum.* Shrubs such as *Melastoma candidum* and exotic *Lantana camara.* as well as the creeper *Mikania micrantha,* which are characteristic of disturbed land, occur in valley bottoms. All of these shrubland/grassland species are widely-distributed and abundant elsewhere in Hong Kong.

**Schematic Vegetation Map of Chek Lap Kok** Exhibit 9.1

*Table 9.1*
*Plant Species Encountered on Chek Lap Kok*
*(excludes cultivated plants and weeds)*

| | | |
|---|---|---|
| *Abrus precatorius* | *Eurya japonica* | *Osbeckia chinensis* |
| *Acacia confusa* | *Eurya macartneyi* | *Paederia scandens* |
| *Acanthus ilicifolius* | *Ficus fistulosa* | *Pandanus tectorius* |
| *Acronychia pedunculata* | *Ficus hirta* | *Pentaphylax euryoides* |
| *Adenosma glutinosa* | *Ficus microcarpa* | *Phoenix hanceana* |
| *Adiantum flabellulatum* | *Ficus superba* | *Pinus* spp. |
| *Adina pilulifera* | *Ficus variolosa* | *Pithecellobium lucidum* |
| *Alyxia sinensis* | *Gahnia tristis* | *Pluchea indica* |
| *Antidesma ghaesembilla* | *Gardenia jasminoides* | *Psidium guajava* |
| *Aporusa chinensis* | *Glochidion macrophyllum* | *Psychotria rubra* |
| *Ardisia crenata* | *Gnetum montanum* | *Pteroloma triquetrum* |
| *Artemisia japonica* | *Gordonia axillaris* | *Pyrrosia adnascens* |
| *Arundinaria hindsii* | *Gymnema sylvestre* | *Rhaphiolepis indica* |
| *Arundinella setosa* | *Helicteres angustifolia* | *Rhodomyrtus tomentosa* |
| *Asparagus cochinchinense* | *Heterosmilax* | *Rhus hypoleuca* |
| *Aster baccharoides* | *gaudichaudiana* | *Rhus succedanea* |
| *Atalantia buxifolia* | *Hibiscus tiliaceus* | *Rhyncospora rubra* |
| *Avicennia marina* | *Homalium cochinchinense* | *Rhus chinensis* |
| *Baeckea frutescens* | *Ilex asprella* | *Rourea microphylla* |
| *Blechnum orientale* | *Ilex pubescens* | *Sapium discolor* |
| *Breynia fruticosa* | *Imperata cylindrica* | *Sapium sebiferum* |
| *Bridelia tomentosa* | *Inula cappa* | *Scaevola sericea* |
| *Brucea javanica* | *Ischaemum* spp. | *Schefflera octophylla* |
| *Bruguiera gymnorrhiza* | *Itea chinensis* | *Scleria levis* |
| *Caesalpinia bonduc* | *Jasminum lanceolarium* | *Scolopia chinensis* |
| *Canavalia cathartica* | *Kandelia candel* | *Scolopia saeva* |
| *Casaurina equisetifolia* | *Lantana camara* | *Selaginella sp.* |
| *Cassia* spp. | *Lepidosperma chinense* | *Smilax china* |
| *Cassytha filiformis* | *Liquidambar formosana* | *Smilax corbularia* |
| *Celastrus hindsii* | *Litsea glutinosa* | *Smilax glabra* |
| *Cerbera manghas* | *Litsea rotundifolia* | *Sporobolus virginicus* |
| *Chrysanthemum indicum* | *Lonicera confusa* | *Sterculia lanceolata* |
| *Clerodendrum inerme* | *Lumnitzera racemosa* | *Strophanthus divaricatus* |
| *Cocculus trilobus* | *Lycopodium cernuum* | *Suaeda sp.* |
| *Cratoxylon cochinchinense* | *Lygodium microphyllum* | *Syzygium buxifolium* |
| *Cuscuta sp.* | *Macaranga tanarius* | *Tetracera asiatica* |
| *Cymbopogon tortilis* | *Mallotus paniculatus* | *Themeda gigantea* |
| *Cynodon dactylon* | *Melanthera bicolor* | *Toxocarpus wightianus* |
| *Dendrotrophe frutescens* | *Melastoma candidum* | *Trema orientalis* |
| *Derris trifoliata* | *Melastoma sanguineum* | *Tricalysia dubia* |
| *Dianella ensifolia* | *Melia azederach* | *Tristania conferta* |
| *Dicranopteris linearis* | *Microcos paniculata* | *Tylophora ovata* |
| *Diospyros morrisiana* | *Mikania* | *Vitex rotundifolia* |
| *Diospyros vaccinioides* | *micranthaMiscanthus* | *Wedelia chinensis* |
| *Embelia laeta* | *floridulus* | *Wikstroemia indica* |
| *Embelia ribes* | *Morinda umbellata* | *Zanthoxylum avicennae* |
| *Eulalia speciosa* | *Mussaenda pubescens* | *Zanthoxylum scandens* |
| *Euonymus chinensis* | *Nepenthes mirabilis* | |
| *Eurya chinensis* | *Neyraudia reynaudiana* | |

*Source : Greiner-Maunsell, 1991*

Several wet valleys above the main areas of cultivation support large populations of the pitcher plant, *Nepenthes mirabilis*. Although this species is not globally or regionally endangered, and is fairly common on granite elsewhere in the Territory, it is a protected species in Hong Kong and the populations on Chek Lap Kok are probably the largest in the Territory. The pitchers of *Nepenthes* harbour a diverse association of aquatic invertebrates, some of which are so far known only from Hong Kong (Disney, 1981). There is no evidence to suggest, however, that the invertebrate fauna associated with the Chek Lap Kok pitcher plants is any different from that of other *Nepenthes* populations in the Territory.

In contrast to the wetlands, the dry, eroded slopes are covered in species-poor vegetation dominated by *Baeckea frutescens, Rhodomyrtus tomentosa, Ischaemum* spp., and a variable component of other common grass and shrub species (Table 9.1). One protected species, *Gardenia jasminoides*, and the palm, *Phoenix hanceana*, which has recently been removed from the protected species list, are found in the hill-slope grasslands, but neither species is rare or threatened in Hong Kong. The occurrence of a number of common orchid species adapted to such habitats, such as the Bamboo Orchid (*Arundina chinensis*), would also be predicted, but none were detected in the survey because of their seasonality. However, although protected, none of these orchid species are rare.

Apart from birds and bats, the only protected animal species known to occur on the island is the Chinese Pangolin (*Manis pentadactyla*), detected by the presence of its characteristic fecal droppings. There was no evidence of the presence of civets, ferret badgers, porcupines or other large native mammals. The occurrence of fruit bats, presumably *Cynopterus sphinx*, is indicated by the characteristic fruit remains under feeding roosts, although no bats were seen during the present study. Previous investigators have reported both fruit bats and a small insectivorous bat. In the absence of suitable habitat, it is considered that the presence of any other protected mammalian species is extremely unlikely.

**Remote Sites**

The locations of the remote sites identified for installation of obstruction lights, terrain cuts and placement of electronic equipment, or airspace-related terrain cuts have been previously shown on Exhibit 2.3.

<u>Tai Lam CP</u>

The southerly hill which would be affected at Tai Lam is covered in woodland and shrubland, of mostly planted and exotic species. A number of protected species are present, notably *Enkianthus quinquefolius*.

<u>Northeast Lantau</u>

The peak and hillside areas on northeast Lantau that would be affected are predominantly fire-maintained grassland, of little ecological value.

<u>Sunset and Lantau Peaks</u>

Both Sunset and Lantau Peaks are areas of great ecological value and sensitivity. Their value arises from the fact that, with Tai Mo Shan in the New Territories, they represent the only areas in the Territory which attain an altitude of more than 800m. As a result of the unusual physical environment, as well as their remoteness from past and present population centres, both peaks support an extremely rich flora of montane species that are rare in both a local and a regional context. In recognition of their ecological value, the northern slopes of the peaks have been designated as Sites of Special Scientific Interest (SSSI). However, it is important to note that rare and interesting species also occur outside the boundaries of the SSSIs.

The Brothers

West Brother Island represents the only sedimentary rock formation in Western Hong Kong. The island was inhabited in the 1950's by labourers working a graphite mine on the island, and the presence of secondary plant communities suggests that the native vegetation and wildlife were destroyed by the inhabitants. The present vegetation is secondary and not very old. It is not of great ecological interest but the density of tall shrubs and some trees is likely to provide a valuable habitat for birds.

The island has a diverse invertebrate fauna but native ground-dwelling mammals other than rats are almost certainly absent. The existence of abandoned tunnels suggested that bats might be present. However, a field survey in May 1991 indicated that the adits are heavily overgrown, and that some have collapsed or become flooded. No bats, or evidence such as droppings, were found.

East Brother Island is similar to West Brother but the vegetation is of lower stature and is of less conservation value. There are no tunnels on East Brother Island.

Lung Kwu Chau

The island shows evidence of intense human impact over a long period. Litter and recent fires show that this impact is continuing. Most of the island is covered with grassland or grass with shrubs, with denser, taller shrubland and small trees behind the shoreland and in a few protected localities. The area on the northeast of the island that will be directly affected by trimming supports some dense shrubland, but the flora is typical of granite areas in the northwest New Territories. The only protected plant found on the island was a single individual of *Pavetta hongkongensis* within the area to be trimmed. The species is neither particularly rare nor under any current threat in Hong Kong.

The island provides habitat for at least two species of rats, one of which may be the Bandicoot rat, *Bandicota indica*. Both species were abundant. Scat evidence of a felid was found, but it is not possible to be certain whether this was a Chinese leopard cat, *Felis bengalensis chinensis*, or derived from a large feral cat.

Sha Chau

Sha Chau has also received major human impact in the past, but is little disturbed at present. Fires appear to be the major threat to the ecology of the island. The vegetation is predominately shrubby grassland, dominated by *Rhodomyrtus tomentosa*. There is also a belt of dense coastal shrubland behind the shore, and this is where the island plants achieve their greatest stature. The flora is typical of granitic headlands in the northwest New Territories but is considerably less diverse than that of Lung Kwu Chau or the Brothers. No rare or protected plant species were observed. The island has a dense population of rats, which may comprise two species. No evidence of larger mammals was found.

### 9.2.2 Avifauna

**Chek Lap Kok**

Observations on avifauna on Chek Lap Kok have resulted in 72 species of birds being recorded. Their seasonal occurrence, reported in Table 9.2, indicates that the total number of species recorded in any month varied from 18 to 39, with an average of 27.

Only seven species (9.7 percent) have been recorded in every month during the period August 1990 to July 1991. However, a number of species which are generally secretive such as *Amaurornis phoenicurus* and *Centropus sinensis* are considered to have been present throughout the period. Nonetheless it is clear that many of the species are of seasonal occurrence. The November observations were made at a time when there was a marked arrival of birds in Hong Kong, as further evidenced by catches made at the Mai Po Nature Reserve and Kadoorie Farm in the subsequent two days.

*Table 9.2*
*Birds Recorded at Chek Lap Kok 1990/91*

| | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr/ May | Jun | Jul |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Phalacrocorax carbo* | | | | | * | * | * | * | | | |
| *Ardeola bacchus* | * | | | | | | | | * | | |
| *Egretta sacra* | * | | | | | | | | | | |
| *Milvus migrans* | | * | * | * | * | * | * | * | * | * | * |
| *Accipiter trivirgatus* | | | | | | | | | * | | |
| *Accipiter* sp | | | | | | | * | | | | |
| *Buteo buteo* | | | | | * | * | | | | | |
| *Francolinus pintadeanus* | | | | | | | | | * | * | * |
| *Amaurornis phoenicurus* | * | * | | | * | | | * | * | * | * |
| *Charadrius dubius* | | | | | | | * | * | * | * | * |
| *Charadrius leschenaultii* | | | | | | | | | | * | * |
| *Tringa ochropus* | | * | | | | | | | | | |
| *Actitis hypoleucos* | * | * | | * | * | | * | * | | | * |
| *Heteroscelus brevipes* | | | | | | | | | | * | * |
| *Larus ridibundus* | | | | | * | * | * | * | | | |
| *Larus argentatus* | | | | | | | * | | | | |
| *Streptopelia chinensis* | * | * | * | * | * | * | * | * | * | * | * |
| *Cuculus micropterus* | | | | | | | | | * | * | * |
| *Eudynamis scolopacea* | * | | | | | | | * | * | * | * |
| *Centropus sinensis* | * | * | | | | * | * | * | * | * | * |
| *Centropus bengalensis* | * | | | | | | | | * | * | * |
| *Apus pacificus* | | | | | | | | * | * | | |
| *Apus affinis* | | | | | | | | | * | | |
| *Halcyon smyrnensis* | * | * | | * | * | | | * | * | * | |
| *Halcyon pileata* | | * | | | | | | | | | |
| *Alcedo atthis* | | * | | | | | | * | | * | |
| *Ceryle rudis* | | | | | | | | * | | | |
| *Hirundo rustica* | * | | | | | | | * | * | * | |
| *Anthus novaeseelandiae* | | | | | | | | | * | | |
| *Anthus hodgsoni* | | | | * | * | * | * | * | | | |

Table 9.2 (Continued)

| | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr/ May | Jun | Jul |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Motacilla flava* | | * | * | | * | | | | * | | |
| *Motacilla cinerea* | | | | * | * | * | * | * | | | |
| *Motacilla alba* | | | * | * | * | * | * | * | | | |
| *Pycnonotus jocosus* | * | * | * | * | * | * | * | * | * | * | * |
| *Pycnonotus sinensis* | * | * | * | * | * | * | * | * | * | * | * |
| *Pycnonotus aurigaster* | * | * | | * | | * | | * | * | | |
| *Luscinia sibilans* | | | | * | | | | | | | |
| *Luscinia calliope* | | | | | | * | * | * | | | |
| *Tarsiger cyanurus* | | | | | | * | * | | | | |
| *Phoenicurus auroreus* | | | | * | | | | | | | |
| *Copsychus saularis* | * | * | * | * | * | * | * | * | * | * | |
| *Saxicola torquata* | | | * | | | | | | | | |
| *Monticola solitarius* | | * | | | | | | | | | |
| *Turdus merula* | | | * | * | | | | * | | | |
| *Turdus hortulorum* | | * | | | * | * | * | * | | | |
| *Turdus pallidus* | | | | | | * | | * | | | |
| *Cettia diphone* | | | | * | | | * | | | | |
| *Cisticola juncidis* | | | | | | | | * | | | |
| *Prinia flaviventris* | * | * | * | * | * | * | * | * | * | * | * |
| *Seicercus burkii* | | | | * | | | | | | | |
| *Orthotomus sutorius* | * | * | * | * | * | * | * | * | * | * | * |
| *Phylloscopus borealis* | | * | | | | | | | | | |
| *Phylloscopus proregulus* | | | | | | | * | | | | |
| *Phylloscopus inornatus* | | | * | * | * | * | * | * | | | |
| *Phylloscopus fuscatus* | | | * | * | * | | | * | | | |
| *Muscicapa latirostris* | | | * | | | | | | | | |
| *Hypothymis azurea* | | | | | * | | | | | | |
| *Garrulax perspicillatus* | * | * | * | * | * | * | * | * | * | * | * |
| *Parus major* | * | * | | | | | * | | | | |
| *Zosterops japonica* | * | * | * | * | * | * | * | * | * | | * |
| *Lanius schach* | * | * | | * | * | * | | | | * | * |
| *Dicrurus macrocercus* | * | * | | | | | | | * | * | * |
| *Urocissa erythrorhyncha* | | | | * | * | * | * | * | * | * | * |
| *Pica pica* | * | | | * | | * | * | * | * | | * |
| *Corvus macrorhynchus* | * | * | | | * | * | * | * | * | * | * |
| *Sturnus nigricollis* | * | | | | | | | | | | |
| *Acridotheres cristatellus* | * | * | * | * | * | * | * | * | * | * | * |
| *Passer montanus* | * | * | * | * | | | * | * | * | * | * |
| *Lonchura punctulata* | | | | * | | | | * | | | |
| *Carduelis sinica* | | | | * | | | | | | | |
| *Emberiza spodocephala* | | | | * | | | * | * | | | |
| *Melophus lathami* | | | | * | | | | | | | |
| TOTAL SPECIES | 26 | 27 | 18 | 31 | 27 | 27 | 32 | 39 | 31 | 26 | 26 |

*Source : Greiner-Maunsell, 1991*

In addition to the species observed during the present study, a further 29 species have been reported from Chek Lap Kok as shown in Table 9.3. However, there is some doubt regarding some of the species recorded by Lofts in 1982.

*Table 9.3*
*List of Birds Previously Recorded from Chek Lap Kok but Not Observed in the Period August 1990 - July 1991*

| Species | Observer |
|---|---|
| *Bubulcus ibis* | L |
| *Accipiter (nisus)* | L |
| *Pandion haliaetus* | L |
| *Falco tinnunculus* | L |
| *Charadrius alexandrinus* | L |
| *Crocethia alba* | L |
| *Scolopax rusticola* | L |
| *Numenius phaeopus* | L M |
| *Tringa nebularia* | L |
| *Tringa glareola* | L |
| *Larus brunnicephalus* | M |
| *Larus crassirostris* | M |
| *Sterna (hirundo)* | M |
| *Streptopelia tranquebarica* | L M |
| *Streptopelia orientalis* | L |
| *Columba livia* | L |
| *Caprimulgus affinis* | M |
| *Coracina melaschistos* | L |
| *Luscinia svecica* | L |
| *Zoothera dauma* | L M |
| *Turdus chrysolaus* | M |
| *Turdus naumanni* | L |
| *Prinia subflava* | L |
| *Acrocephalus arundinaceus* | L |
| *(Yuhina nigrimenta)** | $L_z$ |
| *Dicaeum ignipectus* | L |
| *Lanius cristatus* | L |
| *Carpodacus erythrinus* | L |
| *Emberiza tristrami* | L |

* This is likely to have been an escaped cage bird.

*Sources :*

- *L* — *Lofts, B. (1982) Further replacement airport studies : Faunal survey of Chek Lap Kok*
- *$L_z$* — *Lazell, J.D. (1990) Pers. comm. to D.S. Melville*
- *M* — *Melville, D.S. (1982) Further replacement airport studies : Study of bird populations in the Chek Lap Kok/North Lantau/Castle Peak Area. Report to the Director of Civil Aviation, and unpublished records.*

Studies to date indicate that Chek Lap Kok supports a relatively rich avifauna with a total number of 101 species recorded. Of the species recorded from Chek Lap Kok, one (*Seicercus burkii*) is locally rare in Hong Kong, with only some 10 records (Chalmers, 1986). None of the other species are considered to be rare in the context of Hong Kong, or by international standards. However, it must be stressed that this does not mean that they are of no conservation interest.

All of the birds recorded on Chek Lap Kok are protected under the Wild Animals Protection Ordinance 1980, (Cap. 170). The five species of birds of prey recorded from Chek Lap Kok are protected under the Animals and Plants (Protection of Endangered Species) Ordinance 1988, (Cap. 187).

Habitat types for avifauna are described in Table 9.4 and referenced to Exhibits 8.3 and 9.1. The distribution of species with respect to broad habitat types is also given in Table 9.4. From this it is clear that the majority of bird species are occupying the better vegetated areas of the island. However, the reasons for this are unknown as there are many possible factors such as microclimate, vegetative structure and soil fertility which contribute to this pattern.

*Table 9.4 Bird Habitats and Habitat Use on Chek Lap Kok*

| Habitat | Description | Location Reference | Species Distribution by Habitat |
|---|---|---|---|
| Shore | Rocky and sandy shores around Chek Lap Kok | Exhibit 8.3 (C, B, S) | 15 |
| Marsh | Mangrove and waterlogged grassland/abandoned farmland | Exhibit 8.3 (M) Exhibit 9.1 (2) | 7 |
| Wood | Both native and exotic, includes trees around habitations | Exhibit 9.1 (3) | 30 |
| Farm | Includes fruit plantations, areas around livestock enclosures and buildings | Exhibit 9.1 (6) | 31 |
| Scrub | Vegetation generally shorter than 2 metres, includes poorly vegetated areas on hill tops | Exhibit 9.1 (8) | 20 |
| Air | Birds seen flying over Chek Lap Kok | - | 6 |

*Source: Greiner-Maunsell, 1991*

**Remote Sites**

Tai Lam CP and Lantau

The areas that may be affected by installation of lights or electronic equipment or by terrain cuts in Tai Lam CP and on Lantau are not considered to be of special ornithological significance.

The Brothers

Birds observed on West Brother Island during the field survey carried out in May 1991 are listed in Table 9.5.

*Table 9.5 Birds Observed on West Brother Island*

| | |
|---|---|
| *Black-eared Kite* | *Milvus migrans* |
| *Common Sandpiper* | *Actitis hypoleucos* |
| *Grey-rumped Sandpiper* | *Heteroscellus brevipes* |
| *Crested Bulbul* | *Pycnonotus jocosus* |
| *Chinese Bulbul* | *Pycnonotus sinensis* |
| *Violet Whistling Thrush* | *Myiophoneus caeruleus** |
| *Yellow-bellied Wren-warbler* | *Prinia flaviventris* |
| *Long-tailed Tailorbird* | *Orthotomus sutorius* |
| *Jungle Crow* | *Corvus macrorhynchus* |
| *White-bellied Sea-eagle* | *Haliaeetus leucogaster** |

* Presence inferred from nest or prey remains.

*Source: Greiner-Maunsell, 1991*

East Brother was not visited but the avifauna is considered to be similar to that of West Brother. The regular presence of Black-eared Kites *Milvus migrans* over East Brother suggests nesting, as well as the presence of a regular day (if not night) roost site.

Lung Kwu Chau

This island was declared an SSSI in the 1970s due to the presence of a pair of White-bellied Sea-eagles *Haliaeetus leucogaster*, which nested there. The island was visited in November 1991 and the former Sea-eagle nest site was found to be long abandoned. There was no evidence of Sea-eagles elsewhere on the island, or in the surrounding area. The World Wide Fund for Nature Hong Kong has written to the Hong Kong Government suggesting that this island be removed from the list of SSSIs since the reason for its initial inclusion no longer applies. Although still of biological interest, it is not deserving of SSSI status on ornithological grounds.

Although Sea-eagles no longer nest on the island, a number of other birds are present. Species observed during a brief visit to the island in November 1991 are listed in Table 9.6. A Magpie nest and two Black-eared Kite nests were found. The presence of Reef Egrets suggests that the species may breed in this area as suitable habitat exists on the island. This is a scarce breeding bird in Hong Kong.

*Table 9.6 Birds Observed on Lung Kwu Chau*

| | |
|---|---|
| Cormorant | *Phalacrocorax carbo* |
| Reef Egret | *Egretta sacra* |
| Black-eared Kite | *Milvus migrans* |
| Black-headed Gull | *Larus ridibundus* |
| Spotted Dove | *Streptopelia chinensis* |
| White-breasted Kingfisher | *Halcyon smyrnensis* |
| White Wagtail | *Motacilla alba* |
| Crested Bulbul | *Pycnonotus jocosus* |
| Chinese Bulbul | *Pycnonotus sinensis* |
| Rubythroat | *Luscinia calliope* |
| Long-tailed Tailorbird | *Orthotomus sutorius* |
| Magpie | *Pica pica* |
| Jungle Crow | *Corvus machrorhynchus* |
| Crested Mynah | *Acridotheres cristatellus* |

*Source: Greiner-Maunsell, 1991*

Sha Chau

A brief visit was made to the island in November 1991, when the species listed in Table 9.7 were recorded.

*Table 9.7 Birds Observed on Sha Chau*

| | |
|---|---|
| Cormorant | *Phalacrocorax carbo* |
| Reef Egret | *Egretta sacra* |
| Black-eared Kite | *Milvus migrans* |
| Common Sandpiper | *Actitis hypoleucos* |
| White-breasted Kingfisher | *Halcyon smyrnensis* |
| Richard's Pipit | *Antnus novaeseelandiae* |
| White Wagtail | *Motacilla alba* |
| Crested Bulbul | *Pycnonotus jocosus* |
| Chinese Bulbul | *Pycnonotus sinensis* |
| Blue Rock Thrush | *Monticola solitaria* |
| Jungle Crow | *Corvus macrorhynchus* |

*Source: Greiner-Maunsell, 1991*

Some 800 Cormorants were observed roosting on the west side of the island and it clearly is an important roost site for this species. Tree Island, to the west, is the traditional night-time roost for Cormorants feeding in the Deep Bay area during the day (at least since the mid-1970s). Numbers of wintering Cormorants appear to have increased during the past decade and it is possible that Tree Island is no longer large enough to accommodate all of the birds; thus birds have started to roost on other nearby islands. However it is not known whether Sha Chau is used as a night roost.

The presence of Reef Egrets on an island with suitable nesting habitat suggests that they may breed there. At least three nesting burrows of the White-breasted Kingfisher were found in an exposed bank.

## 9.3 Terrestrial Ecological Impacts

### 9.3.1 Terrestrial Flora and Fauna

**Chek Lap Kok**

Construction of the airport on Chek Lap Kok will lead to almost total destruction of the terrestrial flora and fauna since the small hill to be retained at the south end of the island is too small and dry to preserve any significant fraction of the island's biota. In addition, all the island's wetlands will be lost.

**Remote Sites**

Tai Lam CP and Lantau

Solar or battery-powered obstruction lights will be sited on Sunset and Lantau Peaks and on three peaks in southern Tai Lam CP. Materials will be flown in by helicopter or brought in by foot and the area of disturbance will be minimal, at approximately $2m^2$.

The summits of Sunset and Lantau Peaks are covered in boulders and low grass and shrub vegetation. Because of their location on the popular Lantau Trail, they have already received considerable impact from trampling. Thus the immediate summit areas are not of exceptional ecological value and impacts from the installation of obstruction lights is expected to be minimal. However, there are ecologically sensitive areas within 50m of both summits and if there are any changes in the size or location of the proposed installations, a more detailed assessment of possible impacts on these areas should be carried out.

The peaks in Tai Lam CP are not of special ecological value and the impacts of obstruction light installation and maintenance are not expected to be significant. Similarly to obstruction lights, the possible installation of a radio relay station with an emergency generator on two potential sites on northeast Lantau would have little adverse impact as prefabricated components for construction and refuelling supplies during operation would be flown in by helicopter.

Potential future airspace related terrain cuts at Tai Lam CP could, however, result in major impact on one of the most heavily used Country Park areas and may have significant visual impact. In addition, if haul roads are required for access and removal of spoil, an extended impact area could result. The same would be true for potential terrain cuts on northeast Lantau.

The Brothers, Lung Kwu Chau and Sha Chau

Both Brothers Islands are to be reduced in level to +10mPD, removing $8Mm^3$ of rock. Electronic equipment will be sited on East Brother Island, and a jetty sited on its southeastern corner. There will be an on-site electrical generator which will require fuel storage for six weeks operation and refuelling at monthly intervals.

Electronic equipment may be sited on Lung Kwu Chau and Sha Chau. The northeast part of Lung Kwu Chau would probably be levelled at +60mPD and the existing navigation light relocated to this platform. A landing jetty and generator would be installed. The top of Sha Chau would be removed, requiring disposal of approximately 12,000$m^3$ of material. A small building about 10m square is likely to be required near Tai Lam Kok (Brothers Point), which would be located as low as possible above +10mPD. An emergency generator would be installed.

The impacts of the construction works would be the loss of effectively all the vegetation and associated fauna on both Brothers Islands. There would be local impacts on Lung Kwu Chau, notably the possible loss of *Pavetta hongkongensis* within the construction area, and disturbance of small mammals. Although construction work would be centred on the northern part of the island, the southern part which is well vegetated and of more ecological value, could be impacted by fires started accidentally by construction workers. Impacts at Tai Lam Kok would not likely be significant.

### 9.3.2 Avifauna

**Chek Lap Kok**

The retained hill south of Chek Lap Kok has recently been burnt off and currently supports no birdlife. To all intents and purposes the land formation works will result in the total displacement of the island's avifauna.

Since birds have the freedom of flight, "resident" species (those present throughout the year) are expected to move elsewhere to seek suitable habitats. Migrant species, which will arrive to find Chek Lap Kok no longer inhabitable, will likewise be forced to move elsewhere. Whether such habitats exist and, if so, whether there is spare carrying capacity for additional birds is considered further in Section 9.4.

It can be expected that following vegetation clearance most species will no longer use the cleared areas. Blasting works and associated disturbance from plant, vehicles and operators will have some negative impact on the avifauna, but as long as habitats remain which provide feeding opportunities, it is expected that some birds will continue to frequent the island.

As reclamation progresses it is likely that some areas, once formed, will be relatively little disturbed until construction work commences. Such areas may attract certain species such as shorebirds to roost. Should such areas become vegetated a wider variety of birds could be expected to occur (former reclamation sites at Kowloon Bay and Hung Hom having been particularly attractive to migrant species). However, such bird use of the area will be temporary, and the birds will once again be displaced as construction of runways, taxiways, aprons and buildings proceeds. The final state of the avifauna on Chek Lap Kok will depend on the design of the airport and associated landscaping works.

**Remote Sites**

The siting of obstruction lights, which are understood to be high-intensity white strobe lights, on Sunset and Lantau Peaks is unlikely to affect avifauna, except possibly in periods of low cloud/fog when birds might be attracted to the lights and be killed on impact. In view of the purpose of the lights it clearly is not possible to resite them. Potential bird kills should be monitored and if found to be a problem, mitigation may be necessary.

The cutting of both Brothers Islands to +10mPD will result in the effective loss of all vegetation and hence a significant loss of habitat for birds. The avifauna will therefore be largely displaced. During the excavation works few, if any, birds are likely to be present. However, following completion of the works, birds could be attracted to the site. Species using the sites would depend largely on the future substrate and vegetation cover. Thus, bare rock is likely to attract birds such as Black-eared Kites to roost and possibly other species such as Cormorants *Phalacrocorax carbo*, shorebirds and gulls. Vegetation cover could attract other species. The desirability of attracting birds has to be viewed in the context of possible bird strike hazard.

The construction works on Lung Kwu Chau would adversely affect the northern part of this island, and could disturb nesting Reef Egrets if carried out during their summer breeding season. Disturbance could also be caused to Cormorants roosting on the nearby Sha Chau and Tree Island, during the winter. The presence of fuel stores and refuelling operations could have a potential adverse impact on seabirds as the result of spillage.

## 9.4 Mitigation Measures

### 9.4.1 Terrestrial Flora and Fauna

**Chek Lap Kok**

The destruction of Chek Lap Kok is only part of the total habitat loss resulting from the whole PADS project. The North Lantau expressway/rail corridor, development of the port peninsula, and new town development at Tung Chung and Tai Ho will also have significant negative impacts on the environment. As a result, if recommendations for mitigation are to be meaningful, they must be made in the light of the cumulative impacts of all the developments. Habitats which are likely to be affected by the North Lantau Developments include: coast (rocky and sandy shores), marsh (including mangrove and freshwater), streams and the riparian edge, farmland, woodland (both native and exotic), scrub and grassland. These are broadly similar to the habitats which will be lost through the destruction of Chek Lap Kok. Many of the mitigation measures discussed are also under consideration for recommendation by the NLDS consultants.

<u>Pitcher Plant (*Nepenthes mirabilis*)</u>

Relocation of any plant species from Chek Lap Kok is not considered to be worthwhile. In particular, recent surveys have shown that *Nepenthes mirabilis* is common at permanently wet sites on granite in the north-west New Territories. However, many of these sites are outside Country Parks so enhanced protection is advisable. Indeed, freshwater wetlands of any form are very poorly represented within the existing Country Parks system. It is recommended that urgent consideration be given to protection of representative areas.

<u>Romer's Treefrog (*Philautus romeri*)</u>

The major animal of conservation significance on Chek Lap Kok is *Philautus romeri*. The Romer's treefrog *Philautus romeri* is a relict species, i.e., the remnants of a formerly widespread species existing in a few isolated areas. It is not known what factors have eliminated the frog from its previous range. They could be anthropogenic influences or a result of biotic interactions with predators, competitors, parasites, etc.

As far as is known, *P. romeri* is endemic to the Territory of Hong Kong and exists as three isolated populations on Chek Lap Kok, Lantau Island and Lamma Island. It is extremely unlikely that any of the Chek Lap Kok population will survive the construction and operation impacts of the new airport. Though *P. romeri* appears to be widely distributed on Lantau, the North Lantau and airport developments would undoubtedly have an adverse impact on the population. The frog is small and has a limited clutch size. Populations will therefore be sensitive to damages to their breeding and over-wintering habitats. Local extinction could be avoided if mitigation measures are implemented and legal protection is given to this species to minimise and regulate human encroachment upon their habitats.

There is no advantage in relocating *P. romeri* from Chek Lap Kok onto Lantau or Lamma as the existing populations on these islands would already have fully exploited habitable areas. Overstocking of suitable habitats may lead to crowding, habitat degradation, increased intraspecific competition, and reduction in population viability. Introduction of frogs from Chek Lap Kok to unknown habitats or habitats in which they no longer occur is highly unlikely to succeed.

It has therefore been proposed that mitigation should comprise a detailed field investigation of *P. romeri* on Lantau and Lamma, as well as the establishment and maintenance of a laboratory breeding population through the capture of *P. romeri* from Chek Lap Kok. A self-sustaining laboratory population (if attained) would have the benefits of increasing understanding of the niche requirements of *P. romeri*. Together, data from field and laboratory investigations would provide a basis for the development of management strategies for conservation of the remaining populations on Lantau and Lamma and preservation or enhancement of their habitat. In addition, to gain a better understanding of the population status of the species and to identify as yet uncolonized sites with potential for introduction of the frog, it is considered that a complete survey of possible *P. romeri* habitats should be undertaken and the potential for habitat creation for possible reintroduction addressed.

The main mitigation measures can therefore be summarised as:

- investigation of *P. romeri* habitat utilisation, breeding habits, larval development, biotic interactions and over-wintering behaviour;
- development of a conservation programme for *P. romeri*;
- collation and synthesis of existing scientific data on the biology and ecology of *P. romeri*; and
- establishment and maintenance of a breeding population of *P. romeri* in the laboratory under a controlled environment.

Subsequent to these mitigation measures being identified, a programme was initiated by the University of Hong Kong and the World Wide Fund for Nature, funded by the Royal Hong Kong Jockey Club, to implement the recommendations. A number of adult frogs and spawn have been recovered from Chek Lap Kok and established in captivity, and studies are ongoing on both the frog and its habitat requirements.

<u>Mangrove</u>

Although the mangrove area to be lost on Chek Lap Kok is not large, most of the mangrove of the North Lantau coast will also be lost as a result of the North Lantau developments. Not only is the total amount a significant fraction of the Territory's total mangrove area, but the mangroves of Chek Lap Kok and North Lantau are likely to be ecologically different from those elsewhere in the Territory because of the dominant influence of the Pearl River Estuary on the hydrochemistry of the area. The abundance of *Bruguiera gymnorrhiza*, which is rare elsewhere in the Territory, gives support to this suggestion. However, only a complete survey of all Hong Kong's mangrove systems would provide confirmation.

It is recommended that consideration be given to the creation of new mangrove habitats outside the seawalls, for example using dredged mud from the airport site. The artificial creation of new mangrove habitat has been shown to be a viable conservation option elsewhere in the world and the Hong Kong Government has already successfully planted mangroves in at least two sites in the New Territories. However there are two major problems associated with this. Firstly, the recreated mangrove is unlikely to support the diversity of species present in natural mangrove and therefore cannot be considered a complete substitute. Secondly, attempts to create artificial mangrove outside the area impacted by the airport and related developments would risk damaging natural coastal environments which could otherwise be preserved. Recreation of mangrove within the impacted area is the best option, but may not be possible until after construction has been completed and water and sediment movements have stabilised.

It is understood that the NLDS has recommended some limited mangrove creation in the artificial lake to be formed above Tai Ho. Although beneficial in landscaping terms, this may not be of sufficient size to be ecologically viable. It is also intended that existing mangrove at San Tau be retained, but its ability to survive changes in the flow regime resulting from nearby reclamations for the New Town, particularly post-2011, is unknown.

A further option would be to utilise coastal areas outside the North Lantau development site which have already been anthropogenically impacted. The disused salt pans at Tai O have been identified as a possible site for mangrove recreation, in compensation for those mangroves which will be lost on Chek Lap Kok and North Lantau, and is presently under consideration by Government. The site has been identified for potential recreation/conservation landuse in a recent planning study and with some engineering works to the seawall, bunds and bed-levels, is considered suitable for the propagation of mangroves, which are already present in the shallower areas. This site would be preferred to other potential sites adjacent to the airport and new town as its relatively distant location would reduce the potential for birdstrike hazard. M1

In the meantime, it is essential that urgent consideration is given to providing formal protection for other mangrove areas in the Territory, including the few areas that will survive on Lantau.

**Remote Sites**

<u>Tai Lam CP and Northeast Lantau</u>

Strong recommendations have been made to the engineering team to minimise airspace related terrain cuts, and it is possible that those proposed for Tai Lam CP and northeast Lantau may be avoidable. However, wherever cutting is necessitated, mitigation of impacts should involve careful design and replanting of cut areas. The scope of replanting on hilltops will be limited by potential water shortage, but with bund formation to promote retention of rainwater, and selection of species appropriate for the conditions, re-establishment of vegetative cover should be achievable. Haul and access routes should be selected to minimise the potential for erosion and strict controls exerted to minimise the lateral spread of ground disturbance. Land access routes must be reinstated following the completion of the works.

In view of the potential ecological and aesthetic impact of access routes for siting electronic equipment on northeast Lantau, it has been recommended that on-site excavation is minimised and that prefabricated components are flown in by helicopter. Refuelling of the generator would also be done by helicopter. Recommendations on fuel/oil storage made for other sites (see below) apply.

Sunset and Lantau Peaks

In view of the exceptional ecological importance and sensitivity of these areas, great care should be taken to minimise both the actual "footprint" of the light installation and the incidental damage to surrounding areas during construction. All materials should be brought in by foot or flown in and any excavated material should be taken away for disposal. The precise location of the equipment and any excavation or levelling required should be discussed with representatives from AFD on-site before any work begins.

The major impact during operation is likely to be littering, although litter is regularly collected from this area as it is part of the Lantau Trail. There is also a risk of fire. All those involved in maintenance of the equipment must be made aware of the ecological sensitivity of the sites.

The Brothers

Mitigation measures for vegetation loss have, of priority, to take into account the potential for attracting birds and the possible increase in bird strike hazard. This is discussed further in Section 9.4.3.

Lung Kwu Chau

The southern part of the island is of most ecological value. It is therefore recommended, if the site on this island will be developed, that this part of the island be protected by restricting all construction work and workers to the northeastern part of the island, making the southern part a "no-entry" area This would provide a valuable refuge for small mammals during the construction activity, and would enhance protection of the southern part of the island where the largest trees are found. Recolonization of the disturbed area by small mammals could take place after work was completed.

Under no circumstances should fires (e.g. for cooking) be allowed on the island, and the contractor must ensure that adequate fire-fighting equipment is maintained on the island throughout construction, and staff instructed in its use.

The fuel storage area and generator house would need to be sited and bunded such that any leakage of fuel is contained within the compound and does not contaminate any other areas of the island. The compound also would need to be designed to ensure that, in the event of an emergency fire, it would not spread to the vegetation on the island. In view of the fact that the island has been subject to a hot wild fire in the recent past (winter 1990/91) there would be a requirement for the compound to be safe during such events.

Sha Chau

To minimise potential effects on the terrestrial community, it is recommended that spoil produced as a result of trimming work on the hill in the north of the island be deposited along the west coast where erosion has already been occurring. Effects on the marine evironment at this point would be less than if the spoil were dumped along the coast elsewhere on the island, since the west coast is already receiving sediment input from the eroded hillslopes. Dumping of spoil would need to be carried out to avoid deposition on the sand bar between the two islands.

Tai Lam Kok

No specific mitigation measures would be necessary at Tai Lam Kok, nevertheless recommendations on fuel/oil storage made for other sites would apply.

### 9.4.2 Avifauna

**Chek Lap Kok**

The development of North Lantau will mean that birds displaced from Chek Lap Kok are unlikely to be able to find suitable alternative habitats nearby. The additional loss of habitats elsewhere on North Lantau further means that there will be an increased number of birds trying to colonise a reduced area of suitable habitat.

The loss of better vegetated habitats on Chek Lap Kok highlights the need for action to increase woodland as well as coastal mangroves elsewhere. Mitigation activities will not result in the reconstruction of present habitats (c.f. Simberloff, 1990), as mentioned in reference to mangrove recreation. Nevertheless, with careful management, conditions for wildlife may be improved compared to the situation if no action was taken.

Landscaping works associated with the new towns at Tung Chung and Tai Ho, together with the North Lantau access corridor should use native species wherever possible. Where exotic species are planted as 'nurse' species, long-term management will be necessary to ensure their removal as part of a liberation felling programme. Such planted areas will be beneficial to those species of birds which feed in the canpoy (e.g. *Zosterops japonica*, *Pycnonotus* spp., *Phylloscopus* spp.) However, the lack of ground cover and understorey usually found in such plantations will make them unattractive to many other species (e.g. *Turdus* spp., *Garrulax* spp. *Luscinia* spp.).

In order to accommodate those bird species which will not occupy the urban plantations, additional planting of native species should be undertaken around the remaining "natural" woodlands on Lantau. This planting of species regarded as natural components of the original woodland should be initially undertaken in a band some 200m wide around the edge of existing woods. Additionally, corridors at least 200m wide should be planted to link woodlands currently separated by grasslands. Such action should increase the carrying capacity of the woodlands both for birds and other components of the fauna.

A comprehensive fire control plan, similar to those implemented by the Country Parks Authorities for hill fires in Country Parks and Special Areas, will be needed to ensure that the plantations are not damaged. Efforts should be made to restrict the potential for "fringe development" of the areas between the existing Country Park boundaries and the new towns, for example for container storage or squatter dwellings. If considered suitable by Agriculture and Fisheries Department, such areas could be incorporated within the Country Parks boundaries, to facilitate management and enhance their wildlife conservation value. Alternatively, planning restrictions should be enforced to prevent uncontrolled local development encroaching onto the hillsides.

M4

**Remote Sites**

The Brothers

Given the position of The Brothers Islands under the main flight path, minimisation of bird strike hazard should probably take precendence over on-site ecological mitigation. It could, however, be advantageous to provide shorebird habitat on the islands to attract birds away from the future airport, especially during the spring migration when numbers are likely to be greatest. This could be achieved through limited excavation of the centre of the islands, backfilling with soil and the establishment of suitable, low stature vegetation. Such a measure also could mitigate, at least in part, for the loss of present coastal environments for shorebirds resulting from the loss of Chek Lap Kok, while also improving the aesthetics of the levelled islands.

The loss of shrub and woodland habitats from the two islands should be made good through a compensation planting programme in addition to that already recommended to compensate for loss of such habitats elsewhere.

The cutting works on both islands will require the prior issue of a permit by the Director of Argiculture and Fisheries under Section 15 of the Wild Animals Protection Ordinance (Cap. 170) to allow the destruction of bird nests and their contents. The fact that the Spotted Dove *Streptopelia chinensis* breeds almost throughout the year means that such a permit will be required irrespective of the timing of works.

Lung Kwu Chau

If construction works are carried out on Lung Kwu Chau they should not be conducted during the summer months (April to August inclusive), when Reef Egrets may be nesting. In order to avoid unnecessary disturbance to Cormorants roosting on nearby Sha Chau and Tree Island, works should not take place during the winter months (November to March inclusive). This creates an ideal 'window' for works in September and October. Should programming indicate the need for a longer construction time, all blasting works at least would need to be completed in the period September/October.

Works would need to be restricted to the northern half of the island to avoid unnecessary disturbance to the southern half, which is largely well vegetated and which is of greatest ornithological interest. The landing jetty would need to be fenced to prevent unauthorised access, and hence reduce disturbance to the island, and potential fire hazard.

Fuel unloading (from barges) would need to be strictly controlled to avoid any spillage, this being especially important due to the presence of Reef Egrets, cormorants and gulls - other seabirds, such as terns, also occur in the area seasonally. An oil spill contingency plan would need to be prepared and staff trained to implement it. Necessary equipment, incluidng booms to contain spills, would need to be available for use. Cleansing of oiled birds is difficult, time consuming and usually ineffective; the priority should be to prevent spills and, in the event of a spill, to provide containment.

In view of the potential increase in human disturbance in the area around Lung Kwu Chau and Sha Chau if construction, and subsequently maintenance activities occur, it is recommended that Tree Island be declared an SSSI in view of its importance as the major night time roost site for cormorants in Hong Kong.

The requirement for a permit under Cap. 170 would be similar to that for work on The Brothers.

Sha Chau

Disturbance to roosting cormorants would need to be minimised by making the northern sandy part of Sha Chau a "no-entry" area for construction workers and work-related vessels.

The recommendations made for Lung Kwu Chau with respect to the timing of construction work, fire control and fuel/oil storage facilities apply equally to Sha Chau.

The requirement for a permit under Cap. 170 would be similar to that for The Brothers.

The current construction programme for the airport reclamation and infrastructure is 60 months from May 1992. The dredging and land reclamation of the new platform; and excavation of the island of Chek Lap Kok will be carried out over a 31 month period with sectional handovers, thus allowing a 42 month construction period for the infrastructure. The excavation of Chek Lap Kok will involve excavation and placement of 90 $Mm^3$ of material and will require the prior removal of existing vegetation and organic matter.

Following the removal of organic matter from Chek Lap Kok the island will be excavated using large scale blasting methods. This is not expected to result in the generation of significant quantities of construction waste. Once the reclamation is in place there will be waste associated with the building activity for the airport infrastructure. The waste will comprise various types of building debris including timber, bamboo and mixed soft materials together with building debris from the removal of temporary works. Throughout the period of works there will be a source of domestic waste generated by a permanent on-site working population, and maintenance waste from the maintenance and repair facilities. Some of this waste falls into the category of hazardous materials requiring special handling. This is discussed in Section 11.

As construction waste arisings tend to be site-specific there is no standard methodology available to assess this. Consideration of the scale and scope of operations and the likely construction plant requirements, in conjunction with Government's *Waste Disposal Plan for Hong Kong (1989)*, has been adopted as the basic approach to estimate construction waste arisings.

## 10.1 Waste Arisings

### 10.1.1 Excavation

The excavation of Chek Lap Kok will require stripping the existing vegetation and removal of topsoil. Chek Lap Kok is mainly composed of grassland and low scrub with patches of bare soil on steep slopes and hilltops. There are in addition small pockets of open secondary woodland, trees and tall shrubs and smaller areas of agricultural land. The remaining vegetation on Chek Lap Kok is very sparse, with only approximately ten percent of the island still covered by any dense vegetation. It has been estimated that the remaining vegetation and top soil tied up in the root systems will weigh approximately 25,000 tonnes (t).

### 10.1.2 Infrastructure

According to Government's *Waste Disposal Plan for Hong Kong (1989)* the total construction waste generated in 1988 was equal to 6500 t/d. Excluding material such as building rubble, which can be diverted to public dumps and is of value generally as fill, a figure of 3600 t/d is obtained. This will comprise materials such as timber, site clearance materials and mixed soft materials. This waste generation rate can be expressed in terms of the total annual site area under construction, in order to obtain a value for construction waste arising per unit site area.

In 1988 a total of 314 ha of industrial, commercial and residential floor space was completed (PADS, 1989) which gives a waste factor per unit floor space area of 420 kg/m$^2$. The waste factor is considered to be a conservative figure which may not be directly appropriate to the airport site. For instance, the airport is a "greenfield" site and, although there will be some waste generated from the demolition of temporary works together with waste materials such as concrete, used containers and timber, there should be little generation of demolition rubble associated with construction. Furthermore, the unit waste factor from PADS assumed a mean ratio of floor space to construction area of six to one. For the airport, the ratio is likely to be much lower, particularly for the large facilities such as the terminal, cargo and customs facilities. This lower building intensity will result in reduced waste arisings accordingly.

Construction of the airport will involve construction of a floor space area of nearly one Mm$^2$. Applying the waste load factor, reduced by 50 percent to account for the exclusion of site clearance waste (which has been considered separately) and the more extensive nature of the works, results in estimated waste generated of 210,000t over the duration of the construction works, giving an average of 42,000 t/y or 115 t/d. The same calculation performed using 1987 data yields an average of 94 t/d, indicating a degree of consistency in the various factors used for the estimation. This represents some three percent of Hong Kong's annual construction waste arisings. If the total quantity of construction waste generated by the airport project were to require disposal by landfill, it would, therefore, only occupy about one-half percent of total capacity at the Western New Territories (WENT) landfill.

### 10.1.3 Employee Domestic Waste

Accommodation, canteen and office facilities provided for the Advance Works Contract will subsequently be required for both the SPC and the authorities. Up to 500 people will be employed initially, although it is assumed that many of these will commute to Chek Lap Kok. However it is estimated that facilities will be required to accommodate 100 workers on site. For the period 1994-1996 the number of workers required is estimated to increase substantially to 10,000 in total. It has been assumed that most of these will not be housed on site.

According to the *Waste Disposal Plan for Hong Kong (1989)*, a publicly-collected waste load factor of 0.9 kg/cd may be used to estimate the total waste arisings from the permanent site workforce. This results in a total arising of approximately 0.1 t/d. In addition a reduced waste load factor of 0.2 kg/cd may be used to estimate the waste arising from the temporary workforce. This reduction takes account of the fact that the workforce is present on site for one shift only and will generate a smaller proportion of waste than permanent employees. This results in arisings of approximately 0.3 t/d during 1992-93, rising to an estimated 2 t/d for the later construction years. However, it should be noted that the waste load may increase significantly if a substantial proportion of these workers are housed on site.

### 10.1.4 Maintenance and Repair Wastes

Workshop and other maintenance facilities will be required throughout the construction project and some of these facilities will be provided as part of the AWC. These may be expected to give rise to spent fuel and lubricating oil, used tyres and general cleaning waste (rags, solvents etc). The estimated lubricant usage during the construction period is 300 l/d of which a small fraction will require ultimate disposal. In addition, it is estimated that between 100 and 200 used tyres will require disposal over the project lifetime.

## 10.2 Disposal Alternatives

Under the terms of the Waste Disposal Ordinance (Cap.354) construction waste is classified as a trade waste and as such the Contractor will be responsible for its disposal, although the Collection Authority may provide services for its removal. Ultimately, all airport operating wastes will be disposed of together with wastes generated on North Lantau. Different disposal options were considered by the NLD consultants and the preferred option was transfer of all wastes by containerised barge to the new landfill WENT, due to be commissioned in 1991. A new transfer station would be required at a recommended site at Siu Ho Wan. Major landfill capacity will not be provided on Lantau. The transfer station is unlikely to be operational at any stage of the construction period. Consequently the existing disposal routes on Lantau may be utilised.

Present disposal arrangements on Lantau where there are vehicular access roads are transport by lorry to the modular incinerator at Mui Wo. Until road access to Chek Lap Kok is available, marine collection of waste will be required. Currently wastes are taken by a contracted barge service which operates from Discovery Bay and transports refuse to Kwai Chung Incinerator. Bulky items are taken to a landfill site. A similar service may be operated from Chek Lap Kok which will have a heavy load quay capable of accommodating up to six 2000 ton displacement barges at the same time.

### 10.2.1 Excavation

There is, in principle, no control on the quantity of vegetation waste that may be disposed of at landfill sites, provided this kind of waste is chopped down into small, manageable pieces for ease of handling. However, to save disposal capacity at the landfill site and ensure maximum benefit is obtained from the resources, opportunities should be taken to reuse the material. The Contractor should not be permitted to burn waste such as cleared vegetation or timber within the site. Cleared vegetation should either be chopped or shredded and stockpiled on the site for later use (as a mulch on the upper layers of the reclamation in those areas adjacent to runways and taxiways which will later be grassed); removed off site to the Contractor's tip; or disposed of in some other manner acceptable to the Engineer.

## 10.2.2 Infrastructure

Any suitably inert building material should be utilised as fill and some may be recycled. Perhaps 40 to 50 percent of formwork and most of the material from demolition of existing structures could be used as fill. Drums, containers and scrap metal are all recyclable. However, there will still be significant quantities of waste requiring disposal. These may be transferred by barge to WENT for disposal.

## 10.2.3 Employee Waste

During the later stages of construction work this waste should be removed together with any building waste. In the initial phase, the relatively small quantities of domestic waste involved do not justify the use of containerised facilities. A refuse collection point similar to those used elsewhere in the Territory would give sufficient provision for collection and short term storage of domestic wastes. For environmental hygiene reasons it is recommended that this waste is not stored for any period exceeding 48 hours and preferably only 24 hours.

## 10.2.4 Maintenance

Although the quantities of maintenance and repair wastes generated are not likely to be significant it is recommended that the potential for recycling is considered. Used tyres may be shredded and remelted or crumbed.

Construction activities at the new airport site will involve the importation, storage, use and disposal of materials that may be classified as hazardous materials or chemical wastes. Most are associated with the service and maintenance of earth moving and construction equipment and will primarily include fuel, hydraulic fluids and other similar petroleum-based substances. Others include the raw materials used to produce explosives associated with blasting operations.

## 11.1 Assessment

The sources of potentially hazardous materials and chemical wastes associated with the airport construction project are listed in Table 11.1 and are generally described in this section.

*Table 11.1*
*Sources and Characteristics of Potentially Hazardous Materials, Chemical Wastes and Dangerous Goods Used During Construction Operations*

| Sources | Materials/Wastes/Goods | Characteristics |
|---|---|---|
| Fuel Storage | Petrol, diesel | Accidental spillage and leaks can cause soil, surface water, and/or ground water contamination. Close supervision minimises losses during transfer. Dikes around storage tanks contain spills or leaks. Fuel lines and valves must meet leak tightness specifications. |
| Construction Equipment Servicing and Repair Facility | Oil, grease, hydraulic fluid, lubricants and other petroleum-based substances, used filters and cleaning solvents | Accidental losses (spills) during servicing and repair of heavy equipment can cause localized soil, surface water and/or groundwater contamination. Isolation and confinement of service and maintenance areas minimise potential problems. |
| Airfield Maintenance Facility | Herbicides, insecticides | Proper labelling, storage, application and disposal will minimise potential environmental impacts. |
| Blasting Explosives | Initiation systems, ammonium nitrate, fuel oil | Initiation systems and raw materials used to make explosives during blasting. Storage and use regulated by the Mines Division of CESD. |

*Source: Greiner-Maunsell, 1991*

The excavation, land reclamation and construction of the airport site will involve numerous and varied earth moving and heavy construction equipment. They include hydraulic shovels, loaders, 170-ton trucks, graders, bull dozers, rollers, water trucks, fuel trucks, service trucks, drilling units, cranes, buses and generators. The project will also involve on-site concrete and asphalt plants. These vehicles and equipment require regular fuelling, servicing and repair. As a result, fuel storage and equipment maintenance facilities will be constructed on the airport site and will contain petrol, diesel, oil, grease, lubricants, cleaning solvents, batteries and used filters.

Once the construction project is underway, the periodic application of herbicides and insecticides may be required to control the growth of vegetation and pests. As a result, the project site will likely contain facilities for the storage of these materials.

The major component of bulk explosives used for blasting is ammonium nitrate ($NH_4NO_3$). Because ammonium nitrate is a strong oxidizing agent and can explode if improperly stored and handled, storing quantities in excess of 500t requires the approval of EPD and the Electrical and Mechanical Services Department. As a raw material, ammonium nitrate is difficult to detonate but it becomes explosive when blended together with liquid fuel, usually fuel oil. Normally, the non-explosive blasting agents are transported to the job site by truck and combined as they are loaded into the blast-hole. For the purposes of this project, it is likely that the ammonium nitrate will be delivered and stored in bulk at a specially designated location on the project site in quantities within exempted limits for Potentially Hazardous Installations (PHIs). Initiation systems are classified as Category 1 explosives and their storage will require a license from the Mines Division of the Civil Engineering Services Department.

Presently, there are no specific laws, rules or ordinances governing the definition, use, storage or disposal of hazardous materials. However, EPD is currently preparing a Draft Chemical Waste Regulation and Associated Codes of Practice under the existing Waste Disposal Ordinance. Although the draft regulation has not been completed, reportedly it will address the definition, packaging, storage, labelling, transport, treatment and disposal of hazardous materials that do not meet the PHI criteria.

On the Hong Kong mainland, the Fire Services Department is primarily responsible for handling incidents which involve the leakage or spillage of hazardous chemicals. Similarly, the Marine Department is responsible for dealing with fuel or oil spills in the coastal waters surrounding the Territory.

## 11.2 Existing Environment

Current and historical land uses on Chek Lap Kok essentially preclude the chance that the island has been used for the production, storage or disposal of large quantities of potentially hazardous materials or chemical wastes. A cursory field survey of the airport site by Greiner-Maunsell investigators confirmed that there are no existing large-scale industries, fuel facilities, waste disposal areas or other visible sources of these materials or wastes. At one time, explosives were likely stored somewhere in the northern section of Chek Lap Kok Island during the creation of the existing "test quarry" and seawall.

## 11.3 Mitigation Measures

As previously stated, potentially hazardous materials and chemical wastes associated with construction activities at the new airport site are primarily limited to those required for the fuelling, servicing and repair of earth moving and construction equipment. The raw materials used to make explosives associated with blasting activities will not be stored in quantities in excess of exempted quantities for a PHI.

As a mitigation measure for this project, plans are to isolate the storage and handling of fuel and other petroleum-based fluids in specially designed zones of the Contractor staging areas. In this way, fuel storage, hazardous material and waste disposal vessels can be better protected and properly maintained. Additionally, should an accidental leak, spill, or discharge occur, it can be contained more effectively in these specially prepared areas. Finally, should these materials need to be transported out of these designated zones to the job site, other special precautions can be taken to help prevent them from being discharged to the environment. Should a discharge occur under these conditions, absorbent materials or temporary barriers can be used by the Contractor to help minimize the potential environmental impact. If necessary, plans can then be developed for the clean up and removal of the materials.

Construction explosives for blasting are considered Dangerous Goods and therefore the manner in which these materials are stored and handled at the airport site will be determined by the Mines Division of CESD.

Additionally, the Contractor should be required to coordinate any activities or operations that involve potentially hazardous materials or chemical wastes with the appropriate authorities including EPD, the Fire Services Department and the Marine Department.

Finally, to the extent necessary the Contractor should be required to implement the following hazardous materials/chemical wastes/Dangerous Goods control measures:

- The Contractor should undertake at all times to prevent the uncontrolled disposal of hazardous materials and chemical wastes to the air, soil, surface waters, groundwaters and coastal waters.

- The Contractor should be responsible for collection and disposal of hazardous materials and chemical wastes and ensure that these tasks be carried out by competent and experienced personnel or subcontractors who are licensed to provide such services.

- The Contractor should monitor the safe progress of hazardous materials and chemical wastes from their point of arising to the final disposal point. This process is commonly referred to as "cradle-to-grave" control.

- The Contractor should be responsible for complying with the requirements of the Dangerous Goods Ordinance as they pertain to the use, storage and disposal of nonexempted quantities of these materials.

- The Contractor should be responsible for developing and, if necessary, implementing a plan for the containment and cleanup of hazardous materials, chemical wastes or oil. The plan should be developed in consultation with the Fire Services Department and the Marine Department and consistent with the Water Pollution Control and Oil Pollution Ordinances.

- The Contractor should insure that hazardous materials, chemical wastes and fuel are packed or stored in containers or vessels of suitable design and construction so as to prevent leakage, spillage or escape of the contents under normal conditions of handling, storage and transport.

According to Government estimates 202 people at one time resided on the rural island of Chek Lap Kok. Lam Chau is unpopulated. Both islands will be leveled, except for the southern tip of Chek Lap Kok, to allow for the construction of the airport and all existing land uses eliminated. A relocation program for the villagers instituted by Government has been completed.

Currently the proposed construction site is unreachable by regularly serviced public transport. The villages which comprise Tung Chung on North Lantau Island are reached by limited ferry (kaido) service from Castle Peak to the north and by bus from Silvermine Bay on the south side of Lantau. Silvermine Bay has regularly scheduled ferry service from Hong Kong Island and Kowloon.

Basically, the selected site is located in an undeveloped rural area. The airport, as proposed, will be incorporated by extensive reclamation into a new island formed to the north of Lantau Island, and will be an integral part of the proposed development for a New Town on North Lantau.

### 13.1 Assessment/Existing Environment

The site for the new airport has been previously described. The overall rural nature of the area, as it currently exists, exerts a strong influence on the economic and social structure of the potentially impacted villages.

In 1986, less than 45 percent of the local population was economically active (i.e., working or available for work), compared to over 60 percent for the most populated areas on south Lantau. Over 11 percent of the population was aged 65 years and older. Residential areas are mainly low density and largely owner-occupied; there is no public or aided housing in the area.

The economic and employment base for the area of Chek Lap Kok and Tung Chung is largely agricultural with some cottage type industries surviving. Previous rice paddy operations have been abandoned at Tung Chung and Sha Lo Wan with the exception of one household, although other types of agricultural operations are active.

The major agricultural pursuits include several pig farms and a gazetted fish culture zone in Tung Chung Wan which is scheduled for removal. All of the residents on Chek Lap Kok have been relocated. Thus, no viable economic activities are on going on the island other than those associated with the Advance Works programme.

### 13.2 Socioeconomic Impacts

The projected influx of possibly more than 10,000 construction workers and managers will have an immediate, lasting effect on the existing population in the Tung Chung Valley and neighboring villages such as San Tau (population 40) and Tai Po (population 30). Although the build-up of construction staff will be gradual starting in early 1992, their five year stay will be followed by an influx of permanent employees at the projected airport opening in 1997.

Paramount to any efficient, cost effective project is a ready work force nearby the project site. Thus, along with the usual support service facilities needed by workers and families, the construction of some housing during the 1992 calendar year will be required. The impact of a significant increase in the population of the area is discussed herein.

As reported by the consultant for the North Lantau Development Study "it is anticipated that the following facilities will need to be catered for in the planning of worker accommodation.

1) To be flexible, a mixture of both individual flats for (say) four to six persons and dormitory type accommodation should be planned. These could be housed in two to five storey accommodation blocks with communal facilities.

2) Communal facilities for each block to include laundry, refuse collection centres, toilets and showers.

3) Worker accommodation area will need to be served by the normal housing services including fire-fighting, police, utilities, postal service and medical centre.

4) Sewage treatment facilities to be provided : package treatment plant in short term and pumping main to commission permanent works in long term.

5) Management office, restaurants, shops, recreation area and playing fields may also need to be provided.

6) The area will need to be properly illuminated, fenced and a security system arranged."

While certain fishing areas and jettys will be lost in the reclamation, the economic impact, even for those that will be compensated for the loss of their real assets, will be tremendous for the region. For example, land owners will reap both immediate as well as long-term appreciation of their holdings as the population of the area expands as the new airport nears its opening.

Also, existing retail vendors ready to service the increased population will prosper as demand for their common, everyday services increases with each new construction worker. Wholesale vendors from within the Territory will see some shift in their trade as a population bubble swells on Lantau. The concurrent development of the New Town at Tung Chung will only emphasise the impacts occurring from the construction of the airport.

### 13.2.1 Social Impacts

The sudden, rapid influx of a new population in a relatively new locality, especially for those workers that are skilled enough to be on the job for a few years that might bring a family, will be a source of stress among both the local, original population, as well as among the newcomers. To mitigate this intangible factor, a Town Plan that adopts the guidelines set forth in the *Hong Kong Planning Standards & Guidelines (HKPSG)* will assure that a timely balance exists between the rising population and the serious infrastructure required to support it.

### 13.2.2 Economic Impacts

The rapid introduction of personal liquidity into the rather remote region can result in a temporary imbalance of the supply of goods and services causing an inflationary effect. This can be countered by a diligent effort to provide a ready supply of goods and services to the island.

The primary economic impact resulting from the construction of the proposed airport reclamation will be the elimination of the existing gazetted fish culture zone just north of Tung Chung. The zone area is 17,000m$^2$ and worked by 29 licensees operating 94 rafts. The value of the annual production is not known. This facility is to be removed and its operators compensated by the time the primary reclamation work begins.

Additionally, direct economic impacts of airport construction include the loss of limited agricultural activity on Chek Lap Kok and the elimination of a number of stick net fishing operations around Chek Lap Kok and Tung Chung. The economic value of these was estimated to be approximately $344,000 annually.

On a regional basis, the construction of the airport is considered to be a positive economic impact. A large number of workers and large quantities of construction materials, which will primarily be provided from regional sources, will be required. The positive economic impacts of the additional capital passed through the general economy will be widespread.

## 13.3 Mitigation Measures

The impacts resulting from the construction of the airport on the social and economic structure of the various villages and the area as a whole are unavoidable. From a local viewpoint, the impacts will vary from household to household based on individual circumstances. The Government with the assistance of various Departments has the responsibility to resettle and/or compensate impacted households. The resumption and/or relocation of the fish culture zone should be completed prior to the initiation of the major excavation/reclamation process to reduce the impacts of construction noise and dust, reduced water quality and blasting activities.

## 14.1 Assessment/Existing Environment

Impacted archaeological and historical sites are identified on the islands of Chek Lap Kok, Lung Kwu Chau and Sha Chau. The recognized sites are listed in Table 14.1, and their locations are shown on Exhibit 14.1. In 1990 the Antiquities and Monuments Office of the Government Recreation and Culture Branch commissioned the Hong Kong Archaeological Society to undertake an historical and archaeological survey on Chek Lap Kok. The study commenced in September 1990 and was completed in July 1991.

*Table 14.1*
*Archaeological and Historical Sites Impacted by Airport Construction and Electronic Equipment Siting*

| Site | Location | Map Reference Number |
|---|---|---|
| Tin Hau Temple | Chek Lap Kok | T213 |
| Sham Wan Tsuen Arch. Site | Chek Lap Kok | T11 |
| Fu Tei Wan Arch. Site | Chek Lap Kok | A |
| Kwo Lo Wan Arch. Site | Chek Lap Kok | T12 |
| Ha Law Wan | Chek Lap Kok | B |
| Lung Kwu Chau Arch. Site | Lung Kwu Chau | T27 |
| Sha Chau Arch. Site | Sha Chau | T28 |
| Tin Hau Temple | Sha Chau | T96 |

*Sources:* *Greiner-Maunsell, 1991 and Antiquities and Monuments Office: Recreation and Culture Branch*

Evidence of human occupation dates back more than 6,000 years and suggests an almost continual history of settlement on Chek Lap Kok. Significant cultural deposits from the Neolithic, as well as, the Tang and Sung dynasties were discovered at four known sites including Ha Law Wan, Sham Wan Tsuen, Fu Tei Wan and Kwo Lo Wan.

A Tin Hau Temple located on the north end of Chek Lap Kok as shown on Exhibit 14.1 has been dismantled and is in storage on Lantau Island. At a future date it will be reconstructed on a site reserved in Wong Lung Hang Village Resite, where the indigenous villagers from Chek Lap Kok will eventually be relocated. Excavations at the major site of Sham Wan Tsuen revealed several ancient burial sites, and findings of pottery and coins were made.

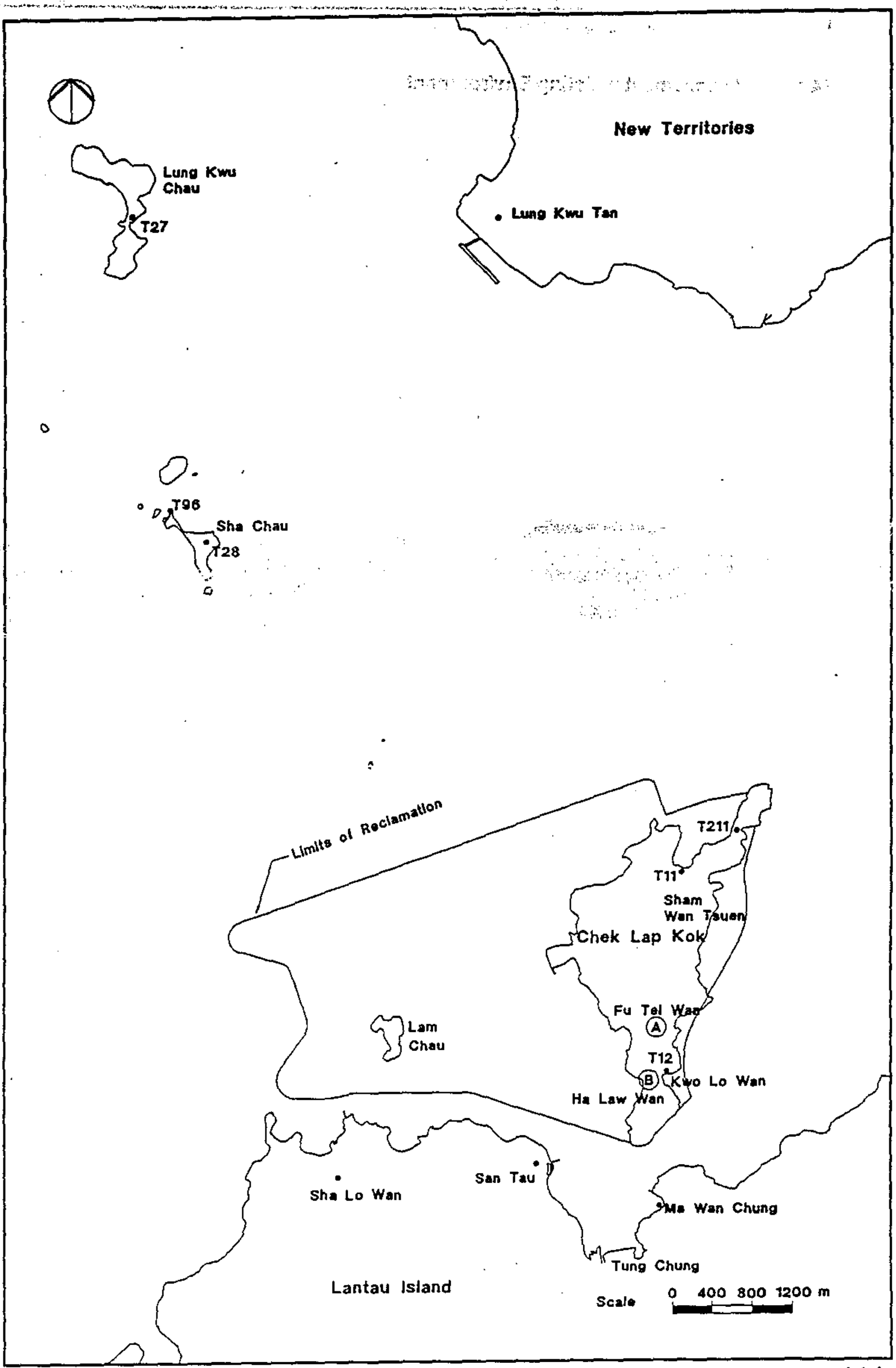



*Exhibit 14.1*
***Archaeological and Historical Sites Impacted by Airport Construction and Electronic Equipment Siting***

Lime kilns which were used to burn coral and seashells to extract lime for fertiliser, construction work and coins were found at Fu Tei Wan, Ha Law Wan, Sham Wan Tsuen and Kwo Lo Wan. At Fu Tei Wan an intact well preserved Tang dynasty lime kiln was unearthed and has been relocated from Fu Tei Wan to the Tung Chung Battery site on Lantau. A proposal has been made by the Antiquities and Monuments Office to the District Lands Office to permanently locate it on a small site immediately adjacent to the battery. A significant Yuan dynasty kiln complex at Ha Law Wan has been partially excavated and it was revealed that iron making may have occurred on this site. Further investigation is needed to determine the exact purpose of the kilns.

Various airport related electronic equipment needs to be located at sites remote from the airport. Proposed sites are located on the islands of Lung Kwu Chau and Sha Chau, approximately seven and four kilometres northwest of the airport respectively. Section 9 of this report contains a brief description of the proposed equipment and placement requirements.

Sha Chau and Lung Kwu Chau are known sites of archaeological interest and are designated on Government's *Listed Items of Archaeological or Historical Interest in Hong Kong Map (1990)* prepared by the Planning Department and the Antiquities and Monuments Office: Recreation and Culture Branch. Both are recognized as Special Sites of Archaeological Interest (SSAI). The delineated area on Lung Kwu Chau encompasses the middle part of the island. The entire area of Sha Chau is listed and a small Tin Hau Temple built in 1862 is located, as previously shown on Exhibit 14.1, on the northwestern tip of the island. On Lung Kwu Chau the construction works associated with the proposed navigation beacon will adversely affect the northern part of the island. On Sha Chau the works area appears to be removed from the main archaeological site and as proposed does not affect the Tin Hau Temple. The approximate location of the proposed improvements, including footpaths and landing jettys, is shown on Exhibits 2.5.3 and 2.5.4 in the Final Report - Civil Engineering.

## 14.2 Impacts/Mitigation Measures

The construction of the airport will almost completely eliminate all of the mentioned archaeological sites on Chek Lap Kok. Although some of the valuable information on man's early development in this area will be irretrievably lost, the extensive excavation and documentation of findings, which might otherwise not have occurred, has mitigated much of the unavoidable destruction.

As previously mentioned, the Tin Hau Temple will be permanently relocated in The Resite Area on Lantau near the villages of the Tung Chung Valley. A portion of the Ha Law Wan excavation site is located within the proposed open space reserve on the southern tip of Chek Lap Kok, and thus, some of the yet to be unearthed kilns and other artefacts may be preserved. A recommendation was made to increase the size of the reserve area to include the Ha Law Wan site by approximately 0.3 hectares. The Site Preparation Contract documents were amended to reflect this change. This will allow the site to be preserved for future study and possibly public display.

Additionally, at the remote sites on Lung Kwu Chau and Sha Chau, efforts should be made to minimise all excavation and any disturbance outside the immediate area where construction will take place.

Airport construction will require excavating and essentially eliminating the islands of Chek Lap Kok, Lam Chau and The Brothers. Much of the open water to the north of Tung Chung will be filled to form the reclamation for the airport and New Town. The future airport site will be a construction site for several years, and the pleasant view from the villages on North Lantau and for visitors to the Country Parks will be disrupted. As the site is gradually transformed into an airport, the services of professional architects and landscape design specialists will be used extensively to assure that the finished airport is aesthetically attractive.

The potential terrain cuts on North Lantau, Lung Kwu Chau, Sha Chau and in Tai Lam Country Park to provide airspace clearance and electronic equipment placement will involve additional aesthetic impacts. Such cuts will be avoided altogether or minimised where possible, and where unavoidable, will include post construction landscaping to provide both aesthetic and habitat benefits, as discussed previously in Section 9 of this report.

During the construction of the airport every effort will be made to limit the visual as well as audible impact upon the area. The noise impacts anticipated during the SPC and BIC construction phases have been dealt with in Section 4 (Noise) and mitigation measures proposed. Visual impacts resulting from the contractors' activities due to the accumulation of waste materials have been considered in Section 10 (Solid Waste) and specific recommendations made regarding the proper disposal of waste.

# Part C

## Issues Relating To Airport Operation

## 16.1 Assessment Methodology

Aircraft generated noise is an important environmental concern associated with the operation of airports worldwide. Therefore, an assessment of the anticipated noise impacts at Chek Lap Kok was performed to determine the effects on off-airport areas. The noise evaluation was conducted in accordance with standards established by ICAO and the U.S. Federal Aviation Administration (FAA). The FAA's Integrated Noise Model (INM), Version 3.9, which is considered a state-of-the-art tool for assessing airport noise exposure, was used to generate noise contours.

The INM contains a standard data base of aircraft performance and noise levels for a representative selection of military, general aviation and commercial passenger aircraft (81 aircraft/engine combinations), including new generation aircraft such as the B757, B767, A300, A310 and BAe-146. The INM allows the user to specify inputs which reflect the unique conditions at Chek Lap Kok. These inputs include variables such as aerodrome elevation, ambient air temperature, runway and flight track geometry and utilisation rates, landing and takeoff profiles, time of day activity distribution, aircraft fleet mix, and overall traffic volume.

The INM was used to develop contours in the NEF metric increments of 25, 30 and 40. The NEF is a cumulative noise exposure measurement based on a perceived noise level scale accounting for pure tone corrections of individual aircraft events.

For the purpose of clarity and in order to enhance the reader's understanding, the following is a brief description of the steps taken to develop the inputs for the INM to generate noise exposure contours:

(1) Establish runway parameters (length, orientation, and threshold location).

(2) Project annual operations for the specified time periods and divide by 365 to determine annual average day total operations.

(3) Determine aircraft fleet mix (including selection of representative aircraft if necessary) and multiply by average day operations to determine operations by aircraft type.

(4) Establish day/night and arrival/departure rates and multiply by step 3.

(5) Analyze available wind data to determine runway end utilisation and multiply by step 4.

(6) Evaluate markets or regions served by departing aircraft, any constraints imposed by terrain or obstructions, airspace route structure and ATC handling procedures to develop flight tracks and determine utilisation rates.

Historical data and existing operational procedures are not available to be used for the basis of inputs. Thus, certain aspects of the information presented below have been derived from data obtained from operations at Kai Tak International Airport, discussions held with government agencies, users, and operator organizations such as IATA, Air Traffic Management Division (ATMD) of CAD, and through the use of professional judgement based on previous experience.

### 16.1.1 Airport Data

The new airport at Chek Lap Kok is expected/assumed to have a runway elevation of 8mPD and the annual average air temperature at the site will be approximately 22.8° Celsius. The airport will consist of two parallel runways aligned with a magnetic heading of 7/25 (ENE/WSW) and a centerline to centerline separation of 1525m.

Each runway will have 3,800m of usable pavement in which no weight or operational restrictions are applied that might prevent full utilisation by any aircraft type. Also, it has been established that the runways will not be staggered. However, due to a minimum altitude clearance of 45.7m (150 feet) over the seawall to accommodate autopilot landing requirements, a minor displacement of the thresholds for each of the runway ends will be necessary. Within this noise analysis, the determination of runway threshold displacement will be used only to specify at what point arriving aircraft are allowed to land. Based on the boundary of the reclamation and the facilities required beyond the end of each runway, the amount of displacement will vary slightly as presented below:

| Runway | Displacement |
|---|---|
| 7R | 189m |
| 7L | 204m |
| 25L | 63m |
| 25R | 204m |

Section 5.1.6 of the First Interim Report provides an in-depth explanation of autopilot landing requirements and the facilities required beyond the runway. In the selected terminal/master plan option, the primary access corridor traverses the site along the eastern boundary to a midfield terminal location and passes beneath the approach to Runway 25L. In order for adequate height clearances to be maintained so that ICAO Annex 14 obstruction limitation surfaces are not penetrated the primary access corridor and sea wall are located a considerable distance from the end of Runway 25L. This separation allows the displaced threshold on Runway 25L to be less than the other runway ends whilst aircraft will still pass over the sea wall at or above the minimum altitude clearance of 150 feet.

### 16.1.2 Aircraft Operational Data

To develop NEF contours, aircraft activity over a 24-hour period must be specified. In order to determine the immediate as well as the long term impacts of the airport, noise contours were generated based on activity levels anticipated for the average day in the years 2000 and 2030.

The year 2000 was selected to represent the first complete year when the airport will be fully functioning and use of all possible modes of operation could be utilised. Although the airport is scheduled for opening in 1997, analysis indicates that construction and commissioning of the second runway could take 18 months to 2 years after the first runway is completed. Additionally, existing Air Traffic Control (ATC) staff are inexperienced in multi-runway operations, thus adequate time for training after the second runway is opened must be allocated to realise the full potential of a parallel runway configuration. In view of the above, the year 2000 was chosen as representing the base year for the two runway airport. In this year, approximately 171,300 annual aircraft movements are projected, resulting in an average daily level of 469 movements.

The forecast of aviation activity indicates that in the year 2040 aircraft movements are projected to be 418,400 annually under "unconstrained conditions". Realistically, it is unlikely that a two parallel runway system will be capable of accommodating this level of aircraft movement. In general, planning manuals such as ICAO - *Airport Planning Manual, Part 1 Master Planning* and the FAA *AC 150/5060-5 - Airport Capacity and Delay* indicate that the capacity of parallel runways with separation in excess of 1311m ranges from 300,000 to 370,000 operations annually.

In regard to the long-term impact, the year 2030 has been selected to represent a "worst case" situation for overall noise impact. There is no significance to the year 2030 other than that the level of operational activity (352,200 annual and 965 average daily operations) which is anticipated to occur within this period approaches the high end of the range discussed above. Beyond this level of activity, it is expected that the airlines will begin utilising a higher percentage of larger seating capacity airplanes, such as the B747-500, in place of smaller aircraft to increase passenger levels without increasing aircraft movements. Thus, if airfield capacity is being reached in the timeframe of about 2030 and aircraft movements stabilise through the use of larger aircraft, the noise impact at 2040 or beyond should not increase.

Since every aircraft type has different operating characteristics and noise signatures, it is necessary to distribute total daily activity amongst as many specific aircraft types as possible. It can be expected that due to research and improvements in engine and wing efficiency as well as other technological advancements the aircraft fleet mix will change drastically in the future. Many of the aircraft currently operating at Kai Tak will most likely not be seen at Chek Lap Kok, having been replaced by aircraft not yet produced, such as the B747-500, B777, A330, and A340. These aircraft are not only expected to be more efficient, but to also have improved operating characteristics over those existing. These aircraft will also be quieter as the mitigation of noise impacts has become a design criteria from the outset of their development.

However, without detailed information available, the noise impact from these aircraft cannot be simulated by the noise model. Thus it becomes necessary to select existing aircraft types with similar operating characteristics to represent future aircraft activity. Since the existing aircraft selected are expected to be noisier than those which will utilise Chek Lap Kok in the future, the results of the analysis are an over-estimation of noise impacts.

In order to project a future aircraft fleet mix, the existing fleet mix at Kai Tak and the historical growth trends were used. Table 16.1 illustrates this data.

*Table 16.1 Historical Aircraft Fleet Mix*

| Aircraft Type | 1989 Aircraft Mix (Percent) | Percent of Category | 1981 - 1989 Growth Trend (Percent) |
|---|---|---|---|
| B747 | 30.9 | 90.9 | 42.2 |
| B747SP | 3.1 | 10.1 | 32.6 |
| Total B747 | 34.0 | 100.0 | 41.3 |
| A300 | 17.5 | 38.3 | 57.6 |
| A310 | 1.8 | 4.0 | 89.6 (84-89) |
| B767 | 5.4 | 11.8 | 75.2 (83-89) |
| DC10 | 5.5 | 12.0 | 3.8 |
| L1011 | 15.5 | 33.9 | 51.2 |
| Total OWB* | 45.7 | 100.0 | 55.8 |
| B707 | 0.9 | 4.4 | -668.8 |
| B727 | 0.3 | 1.5 | -614.6 |
| BAE-146 | 1.8 | 8.9 | 98.9 (87-89) |
| B737S | 1.2 | 5.9 | 64.4 (88-89) |
| B737 | 11.6 | 57.2 | 89.8 |
| B757 | 2.1 | 10.3 | 93.1 (86-89) |
| DC8-60/DC8-70 | 0.3 | 1.5 | 83.6 (85-89) |
| DC-9/MD80 | 1.3 | 6.4 | 56.8 (84-89) |
| Others | 0.8 | 3.9 | 72.1 |
| Total NB** | 20.3 | 100.0 | 48.6 |

Note: The BAC-11, Concorde, DC-8, DC-9 and Trident aircraft were eliminated from the analysis as having less than 0.1 percent of the total activity.

* OWB - Other wide-bodied aircraft.
** NB - Narrow-bodied aircraft.

*Source: Greiner-Maunsell, 1990*

With the popularity of the B747-400 and the anticipated production of the B747-500 it is assumed that B747's will remain active in Hong Kong throughout the planning period. However, the INM which is used to generate the noise contours only contains noise and performance information for the B747-200 aircraft which is an early B747 derivative. Although later B747 models use more powerful engines, extensive research has been carried out over recent years to reduce the overall noise impact of jet engines. Thus, in utilizing the B747-200 to represent all B747 aircraft it is considered that the estimated noise levels calculated by the INM for this category provides a conservative estimate.

Although the B747 family of aircraft has remained in a category of its own for over two decades, Airbus Industrie is currently developing and expects to initiate production by 1992 of a new four-engine wide-bodied aircraft type called the A340. The A340 is expected to accommodate 260 to 300 passengers and have an approximate maximum gross takeoff weight of 554,000 lb. Since this aircraft is not currently in production, only limited information regarding operational and noise characteristics is available and the data is not contained in the INM. Information on the market the A340 is intended to serve, provided by Airbus Industrie, indicates a market such as Hong Kong can expect to have activity by this aircraft sometime in the future. Based on the weight, range, and four-engine noise emission of the A340, it would most likely compete in the B747 market as well as produce similar or slightly less noise emissions. Therefore the B747-200 was determined to be a suitable representative for the A340.

In regard to the category of Other Wide Bodied (OWB) aircraft, five aircraft have historically fallen into this grouping. This category can be further broken down into twin-engine aircraft (A300, A310 and B767) and three-engine aircraft (DC-10 and L-1011). Since the A300 and A310 have similar operating and performance characteristics as well as noise impact, the A300, the most active of the two at Kai Tak, was selected to represent both. Another aircraft type being developed by Airbus Industrie is the A330 aircraft. The A330, scheduled to be in service by 1992, is a twin-engined wide-bodied aircraft with a seating capacity of approximately 300 to 500 passengers and a maximum gross takeoff weight of approximately 460,000 lb. Based on the similarities of the A310 and A330 to the A300 aircraft, it is expected that these more advanced new technology aircraft will eventually replace the A300. However, neither the A310 or the A330 are contained within the INM, thus the A300 was used to represent all three aircraft.

The B767 is a relatively new aircraft type which has shown tremendous growth historically and represents a relatively significant share of the existing market. It was also selected to represent twin-engine OWB aircraft. Similar to Airbus Industrie, the Boeing Corporation is currently developing new aircraft types such as the B777 (previously named B767-X). The B777, scheduled to be in production by 1995 is a twin-engined wide-bodied aircraft slightly larger than the B767 in nearly all aspects. Preliminary Boeing data indicates that noise emissions for the two aircraft types will be very similar. Thus, the B767 is an adequate substitute for the B777 and any of its future derivatives.

The three-engine OWB aircraft category is represented by the DC-10 and L-1011. However, these aircraft types are no longer in production and eventually through attrition will be discontinued from service. In 1989 the L-1011 aircraft accounted for a majority of the three-engine OWB aircraft activity, however, no future derivative of this aircraft is expected. On the other hand, the McDonnell-Douglas MD-11 has recently entered the production stage and will serve as a replacement for the DC-10. Therefore, for the purpose of this noise analysis it was assumed in the year 2000 that the L-1011 would be operating in the Hong Kong market, however by the year 2030 this aircraft will almost certainly no longer be operating and no replacement is foreseen. To account for the activity of the MD-11 aircraft the DC-10 was selected as the most suitable representative due to the lack of operating and noise emission information available within the INM for the MD-11.

In general the historical growth of the twin-engine OWB aircraft has outpaced that of the three-engine OWB aircraft and this trend is anticipated to continue.

Under 1989 conditions three aircraft types (B737, B757 and BAe146) accounted for approximately 82 percent of the total Narrow Bodied (NB) aircraft activity. In addition, these aircraft are amongst the newest aircraft models currently under production and represent a wide range of aircraft size and passenger seating capability (i.e. BAe-146 90-112 passengers, B737 120-159 passengers, and B757 185-220 passengers).

All of the other NB aircraft operating at Kai Tak in 1989, with the exception of the MD-80 which has similar operating and noise characteristics as the B737, are no longer in production. Consequently, it is assumed they will eventually disappear from the Hong Kong market. For these reasons, the B737, B757 and the BAe-146 were selected to represent all NB aircraft in the years 2000 and 2030.

Based on 1989 activity and the historical growth trends previously shown in Table 16.1, the projected aircraft fleet mix is estimated to be as shown in Table 16.2.

A small portion of the total aircraft activity is anticipated to be performed by a wide variety of small aircraft and helicopters. These aircraft are expected to range in size from the smallest single-engine piston (e.g. C-172, PA-28) to business jet aircraft (e.g. Gulfstream II, Lear 35, Falcon 50).

In the year 2000 light aircraft and helicopters are expected to account for approximately 11,800 operations or 6.9 percent of the total activity. Light aircraft and helicopter activity in 2030 is anticipated to increase slightly to a level of approximately 16,200 operations but the overall percentage in relationship to the total decreases to 4.6 percent. Tables 16.3 and 16.4 indicate the projected aircraft mix by user group within aircraft categories for the years 2000 and 2030.

However, it should be noted that even if all the light aircraft and helicopter operations were performed by the largest of the light aircraft the noise produced would still be inconsequential to the total noise impact. For example, it will require the combined noise output of approximately 256 Gulfstream IV departures to be equivalent to the output of just one B747-200 aircraft departure. Thus a single B747-200 generates enough noise to overshadow nearly a week's worth of activity by the light aircraft and helicopters. Although on a single event basis the aircraft will be heard, the contribution of light aircraft and helicopters to the overall noise environment and especially the noise contours which are based on an average day's worth of activity will be insignificant. As result, light aircraft and helicopters were eliminated from the analysis.

*Table 16.2 Summary of Projected Aircraft Fleet Mix by Category (Percent)*

| Aircraft Type | 1989 | 2000 | 2030 |
|---|---|---|---|
| <u>747</u> | | | |
| B747-200/B747-400/B747-500/A340 | 100.0 | 100.0 | 100.0 |
| Total | 100.0 | 100.0 | 100.0 |
| <u>OWB</u> | | | |
| A300/A310/A330 | 42.3 | 45.0 | 50.0 |
| DC-10/MD11 | 12.0 | 5.0 | 15.0 |
| L-1011 | 33.9 | 30.0 | 0.0 |
| B767/B777 | 11.8 | 20.0 | 35.0 |
| Total | 100.0 | 100.0 | 100.0 |
| <u>NB</u> | | | |
| B737 | 63.1 | 60.0 | 45.0 |
| B757 | 10.3 | 25.0 | 40.0 |
| BAe-146 | 8.9 | 15.0 | 15.0 |
| B727/B707 | 5.9 | 0.0 | 0.0 |
| DC8-60/DC8-70 | 1.5 | 0.0 | 0.0 |
| DC9/MD80 | 6.4 | 0.0 | 0.0 |
| Other | 3.9 | 0.0 | 0.0 |
| Total | 100.0 | 100.0 | 100.0 |

*Source: Greiner-Maunsell, 1990*

*Table 16.3 Year 2000 - Projected Aircraft Mix (Percent)*

| User-Group | 747 | OWB | NB | Light | Heli. | Total |
|---|---|---|---|---|---|---|
| Passenger Aircraft | 34.1 | 49.9 | 16.0 | 0.0 | 0.0 | 100.0 |
| Freighters | 85.0 | 10.0 | 5.0 | 0.0 | 0.0 | 100.0 |
| Non-Revenue | 42.0 | 44.5 | 13.5 | 0.0 | 0.0 | 100.0 |
| Civil Local | 7.1 | 7.5 | 5.9 | 71.3 | 8.2 | 100.0 |
| Military | 0.0 | 0.0 | 5.0 | 19.7 | 75.3 | 100.0 |
| Overall Percentage | 36.7 | 42.3 | 14.1 | 3.0 | 3.9 | 100.0 |

*Source: Greiner-Maunsell, 1990*

*Table 16.4 Year 2030 - Projected Aircraft Mix (Percent)*

| User-Group | 747 | OWB | NB | Light | Heli. | Total |
|---|---|---|---|---|---|---|
| Passenger Aircraft | 33.7 | 49.5 | 16.8 | 0.0 | 0.0 | 100.0 |
| Freighters | 85.0 | 10.0 | 5.0 | 0.0 | 0.0 | 100.0 |
| Non-Revenue | 42.0 | 44.5 | 13.5 | 0.0 | 0.0 | 100.0 |
| Civil Local | 7.1 | 7.5 | 5.9 | 71.3 | 8.2 | 100.0 |
| Military | 0.0 | 0.0 | 5.0 | 19.7 | 75.3 | 100.0 |
| Overall Percentage | 40.3 | 40.8 | 14.3 | 1.8 | 2.8 | 100.0 |

*Source: Greiner-Maunsell, 1990*

With the removal of the light aircraft and helicopter categories, the overall percentages (From Tables 16.3 and 16.4) for the remaining categories change slightly as shown in Table 16.5.

*Table 16.5 Refined Aircraft Mix by Category (Percent)*

| Year | 747 | OWB | NB | Total |
|---|---|---|---|---|
| 2000 | 39.0 | 45.9 | 15.1 | 100.0 |
| 2030 | 42.3 | 43.0 | 14.7 | 100.0 |

*Source: Greiner-Maunsell, 1990*

This refined aircraft mix by category is applied to the percent breakdown by aircraft type presented in Table 16.2 to determine the average daily activity by specific aircraft type.

Before these operations can be distributed by runway end and flight track the day/night split and the arrivals/departures split must be determined. The day/night split is a critical factor in noise analysis due to the 10-decibel penalty applied within the NEF noise metric to all night operations to account for an increased annoyance. The noise produced by adding 10-decibels to one night operation is equivalent to the noise produced by ten operations of the same aircraft during the day. Based on the 24-hour schedule of aircraft operations, 12 percent of the total activity occurs during the nighttime period (10:00 pm to 7:00 am) as summarised in Table 16.6. Also, the 24-hour schedule indicates that arrivals account for approximately 50 percent of the operations for both the day and night periods. Therefore these factors were utilised in the development of the noise contours.

*Table 16.6* ***Projected Busy-Day Aircraft Movements***

| | Hour of Day | Percent Busy Day 2000 (1) | Percent Busy Day 2030 (1) | Percent Arrivals by Hour (2) |
|---|---|---|---|---|
| | 0 - 1 | 0.8% | 0.8% | 50.0% |
| | 1 - 2 | 1.0% | 1.0% | 50.0% |
| | 2 - 3 | 0.6% | 0.7% | 57.1% |
| | 3 - 4 | 0.3% | 0.3% | 42.9% |
| | 4 - 5 | 0.0% | 0.0% | 50.0% |
| | 5 - 6 | 0.0% | 0.0% | 50.0% |
| | 6 - 7 | 0.9% | 0.9% | 100.0% |
| | 7 - 8 | 2.4% | 2.4% | 100.0% |
| | 8 - 9 | 3.9% | 4.0% | 20.0% |
| | 9 - 10 | 5.4% | 5.4% | 44.4% |
| | 10 - 11 | 5.9% | 5.9% | 57.1% |
| | 11 - 12 | 5.9% | 5.8% | 47.4% |
| | 12 - 13 | 6.3% | 6.2% | 53.3% |
| | 13 - 14 | 7.5% | 7.5% | 52.2% |
| | 14 - 15 | 7.5% | 7.9% | 57.1% |
| | 15 - 16 | 7.5% | 7.5% | 40.9% |
| | 16 - 17 | 7.2% | 7.0% | 42.9% |
| | 17 - 18 | 5.8% | 5.8% | 47.1% |
| | 18 - 19 | 6.6% | 6.6% | 71.4% |
| | 19 - 20 | 5.5% | 5.5% | 38.5% |
| | 20 - 21 | 5.4% | 5.4% | 50.0% |
| | 21 - 22 | 5.4% | 5.3% | 53.9% |
| | 22 - 23 | 5.4% | 5.3% | 44.4% |
| | 23 - 24 | 2.8% | 2.8% | 40.0% |
| | Total | 100.0% | 100.0% | |
| Daytime Operations (hours) | 700 - 2100 | 88.2% | 88.2% | 51.0% |
| Nighttime Operations (hours) | 2200 - 600 | 11.8% | 11.8% | 49.0% |
| Total | | 100.0% | 100.0% | 100.0% |

Notes: (1) Derived from Figure 3 in "Chek Lap Kok Airport Master Plan Review". Final Report, October 1988. Peak hours were adjusted to reflect SBR.

(2) Derived from Official Airline Guide (OAG) Schedule for August 1990. These same percentages are applied for both 2000 and 2030 hourly aircraft demand.

*Source: Greiner-Maunsell, 1990*

### 16.1.3 Runway and Flight Track Utilisation Data

Once the activity is broken down by aircraft type it becomes necessary to distribute these operations to the various destinations. The aircraft destination is necessary to determine stage lengths which are used in the noise model. Stage length information forms the basis for assigning aircraft different departure profiles (operating characteristics) based on gross takeoff weight. For the development of noise contours, stage lengths were assigned by taking the non-stop city-pair aircraft destinations and determining the Nautical Air Miles (NM) to each of the markets. Stage lengths and a breakdown of activity by category to each of the markets was derived using the aircraft mix from Table 16.5 and the market distribution, and are presented in Table 16.7.

For the noise model to accurately portray the noise impacts created by aircraft as they proceed to their destinations it is necessary to determine the runway and flight track utilisation rates which these operations will use. Based on an analysis of wind data collected at Chek Lap Kok over the last 10 year period, it has been determined that winds are predominantly from the east. As a result, the Runway 7 ends would be favored approximately 70 percent of the time and the Runway 25 ends would accommodate the remaining 30 percent. However, it was also determined that a relatively high percent of the time wind speed is 5 knots or less. If adequate runway length exists, large aircraft can safely depart with a slight tailwind component. Operationally, departures to the west of Chek Lap Kok over open water provide an additional safety margin in case of an emergency on takeoff, and places little, if any, restriction on an aircraft with a low climb gradient capability. With the known obstructions associated with the terrain to the north, east, and south of Chek Lap Kok, departures to the east offer little in flexibility for contingency procedures, may deny independent operations (subject to further review), and may impact some operator's declared takeoff distances. In particular, a pilot of an aircraft taking off under maximum takeoff weight conditions may wish to use Runway 25L/R during tailwind conditions. Air Traffic Control (ATC) coordination and approval would be required of this ad hoc procedure.

For this modelling effort it has been assumed that operations from Runway 25L/R at Chek Lap Kok can be safely accomplished with up to a 5 knot tailwind. There is no intent to impose an operational restriction on the new airport, but to establish for the derivation of noise contours, a representative proportion of departures using Runways 25L/R and 7L/R. By assuming a slight tailwind component as indicative of the limit at which pilots would opt to use Runway 25L/R the proportion of operations which would use Runway 25L/R and Runway 7L/R are 45 and 55 percent respectively. The noise contours presented within this report are based on this runway utilisation split.

The final input needed to generate noise contours for Chek Lap Kok is the assignment of aircraft to flight tracks based on the runway utilisation. According to ICAO manual *Procedures for Air Navigation Services, Aircraft Operations (PANSOPS), Volume I*, an arriving aircraft should be aligned with the localizer signal generally set on the extended runway centerline during the intermediate and precision segments of an instrument approach. The optimum length of each of these segments is 5 NM. Therefore, considering that arriving aircraft will be aligned with the extended runway centerline for approximately 10 NM, which is well beyond the extent of the noise contours, it was assumed that all arrival tracks will be straight-in.

*Table 16.7 Summary of City-Pair Aircraft Movement – Projections by Market*

| City-Pair | Stage Length (nm) | Departures | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Year 2000 | | | | Year 2030 | | | |
| | | 747 | OWB | NB | Total | 747 | OWB | NB | Total |
| Japan | Stage 4 | 12.9% | 5.9% | 0.2% | 19.0% | 14.3% | 5.6% | 0.2% | 20.1% |
| United States | Stage 7 | 3.6% | 0.0% | 0.0% | 3.6% | 3.6% | 0.0% | 0.0% | 3.6% |
| Australia | Stage 6 | 2.8% | 0.0% | 0.0% | 2.8% | 2.5% | 0.0% | 0.0% | 2.5% |
| Taiwan | Stage 1 | 2.6% | 13.1% | 0.0% | 15.7% | 2.5% | 11.9% | 0.0% | 14.4% |
| United Kingdom | Stage 7 | 2.8% | 0.0% | 0.0% | 2.8% | 2.9% | 0.0% | 0.0% | 2.9% |
| Singapore | Stage 3 | 3.4% | 1.4% | 0.0% | 4.8% | 3.1% | 1.0% | 0.0% | 4.1% |
| Thailand | Stage 3 | 1.9% | 9.8% | 0.2% | 11.9% | 1.9% | 8.2% | 0.1% | 10.2% |
| Malaysia | Stage 3 | 0.0% | 2.1% | 0.0% | 2.1% | 0.1% | 1.7% | 0.0% | 1.8% |
| Indonesia | Stage 4 | 0.2% | 1.4% | 0.2% | 1.8% | 0.1% | 1.6% | 0.1% | 1.8% |
| Philippines | Stage 2 | 1.0% | 4.7% | 0.0% | 5.7% | 1.4% | 5.2% | 0.0% | 6.6% |
| Canada | Stage 7 | 1.2% | 0.4% | 0.0% | 1.6% | 1.4% | 0.6% | 0.0% | 2.0% |
| India | Stage 5 | 0.7% | 0.0% | 0.0% | 0.7% | 1.0% | 0.0% | 0.0% | 1.0% |
| West Germany | Stage 7 | 1.5% | 0.0% | 0.0% | 1.5% | 1.8% | 0.0% | 0.0% | 1.8% |
| South Korea | Stage 3 | 0.7% | 3.7% | 0.0% | 4.4% | 0.8% | 3.5% | 0.0% | 4.3% |
| China 50% / 50% | Stage 2 / Stage 3 | 1.9% | 3.1% | 14.1% | 19.1% | 2.8% | 3.3% | 13.7% | 19.8% |
| Middle East | Stage 6 | 0.5% | 0.2% | 0.4% | 1.1% | 0.5% | 0.3% | 0.4% | 1.2% |
| Other European Mkts | Stage 7 | 1.2% | 0.0% | 0.0% | 1.2% | 1.4% | 0.0% | 0.0% | 1.4% |
| Other Markets | Stage 7 | 0.0% | 0.0% | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% | 0.1% |
| New Markets | Stage 3 | 0.0% | 0.2% | 0.0% | 0.2% | 0.1% | 0.1% | 0.2% | 0.4% |
| Overall | | 38.9% | 46.0% | 15.1% | 100.0% | 42.3% | 43.0% | 14.7% | 100.0% |

*Source: Greiner-Maunsell, 1990*

For departing aircraft, the breakdown of activity by flight track is more complex. According to ICAO recommended procedures, departing aircraft should not initiate a turn in any direction until reaching a minimum altitude of 120m (394 feet). Under normal operating conditions, the majority of the aircraft would reach this altitude near the departure end of the runway. Based on the ability of aircraft to make turns soon after take off coupled with the desire of ATC to expedite traffic out of the airport area, it is assumed that departing aircraft will be guided on course to their destinations as quickly as possible. Based on discussions with ATC personnel, an evaluation of the surrounding terrain and existing airspace structure and a review of the previous consultancy's efforts, departure flight tracks were developed as depicted on Exhibit 16.1.

The allocation of aircraft activity over the various flight tracks is a process of many steps and requires the consideration of numerous variables. These variables include terrain surrounding Chek Lap Kok, existing and potential airspace structure, ultimate destination of the aircraft, performance capabilities of the aircraft, the aircraft's takeoff weight, and ATC handling procedures.

At this point, it should be noted that for the purposes of the noise analysis the distribution of aircraft activity over the various tracks must take into account average operational modes under all weather conditions expected to occur during the year as opposed to specific situations which may happen infrequently. In addition, it must be pointed out that without historical data which would be available at an existing airport with well established procedures it was necessary in some instances to rely upon judgement based on relevant experience.

The methodology of allocating aircraft movements to flight tracks, as previously mentioned, involves a number of steps which comprise:

(1) Determine activity by region and aircraft utilised;

(2) Determine breakdown of activity by runway end (i.e. east/west);

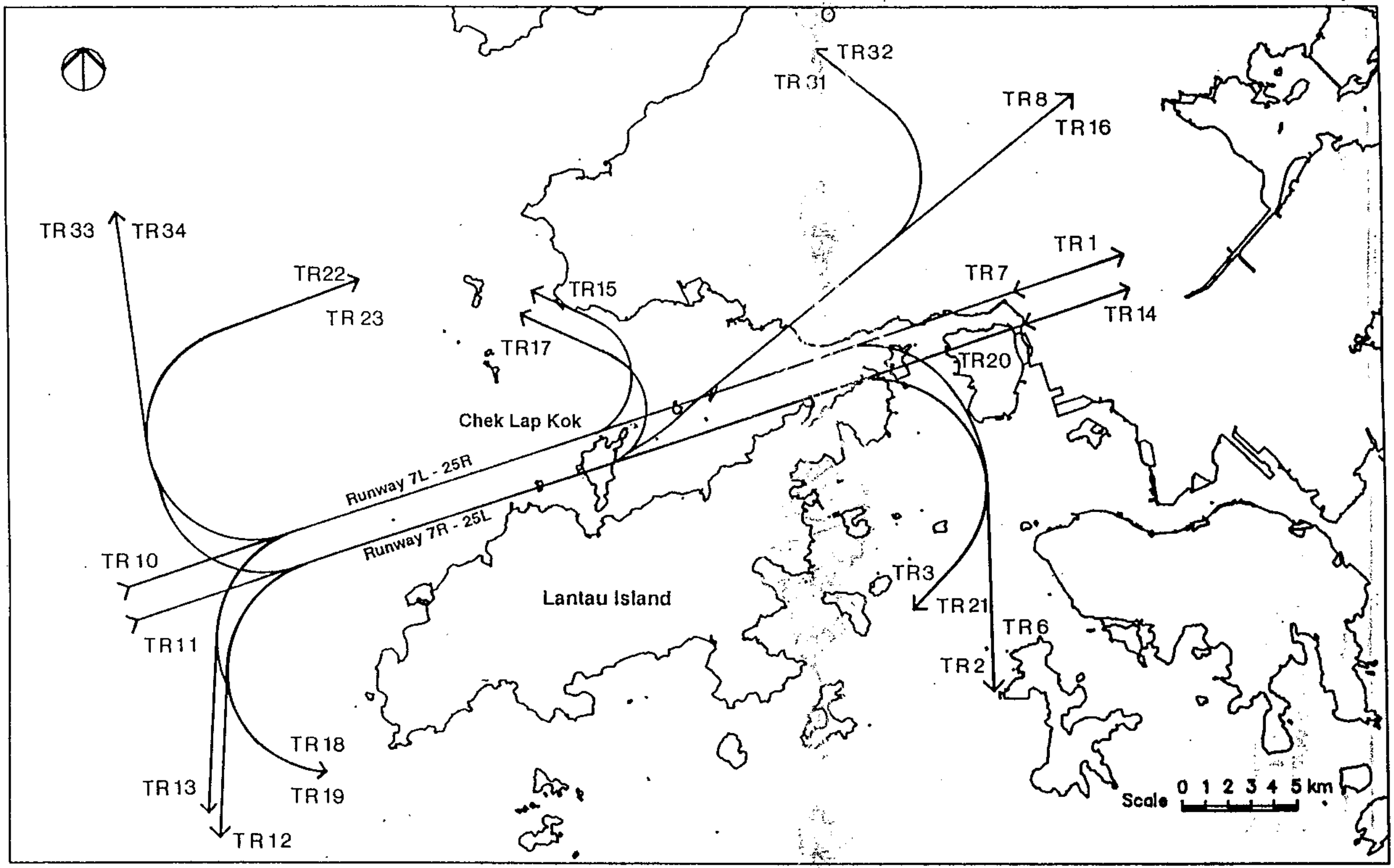
(3) Evaluate destination in relationship to airspace structure;

(4) Correlate destination to possible aircraft weight and performance characteristics; and

(5) Estimate ATC traffic handling procedures.

The first of these steps (1) is to determine the ultimate destination of the aircraft and the types of aircraft being utilised at these destinations. For the purposes of this noise analysis the markets: United Kingdom, West Germany, other European markets, and other markets were grouped together because of their similar location, resulting in a total of 16 markets or regions. Operational activity by aircraft type were further broken down based on the previously discussed distribution.

Step 2 assumes 45 percent of aircraft operations would be conducted on Runway 25L/R and 55 percent would utilise Runway 7L/R (see discussion provided in reference to runway utilisation).




*Flight Tracks* **Exhibit 16.1**

In describing further steps, traffic routing to Japan is used as an example. For this traffic it was assumed that a majority of the activity would flow in that direction immediately after takeoff. When considering that the primary route to Japan in the existing airspace structure is along the eastern coast of China it was further assumed that a majority of these aircraft would utilise flight tracks with the most direct path to the existing primary route (Step 3).

The average distance to the four destinations served in Japan is approximately 1500 nautical air miles which in comparison to the overall maximum range of the B747 and OWB aircraft is relatively short and about average for the NB aircraft. Therefore it was assumed (Step 4) a small percentage of the B747 and OWB aircraft (10 percent) and a slightly larger percentage of the NB aircraft (20 percent) would utilise the "reservoir route" (Tracks 8 and 16). In general it was assumed that B747 and OWB aircraft would not utilise the "reservoir route" unless the aircraft weight allowed adequate climb performance and/or good weather prevailed. It was felt NB aircraft with slightly better climb performance would be more likely to use the procedure.

Based on the above assumptions/data and an estimate of ATC handling procedures (Step 5) it was judged that for the aircraft departing to Japan on Runway 7L/R (55 percent), the majority (80 percent) would depart straight-out (Tracks 1 and 14). A small percent (10 to 20 percent) would utilise the "reservoir route" (Tracks 8 and 16) and the remaining 10 percent would utilise Tracks 2 and 6. The utilisation of Tracks 2 and 6 represents the activity for either weather and/or ATC traffic handling reasons where traffic would initially head south then intercept an easterly radial from the Cheung Chau VOR, and finally intercept the radial to Japan.

A general assumption utilised throughout this analysis is that ATC will attempt, in a majority of the cases, to segregate operations to the appropriate runway to avoid crossing aircraft paths (Step 5). For instance, an aircraft departing through the reservoir route would be instructed to depart Runway 7L as opposed to Runway 7R to avoid crossing the path of aircraft departing Runway 7L. It is assumed that ATC will be successful in accomplishing this task approximately 70 to 80 percent of the time. For the Japanese example, this situation is reflected in the utilisation split between Tracks 8 and 16 as well as Tracks 2 and 6, however in general the importance of segregating traffic diminishes the further path crossing occurs from the airport.

In regard to the 45 percent of Japan activity which departs on Runway 25L/R many of the above assumptions apply. In this situation a majority of the aircraft would be turned onto a northeasterly heading which is a more direct route to Japan. However, due to potential airspace conflicts with aircraft operating to the north of the airport and considering the more well established route structure south of the airport (i.e. Cheung Chau VOR to Taipei), a more even distribution (i.e. north/south) was assumed than that utilised for departures on Runway 7L/R. As a result 70 percent of the aircraft departing Runway 25L/R to Japan utilise Tracks 22 (15 percent) and 23 (55 percent) while the remaining 30 percent utilise Tracks 18 (5 percent) and 19 (25 percent).

Finally, it is important to note that in allocating aircraft to tracks it was assumed that airlines and ATC would strive towards routing traffic in the most efficient manner. However, as was noted in the beginning of this discussion the noise analysis must consider "average" situations and therefore minority percentages of the activity are assumed to utilise a less direct route to account for weather conditions and/or ATC traffic handling procedures. As a result of this multi-step process, all of the aircraft activity was distributed to the various destinations as shown in Table 16.8.

*Table 16.8 Departure Track Utilisation by Region*

| Region | Runway 7(55%) | 747 | OWB | NB | Runway 25(45%) | 747 | OWB | NB |
|---|---|---|---|---|---|---|---|---|
| Japan | Track 1 = | 40% | 40% | 35% | Track 18 = | 5% | 5% | 5% |
| | Track 14 = | 40% | 40% | 35% | Track 19 = | 25% | 25% | 25% |
| | Track 8 = | 8% | 8% | 15% | Track 22 = | 15% | 15% | 15% |
| | Track 16 = | 2% | 2% | 5% | Track 23 = | 55% | 55% | 55% |
| | Track 2 = | 3% | 3% | 3% | | | | |
| | Track 6 = | 7% | 7% | 7% | | | | |
| United States | Track 1 = | 45% | | | Track 18 = | 5% | | |
| | Track 14 = | 45% | | | Track 19 = | 25% | | |
| | Track 6 = | 7% | | | Track 22 = | 15% | | |
| | Track 2 = | 3% | | | Track 23 = | 55% | | |
| Australia | Track 6 = | 60% | | | Track 18 = | 15% | | |
| | Track 2 = | 20% | | | Track 19 = | 75% | | |
| | Track 1 = | 10% | | | Track 12 = | 5% | | |
| | Track 14 = | 10% | | | Track 13 = | 5% | | |
| Taiwan | Track 6 = | 30% | 30% | | Track 18 = | 20% | 20% | |
| | Track 2 = | 10% | 10% | | Track 19 = | 80% | 80% | |
| | Track 1 = | 30% | 30% | | | | | |
| | Track 14 = | 30% | 30% | | | | | |
| United Kingdom, West Germany, Other European Mkts, and Other Markets | Track 1 = | 45% | | | Track 22 = | 15% | | |
| | Track 14 = | 45% | | | Track 23 = | 75% | | |
| | Track 6 = | 7% | | | Track 18 = | 3% | | |
| | Track 2 = | 3% | | | Track 19 = | 7% | | |
| Singapore | Track 6 = | 75% | 75% | | Track 18 = | 15% | 15% | |
| | Track 2 = | 15% | 15% | | Track 19 = | 75% | 75% | |
| | Track 1 = | 5% | 5% | | Track 12 = | 7% | 7% | |
| | Track 14 = | 5% | 5% | | Track 13 = | 3% | 3% | |
| Thailand | Track 3 = | 15% | 15% | 15% | Track 12 = | 80% | 80% | 80% |
| | Track 21 = | 75% | 75% | 75% | Track 13 = | 20% | 20% | 20% |
| | Track 6 = | 7% | 7% | 7% | | | | |
| | Track 2 = | 3% | 3% | 3% | | | | |

*Table 16.8 Departure Track Utilisation by Region (Cont'd)*

| Region | Runway | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 7(55%) | | | | 25(45%) | | | |
| Malaysia | | 747 | OWB | | | 747 | OWB | |
| | Track 6 = | 75% | 75% | | Track 18 = | 15% | 15% | |
| | Track 2 = | 15% | 15% | | Track 19 = | 75% | 75% | |
| | Track 3 = | 3% | 3% | | Track 12 = | 7% | 7% | |
| | Track 21 = | 7% | 7% | | Track 13 = | 3% | 3% | |
| | 7(55%) | | | | 25(45%) | | | |
| Indonesia | | 747 | OWB | NB | | 747 | OWB | NB |
| | Track 6 = | 75% | 75% | 75% | Track 18 = | 15% | 15% | 15% |
| | Track 2 = | 15% | 15% | 15% | Track 19 = | 75% | 75% | 75% |
| | Track 3 = | 3% | 3% | 3% | Track 12 = | 7% | 7% | 7% |
| | Track 21 = | 7% | 7% | 7% | Track 13 = | 3% | 3% | 3% |
| | 7(55%) | | | | 25(45%) | | | |
| Philippines | | 747 | OWB | | | 747 | OWB | |
| | Track 6 = | 75% | 75% | | Track 18 = | 15% | 15% | |
| | Track 2 = | 15% | 15% | | Track 19 = | 75% | 75% | |
| | Track 1 = | 5% | 5% | | Track 12 = | 7% | 7% | |
| | Track 14 = | 5% | 5% | | Track 13 = | 3% | 3% | |
| | 7(55%) | | | | 25(45%) | | | |
| Canada | | 747 | OWB | | | 747 | OWB | |
| | Track 1 = | 45% | 45% | | Track 18 = | 5% | 5% | |
| | Track 14 = | 45% | 45% | | Track 19 = | 25% | 25% | |
| | Track 6 = | 7% | 7% | | Track 22 = | 15% | 15% | |
| | Track 2 = | 3% | 3% | | Track 23 = | 55% | 55% | |
| | 7(55%) | | | | 25(45%) | | | |
| India | | 747 | | | | 747 | | |
| | Track 3 = | 10% | | | Track 33 = | 10% | | |
| | Track 21 = | 40% | | | Track 34 = | 40% | | |
| | Track 31 = | 20% | | | Track 12 = | 40% | | |
| | Track 32 = | 5% | | | Track 13 = | 10% | | |
| | Track 1 = | 13% | | | | | | |
| | Track 14 = | 12% | | | | | | |
| | 7(55%) | | | | 25(45%) | | | |
| South Korea | | 747 | OWB | | | 747 | OWB | |
| | Track 8 = | 25% | 25% | | Track 22 = | 15% | 15% | |
| | Track 16 = | 10% | 10% | | Track 23 = | 75% | 75% | |
| | Track 1 = | 28% | 28% | | Track 18 = | 3% | 3% | |
| | Track 14 = | 27% | 27% | | Track 19 = | 7% | 7% | |
| | Track 6 = | 7% | 7% | | | | | |
| | Track 2 = | 3% | 3% | | | | | |

*Table 16.8 Departure Track Utilisation by Region (Cont'd)*

| Region | Runway | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 7(55%) | | | | | 25(45%) | | | | |
| China | | | 747 | OWB | NB | | | 747 | OWB | NB |
| | Track 15 | = | 0% | 0% | 7% | Track 33 | = | 0% | 0% | 5% |
| | Track 17 | = | 0% | 0% | 3% | Track 34 | = | 0% | 0% | 20% |
| | Track 8 | = | 25% | 25% | 20% | Track 22 | = | 20% | 20% | 10% |
| | Track 16 | = | 5% | 5% | 5% | Track 23 | = | 80% | 80% | 65% |
| | Track 31 | = | 0% | 0% | 10% | | | | | |
| | Track 32 | = | 0% | 0% | 5% | | | | | |
| | Track 1 | = | 35% | 35% | 25% | | | | | |
| | Track 14 | = | 35% | 35% | 25% | | | | | |
| | 7(55%) | | | | | 25(45%) | | | | |
| Middle East | | | 747 | OWB | NB | | | 747 | OWB | NB |
| | Track 1 | = | 15% | 15% | 12% | Track 33 | = | 10% | 10% | 10% |
| | Track 14 | = | 15% | 15% | 13% | Track 34 | = | 40% | 40% | 40% |
| | Track 31 | = | 15% | 15% | 20% | Track 12 | = | 40% | 40% | 40% |
| | Track 3 | = | 10% | 10% | 10% | Track 13 | = | 10% | 10% | 10% |
| | Track 21 | = | 40% | 40% | 40% | | | | | |
| | Track 32 | = | 5% | 5% | 5% | | | | | |
| | 7(55%) | | | | | 25(45%) | | | | |
| New Markets | | | 747 | OWB | NB | | | 747 | OWB | NB |
| | Track 15 | = | 0% | 0% | 7% | Track 33 | = | 0% | 0% | 5% |
| | Track 17 | = | 0% | 0% | 3% | Track 34 | = | 0% | 0% | 20% |
| | Track 8 | = | 25% | 25% | 20% | Track 22 | = | 20% | 20% | 10% |
| | Track 16 | = | 5% | 5% | 5% | Track 23 | = | 80% | 80% | 65% |
| | Track 31 | = | 0% | 0% | 10% | | | | | |
| | Track 32 | = | 0% | 0% | 5% | | | | | |
| | Track 1 | = | 35% | 35% | 25% | | | | | |
| | Track 14 | = | 35% | 35% | 25% | | | | | |

*Source: Greiner-Maunsell, 1990*

## 16.2 Existing and Post Construction Environment

The area of Lantau Island in the vicinity of Chek Lap Kok is rural with most of the land in either a natural state or under cultivation. The NSRs are primarily in villages where noise is most commonly generated by domestic activities. Less frequent sources of noise are agricultural and recreational activities as well as motorized vehicles (e.g. boat, bus, aircraft). A quantitative evaluation of background noise levels covering this specific area was made by the North Lantau Development (NLD) consultant team early in 1991 and has been documented in the report: *Background Noise Survey for the North Lantau Development Project (February 1991)*.

Starting in late 1991, and continuing through the completion of the new airport, the area around what is currently Tai Po and Tung Chung will be completely redeveloped and transformed into an urban area. Surface transportation facilities to the airport and New Town will carry heavy traffic.

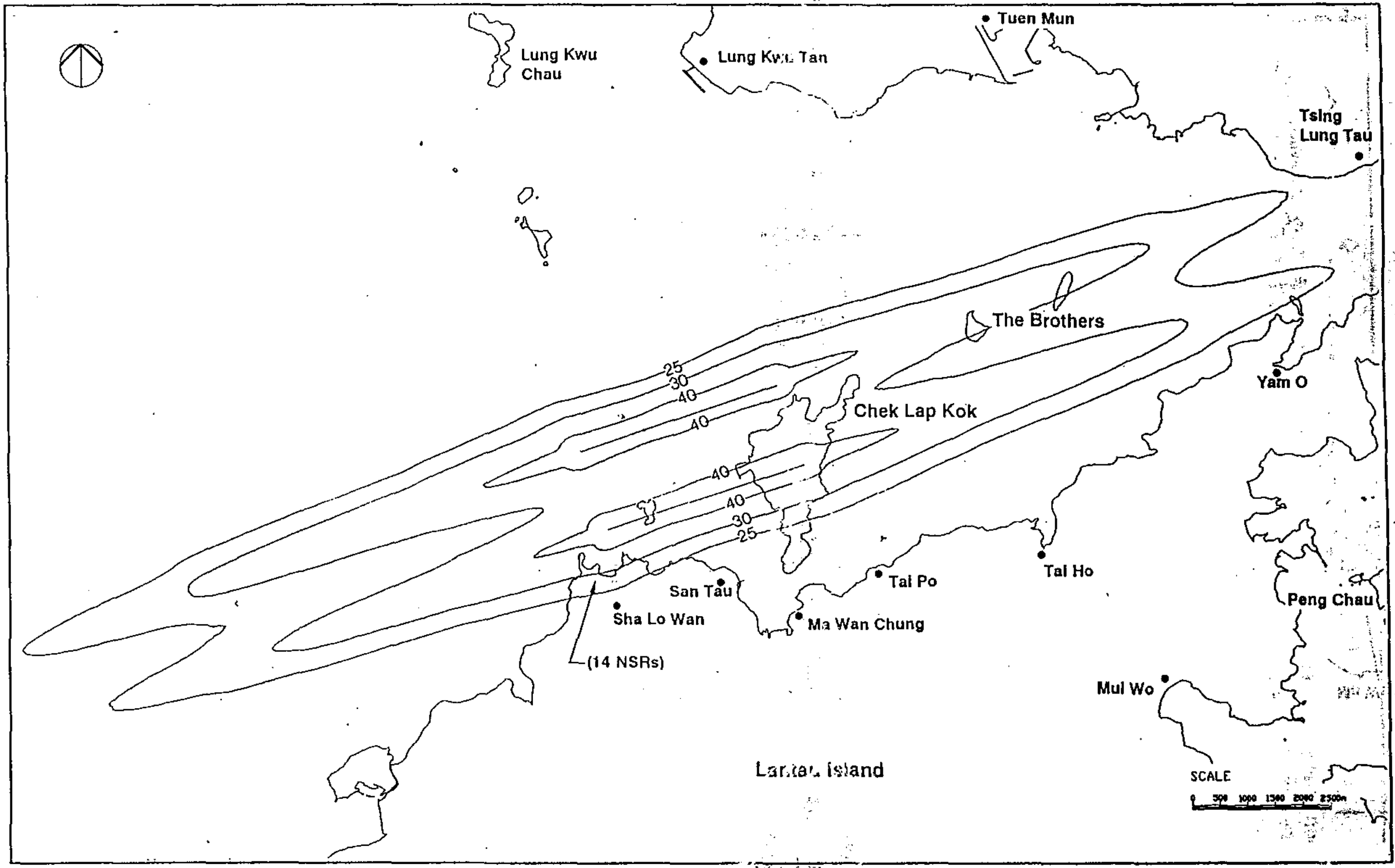
## 16.3 Noise Impacts

### 16.3.1 Arrivals and Departures

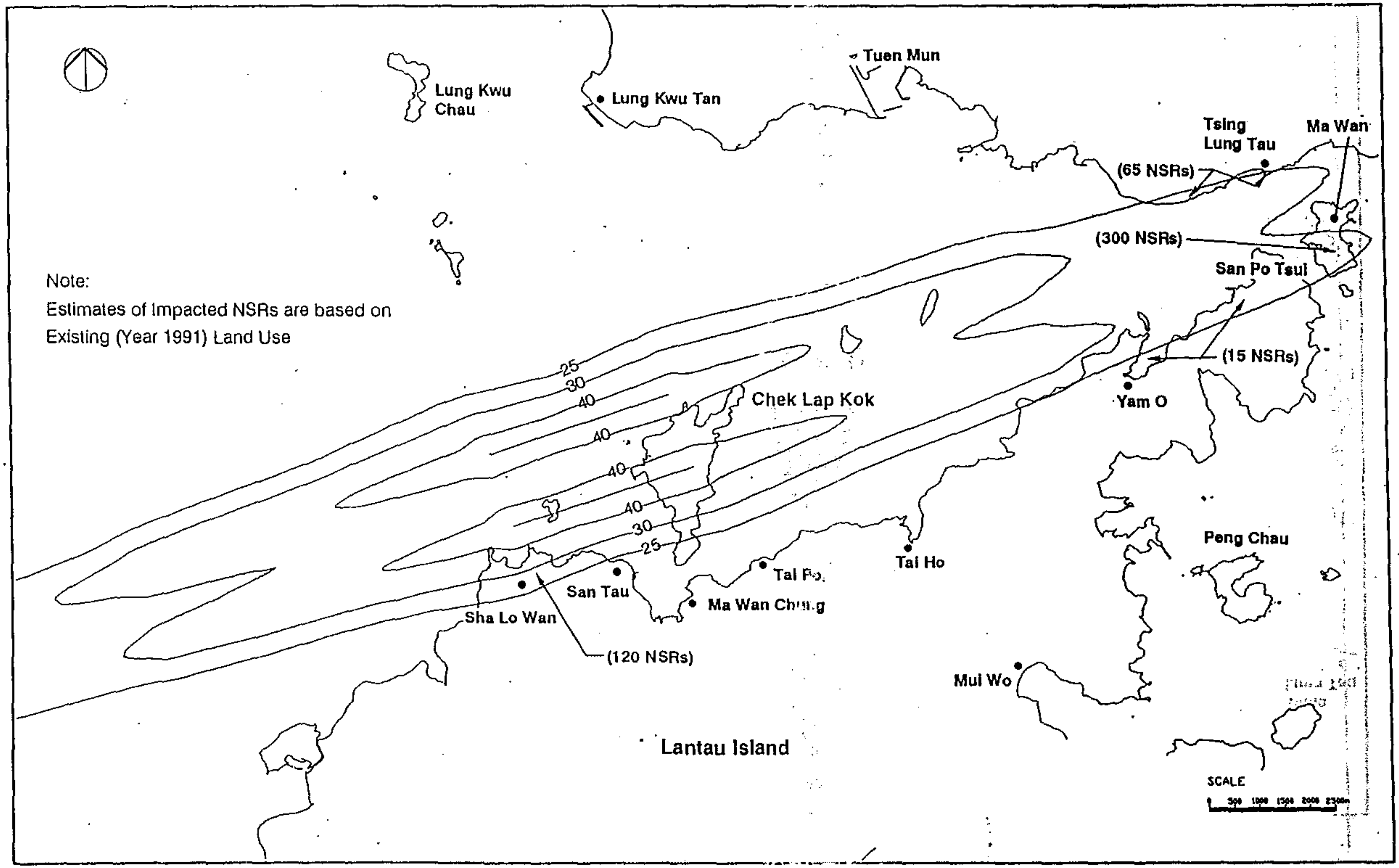
Noise Exposure Forecast contours for 25, 30 and 40 values were generated for the years 2000 and 2030, and are shown on Exhibits 16.2 and 16.3. Based on existing (year 1991) land use, in the year 2000 only approximately 14 NSRs, all along the shore of Sha Lo Wan, will be within the 25 NEF contour. In the year 2030, also based on existing land use, approximately 500 NSRs are projected to be within the 25 NEF contour. These NSRs are primarily located in and around the village of Sha Lo Wan and on the island of Ma Wan, with a few being scattered along the north coast of Lantau and along Castle Peak Road. Approximately 14 of these NSRs, all along the shore of Sha Lo Wan, are projected to be within the 30 NEF contour in the year 2030.

### 16.3.2 Ground Operations

Detailed analyses of noise generated by maintenance run-ups and other apron activities have been conducted at a number of large international airports, including the Kai Tak facility. Results of three of these studies are documented in: *Study of the Noise Impact of Ground Operations at Hong Kong International Airport - Kai Tak (1988)*, *Aircraft Maintenance Run-Up Noise Impact at Dallas - Fort Worth International Airport (1991)*, and *Aircraft Maintenance Run-Up Pad and Noise Suppression System Phase I Planning at Port Columbus International Airport (1991)*. The Kai Tak study was based on B747 engine run-ups, since this is the predominant aircraft type being worked on in Hong Kong. The study determined that unattenuated noise levels from run-ups were at acceptable levels in all cases where the aircraft was more than 1000m from the nearest NSR. At the new airport the maintenance run-up pad will be approximately 2300m from Sha Lo Wan and approximately 4500m from Ma Wan Chung, and a barrier which will provide a noise reduction of at least 10 dB(A) will be constructed with the specified purpose of minimising noise levels at the NSRs as shown on Exhibit 16.4. Based on these distances, the construction of the noise barrier, and results of studies referenced above, the maximum noise level due to a B747-400 maintenance run-up should be between 50 and 55 dB(A) at Sha Lo Wan and even less at Ma Wan Chung.

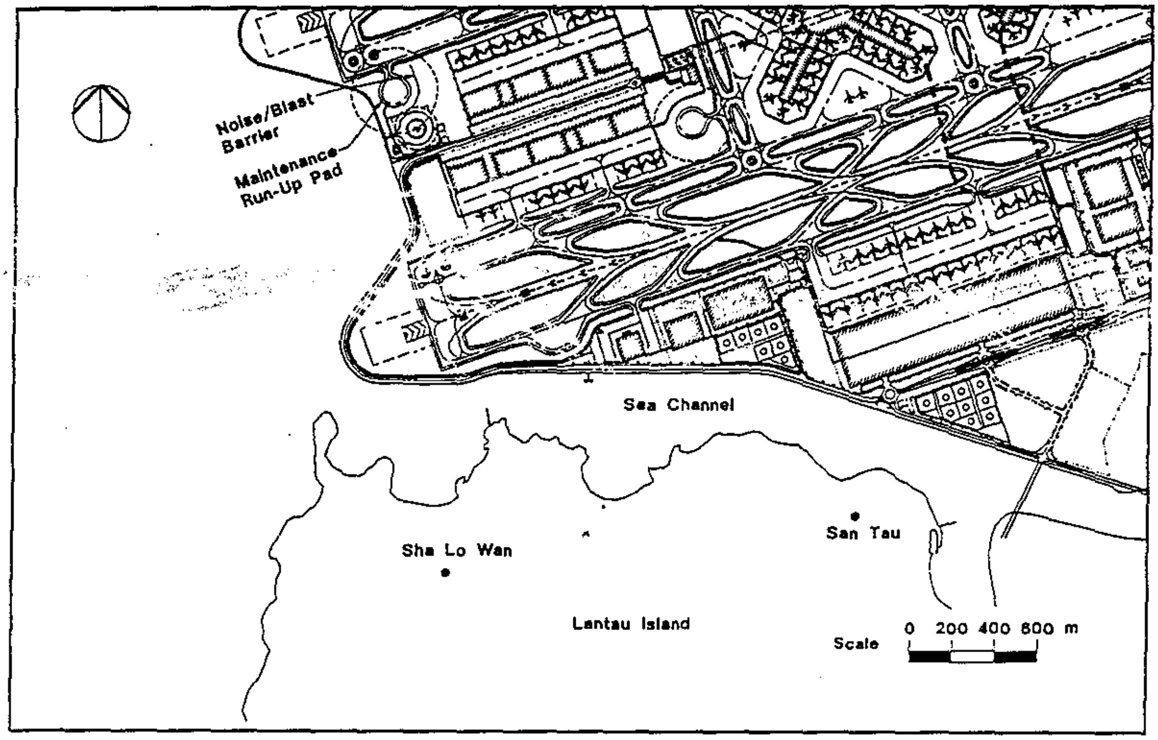



*NEF Noise Contours for Year 2000* ***Exhibit 16.2***




*NEF Noise Contours for Year 2030* ***Exhibit 16.3***

Other apron activities, such as aircraft operating in the cargo area, will come no closer than within 1800m of Ma Wan Chung. If three aircraft had their engines operating at this closest point, which should be representative of a "worst case" operating condition, then the noise level at Ma Wan Chung would be between 55 and 60 dB(A). The noise level generated by a single aircraft taking off or landing will be more than 10dB(A) higher than that generated by all ground operations combined, including maintenance run-ups. Ground operations will therefore not have a significant impact on the North Lantau noise environment.




*Location of Maintenance Run-Up Pad* *Exhibit 16.4*

## 16.4 Mitigation Measures

Throughout the master planning process noise impacts have been an important consideration in developing and selecting alternative facility locations and configurations. In the Phase 1 screening process runway configurations and alignments were favoured which minimised noise impacts. Later, the midfield location of aircraft maintenance facilities was selected from several alternative locations, all of which would have been closer to NSRs. Additionally, a noise/blast barrier is proposed to shield the maintenance run-up pad from NSRs, and thus noise from this type of activity is even further reduced.

For those NSRs which fall within the 25 NEF, year 2000 noise contour, relocation is recommended. All of these NSRs are also impacted by construction noise and are to be provided mitigation for these impacts. Rather than providing some mitigation for construction noise and then additional mitigation for operational noise, it is recommended that residents of these NSRs be compensated just once by means of permanent relocation. All new construction of NSRs within the 25 NEF, year 2030 noise contour, should be prohibited.

Although the use of 25 NEF contours represents one of the best methods available to identify noise impacted areas and to guide land use planning for planned development, the noise produced by individual events will be heard outside of this contour and may be considered an impact. To assist the NLDS team to create a development which will minimise the noise impacts associated with the 24-hour operation of the airport, single event noise exposure levels were determined for the future New Town area. These are expressed as Sound Exposure Levels (SELs) and are representative of the noise generated by a single aircraft taking off. The SELs for a B747, projected to be the most common aircraft at the new airport in the year 2000, are estimated to range between 70 and 80 dB(A) in the area of the New Town, which is roughly equivalent to recurring aircraft noise levels at Whampoa Garden, with an $L_{max}$ of approximately 60 to 75 dB(A).

### 16.5 Modelling, Monitoring and Audit

The Master Plan and associated operational forecasts should be updated prior to the airport opening in 1997. Subsequent to the opening of the airport the Master Plan and operational forecasts should be updated in five year increments. During each revision of the Master Plan, operational noise should be modelled based on a revised forecast. This should be done using the then current noise model which will have new, and likely quieter aircraft in the data base. During each of the noise modelling updates, 25 NEF contours should be projected for the existing year and the fifth year into the future.

A portable noise meter, capable of interfacing with a computer system, should be used to validate the modelled contours. This meter should be used at a number of sites in order to obtain data on flight tracks and representative aircraft types. Such an instrument can also be used to document recurring noise levels at a specific NSR if a complaint is received regarding excessive noise. However, it cannot identify the exact noise level of the specific event which caused the complaint. After contours have been validated they should be reviewed with EPD and if newly impacted NSRs are identified within these contours then mitigation measures should be developed and implemented. This recurring review/audit should also be used to determine when, if ever, it becomes advisable to install a permanent noise monitoring system.

The operation of the airport will have an impact on air quality in the vicinity of the site. Unfortunately, emissions from aircraft, motor vehicles, fuel storage and other airport support facilities are unavoidable. However, these emissions will occur in combination with those associated with other nearby sources including the New Town, the North Lantau Expressway (NLE), the power generating stations at Castle Peak and Black Point along with emissions from other developments on Lantau Island and the Hong Kong mainland.

The quantity, distribution and impact of airport-related emissions will vary depending on the time of day, source-receptor locations and local meteorological conditions. Fortunately, the remote, island location of the airport will help disperse air emissions quickly into the atmosphere and, in most cases, out to sea or over uninhabited land areas. Various design and operational elements of the airport will also serve to mitigate the potential air quality impact.

In order to evaluate the effects of the new airport on air quality, an assessment was conducted. The assessment approach was developed in cooperation with the Air Policy Group of EPD.

## 17.1 Assessment Methodology

For the purpose of this assessment, the various sources of air emissions were first identified and characterised. Based on the design and operational elements of the Master Plan, the type and amount of emissions associated with the primary sources were estimated as an emissions inventory. Using atmospheric dispersion computer models, the impact of these emissions in the vicinity of the airport was predicted. Finally, in order to more fully evaluate these potential effects, both "worst case" and "most probable" conditions were analysed.

### 17.1.1 Sources of Air Emissions

Based on the Master Plan, existing conditions at Kai Tak Airport and what is known about other major airports worldwide, various sources of air emissions have been identified. These emissions comprise by-products of fossil fuel combustion in aircraft, ground support equipment and motor vehicles; evaporative hydrocarbon emissions from fuel storage and transfer facilities; and a wide assortment of other emissions associated with airport support services. These various sources and emissions are summarised in Table 17.1 and are briefly discussed below.

*Aircraft*

Most exhaust from aircraft engines consists of substances that are not regarded as air pollutants. These include nitrogen, oxygen and water vapour. However, several components, such as carbon monoxide, hydrocarbons, nitrogen oxides and particulate matter, are considered air pollutants. These pollutants are emitted in varying amounts depending on the aircraft engine type and operational mode.

*Table 17.1 Operational Sources of Air Emissions*

| Sources | Emission(s) | Characteristics |
|---|---|---|
| Aircraft | - Carbon monoxide<br>- Hydrocarbons<br>- Nitrogen oxides<br>- Particulate matter | - Exhaust products of fuel combustion which vary greatly depending on aircraft engine type, power setting and period of operation. Except for short periods of take-off and approach, aircraft altitude precludes measurable off-site ground level impacts. |
| Ground Support Equipment | - Carbon monoxide<br>- Hydrocarbons<br>- Nitrogen oxides<br>- Particulate matter<br>- Sulphur dioxide | - Exhaust products of fuel combustion from service trucks, tugs, belt loaders and other portable equipment. Overall, a minor source of airport-related air emissions. |
| Fuel Storage and Transfer | - Hydrocarbons | - Formed from the evaporation and vapour displacement of fuel from storage tanks and fuel transfer facilities. Emissions vary with fuel usage, type of storage tank, refueling method, fuel type, vapour recovery, climate and ambient temperature. |
| Aircraft Maintenance Facilities | - Hydrocarbons<br>- Particulate matter<br>- Nitrogen oxides<br>- Carbon monoxide | - Evaporative emissions from cleaning solvents, paints and waste products. Dust from machining, grinding and scraping operations. Aircraft engine emissions from aircraft engine testing facilities. |
| Motor Vehicles | - Carbon monoxide<br>- Hydrocarbons<br>- Nitrogen oxides<br>- Particulate matter<br>- Sulphur oxides | - Exhaust products of fuel combustion from patrons, employees and cargo traffic approaching, departing and moving about the airport site. Emissions vary greatly depending on vehicle type, distance travelled, operating speed and ambient conditions. On-site emissions confined to access/egress roadways and parking facilities. |
| Fire Training Facility | - Smoke | - Short-têrm by-product of burning jet fuel during periodic drills for CFR personnel. |
| Utilities | - Diesel exhaust<br><br>- Chloroflorocarbons | - Exhaust products from back-up diesel powered generators during emergency conditions.<br><br>- Incidental discharges from air conditioning systems and fire extinguishers. |
| Space Heating and Food Preparation | - Carbon monoxide<br>- Hydrocarbons<br>- Nitrogen oxides<br>- Smoke | - Exhaust products of fossil fuel combustion from boilers dedicated to indoor heating requirements.<br><br>- Emissions associated with the food service industry. |

*Source : Greiner-Maunsell, 1991*

The operational cycle of an aircraft is comprised of two operations: landing and take off. For the purposes of this assessment, landing operations also included approach and taxi-in and take off operations also included taxi-out, delay periods and climbout. Engine emissions vary between each mode because at power settings other than cruise, engine performance is less than optimum. For example, when aircraft are idling, carbon monoxide and hydrocarbon emissions are highest. However, during take-off and climb-out, these emissions decrease and nitrogen oxide emissions are predominant. Particulate matter is also produced during take-off and climb-out and to a lesser extent during landing and taxiing. Aircraft engines are not a significant source of sulfur dioxide emissions.

At the airport, aircraft emissions are also a function of airfield operational characteristics. For example, long taxiing distances, taxiway queues and terminal area delay periods contribute to increased emissions. Wind patterns and other weather conditions also play important roles. Except for the short periods of take-off, climb-out, landing and approach, aircraft altitude diminishes the chance of off-site aircraft emissions having any discernible ground level impact.

*Ground Support Equipment*

Aircraft ground support vehicles and equipment include light and heavy duty trucks, tractors, vans, tow-tugs, belt loaders, forklifts, power generators and portable work platforms. Emissions are a function of the type and amounts of fuel consumed and such factors as airport size, layout, activity level and local weather conditions. In most cases, the engines are turned off when servicing the aircraft. Two exceptions are power generators and tow-tugs.

*Fuel Storage and Transfer*

Airport fuel storage and transfer facilities are considered sources of evaporative hydrocarbon emissions. However, because Jet A-1 has a low vapour pressure, these emissions are generally well confined within their tanks or containment vessels although they will vary with the type of storage facility; type of fuel; fuel usage; ambient temperature; and the presence, or absence, of a vapour recovery system. At the airport, most of the jet fuel will be stored at the two co-located above ground tank farms at the south side support area. Other, smaller, above ground and below ground fuel storage facilities will exist throughout the airport for avgas, petrol and diesel fuel. Fuel transfer will be accomplished primarily through an underground fuel distribution system or the use of tanker trucks.

*Aircraft Maintenance*

The maintenance, repair and servicing of aircraft will take place primarily at the midfield support area located near the west end of the runways. These facilities will consist of aircraft hangars, aprons, engine test cells and a wide variety of production work shops and stores.

The repair of aircraft airframes, engines and components will involve a number of different operations that give rise to vapours, mists and particles. These operations include the stripping, cleaning and plating of metal and the application of adhesives and other similar products. Depending on the operation, these emissions can be acidic or alkaline and can contain cyanide, chlorine or a wide variety of organic compounds. Wherever possible, these materials are recovered as gases, mists or aerosols or are recondensed to the liquid state for re-use. In other cases, filters or dilution air are used to reduce the levels of ambient concentrations. The allowable emission limits for each source will be determined, in part, by the best practicable means approach and EPD guidelines to the extent they exist at the time the facilities are constructed.

Aircraft painting operations also produce vapours and particles from paint, paint flakes, cleaning solvents and resins. These operations are generally conducted in hangars that are equipped with negative ventilation systems that prevent discharges to outside air. Engine test cells, used to repair and test engines under controlled conditions, emit exhaust gases that are collected and discharged through stacks.

*Fire Training Facility*

The fire training facility, remotely located on the west end of the airport, will be used intermittently by Rescue and Firefighting (RFF) personnel for fire training exercises. Black smoke from the burning jet fuel will occur briefly during each drill before the fire is extinguished. However, each drill will last approximately 15 minutes and will be conducted only under favourable meteorological conditions. Under prevailing wind conditions, when the wind is from the east, the smoke will be blown out to sea.

*Utilities*

Electric power will be supplied to the airport by the local power company. The only minor exceptions are several support facilities critical to sustaining airport operations that also have back-up diesel powered generators used during emergency conditions.

Both chloroflorocarbons (CFC) used in air-conditioning systems and halons used as fire extinguishers, are regulated under the Ozone Layer Protection Ordinance and, therefore, their use in Hong Kong will be restricted to essential uses.

*Waste Disposal, Space Heating and Food Preparation*

Waste materials at the airport will be disposed of properly according to the waste type. Domestic and select industrial wastes will be discharged to the foul sewer system for treatment in a wastewater treatment plant. Other industrial, chemical and hazardous waste will be collected and recycled or transported off-site for disposal. Solid waste will be stored temporarily on-site before removal and off-site disposal. No waste materials will be incinerated on-site or burned in open pits.

Space heating requirements will be met primarily with electricity generated at an off-site power utility. However, small gas and oil burners may be used by various airport support facilities.

The airport catering, employee canteens and terminal complex food services will generate emissions during food preparation. However, these emissions are non-toxic and not considered a significant source of air pollution.

*Motor Vehicles*

Airport-related motor vehicle emissions are those attributable to passenger, employee and cargo ground traffic travelling to, from, and moving around the airport site. These emissions are primarily a function of traffic volume, distance travelled, roadway operating conditions, fleet characteristics and weather. On-site, these emissions are generally confined to access/egress roadways, kerb sides and parking facilities.

Because the airport access patterns will extend to all parts of the Hong Kong roadway network, the impacts of the off-site emissions are difficult to distinguish from other motor vehicle traffic.

It is unlikely that the other airport support facilities will generate air emissions in amounts large enough to warrant special consideration in the Master Plan. These facilities include the passenger terminals, airport management offices, air traffic control tower, postal service facilities, police station, communications centre and the RFF/Sea Rescue Facilities. Minor exceptions may include back-up emergency generators.

All other aiport-related industry will be located at the industrial park on North Lantau. Industrial emissions generated by these activities will be required to comply with the APCO regulations and impacts will be addressed by the North Lantau Development Study.

### 17.1.2 Models

The various sources of air emissions at the airport have been identified and described. The impact of these air emissions on future air quality conditions in the vicinity of the airport has been analyzed and is discussed below. This analysis is comprised of two primary elements: (1) air emission inventories; and (2) atmospheric dispersion modelling.

*Emission Inventories*

Based on Master Plan forecasts of 2040 airport activity levels, average year, average day and busy day emission inventories were computed. The inventories were developed from aircraft and ground-support equipment operational data, motor vehicle traffic volumes, fuel storage and usage quantities, and source-specific emission factors.

For this analysis, the average year emissions inventory was based on 375,50[illegible] operations. From this, the average day and busy day inventories were based on 1,028 and 1,106 daily operations, respectively. As previously explained, an operation consists of either a take off operation or a landing operation. Emissions were computed for CO, $NO_x$, HC, $SO_x$ and particulate matter.

The aircraft fleet mix used in the analysis contains current aircraft which will be replaced by more efficient and less polluting aircraft by 2040. Therefore, the fleet mix is the most current information available and represents "worst case" conditions.

The inventories included emissions discharged from arriving and departing aircraft. Specifically, arriving aircraft were simulated from final approach to runway landing and then taxiing to the terminal, air cargo apron or general aviation area. Similarly, departing aircraft were simulated travelling from these areas, to the runways, during take-off and into climb-out. Airfield delay periods attributable to runway crossings, taxiway queues and terminal area conflicts were also included. Aircraft emissions above 900 metres were not simulated because aircraft altitude significantly diminishes any potential ground level impacts.

Taxi-in/taxi-out analysis reflects typical taxiing distances from the terminal, air cargo apron and general aviation areas to the runway ends. An idle emission rate and a uniform taxiing speed of 35km/hr was assumed for all aircraft. Ground-based delay periods were assumed to average 5.2 minutes per operation. Aircraft approach/landing emissions were computed for all arriving aircraft with time-in-mode ranging from 1.8 to 6.6 minutes, depending on the aircraft type. Take-off emissions, when the aircraft engines are under full power, were simulated from initial start up to rotation, a time of approximately 0.6 minutes. Aircraft climb-out emissions to 900m are based on aircraft-specific times-in-mode ranging from 2.4 to 6.6 minutes per operation. Finally, helicopter operations were accounted for in similar fashion during landings and climb-outs.

Emissions from ground support equipment and service vehicles were calculated according to the number of aircraft operations; the aircraft service requirements; and the average service times, by vehicle type. These data produce conservatively high emission estimates by assuming service vehicle engines remain running during the service period and do not reflect that this equipment will likely be electric-powered by 2040.

Motor vehicle emissions were computed for airport passenger, employee, and cargo surface traffic travelling to, from and moving about the airport site. Vehicle Kilometres Travelled (VKT) were derived from forecast traffic volumes and a weighted-average trip length to Tung Chung, Lantau Island, Hong Kong Island, Kowloon and the New Territories. Motor vehicle emission rates were based on an average speed of 73km/hr.

Hydrocarbon emissions from fuel storage and transfer facilities were calculated for the proposed 16-tank above ground fuel farms. Storage losses assume that each tank contains 10,000,000 litres of Jet A-1 and that the tanks are fixed roof and maintained in good condition. Working losses assume that the entire storage volume is turned over every six days.

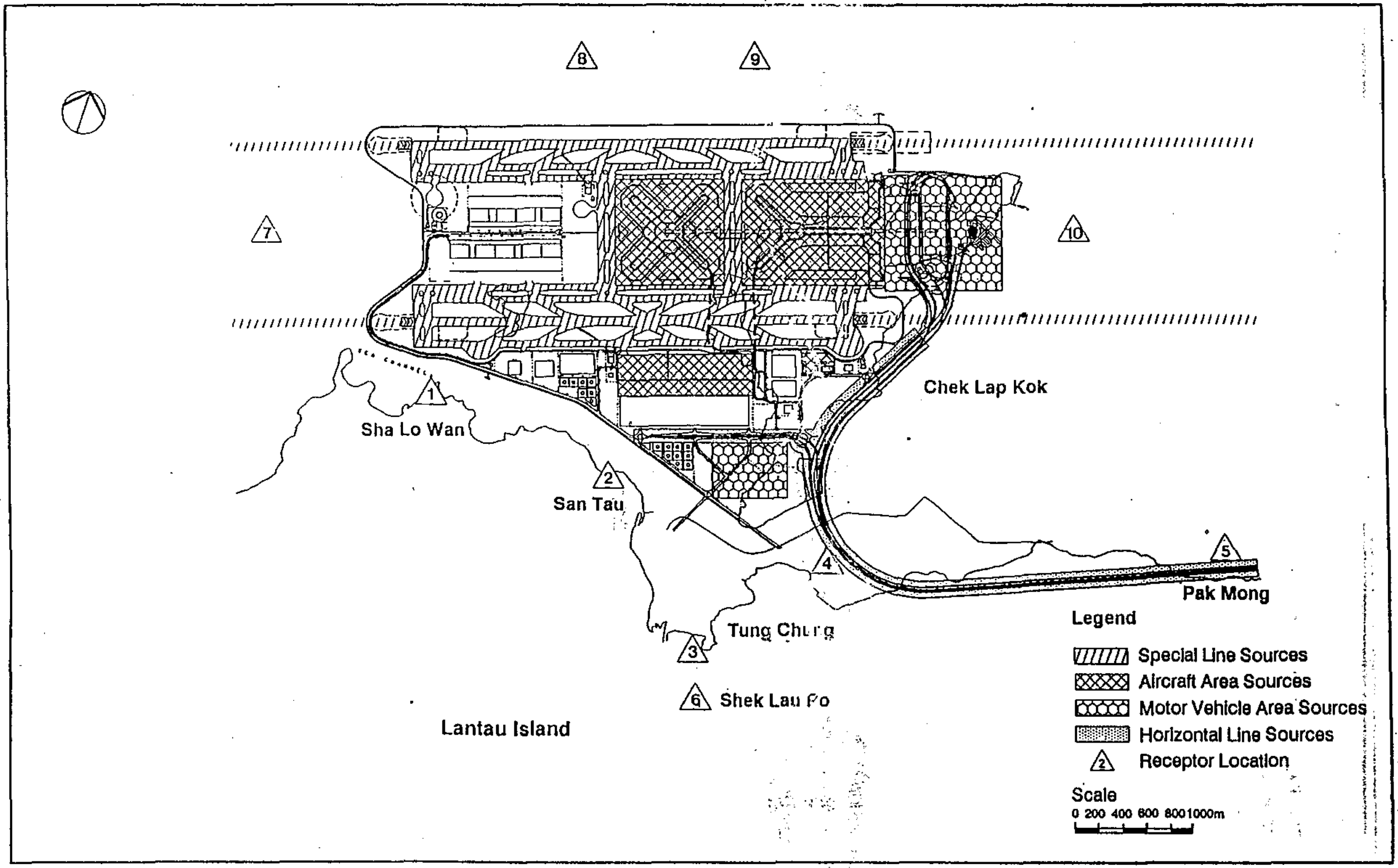
Air emissions from aircraft maintenance facilities, the fire training facility, on-site utilities, and other similar sources discussed previously in Section 17.1.1 were not included. Aircraft and ground support equipment maintenance facility emissions will vary considerably depending on individual source and unique characteristics of the operation. In most cases, these air emissions will be controlled with process-specific recovery methods including use of the best practicable means approach. By comparison, aircraft engine test cells represent relatively small contributions of air emissions to the overall airport total. Similarly, the fire training facility will be used intermittently and the fire drills will last for only several minutes. Finally, back-up generators for critical utilities will be used only during emergencies.

The result of the airport emissions inventories for yearly, average day and busy day conditions for the year 2040 are summarised and discussed in Section 17.3.1 (Emissions Inventory).

*Dispersion Models*

Utilising similar methodology developed for the emissions inventory, combined with local meteorological data and the airport layout plan, atmospheric dispersion modelling was used to predict CO and $NO_2$ levels in the vicinity of the airport. In this way, the air quality impact of the airport can be compared directly to the AQOs.

For this analysis, the U.S. EPA Point-Area-Line (PAL) sources model was selected. PAL is a widely accepted Gaussian-plume model designed to assess air quality impacts from a variety of complex sources, including airports. The standard area and line source subroutines in PAL enable the simulation of runways, taxiways and roadways as line sources; terminal areas and aircraft aprons as area sources; and aircraft approach and climb-out operations as elevated, line sources with end points at different heights above the ground. The most recent version of PAL (PAL 2.1) was used. The location of the various sources are shown on Exhibit 17.1.




*Dispersion Modelling Source and Receptor Locations* **Exhibit 17.1**

The PAL model grid was developed using a Cartesian coordinate system and the 1:10,000 scale airport layout plan. From this, the individual runway, taxiway, roadway and area source locations and dimensions were determined. Consistent with the Master Plan, the two east-west runways were designated 7L/25R and 7R/25L. Taxiways were designated according to the connecting runways and the four aircraft area source destinations: the passenger terminal, passenger concourse, air cargo apron and general aviation area. Similarly, the two motor vehicle area sources were designated as main terminal and air cargo. The access/egress roads were designated as entrance, main terminal or air cargo.

Aircraft approach and climb-out operations were simulated as elevated line sources, 4km in length from the runway ends. Based on a 19:1 glide slope, approach emissions were included from an altitude of 210m. Climb-out emissions were included up to 267m based on a 15:1 slope. A weighted average aircraft speed of 84m/sec was assumed for both the approach and climb-out operations.

Take-off emissions were simulated as level line sources based on the length of each runway. The initial and final aircraft speeds were assumed to be 0m/sec and 84m/sec, respectively. Landing emissions were also simulated as level line sources based on the length of each runway. The initial and final aircraft speeds were 84m/sec and 0m/sec.

Taxi-in and taxi-out emissions were calculated from the measured distances between the four runway ends and the main terminal, air cargo or general aviation area sources. An average taxi speed of 35km/hr was assumed and ground based delay periods were included.

The aircraft area source emissions were developed independently for the terminals, cargo apron and general aviation areas. The function and size of each area source determined the number of operations and the internal distance aircraft travelled. Aircraft delay emissions attributable to 5.2 minutes per operation were also included. The two motor vehicle area sources included all inbound and outbound trips and excess emissions generated by idling motor vehicles.

Motor vehicle movements on the airport access roads, terminal access/egress roads and cargo roads were simulated as horizontal line sources and based on hourly traffic volumes and roadway geometry. An average speed of 73 km/hr was assumed for vehicles on the main access road and a speed of 56 km/hr was assumed for vehicles travelling the cargo area access road and terminal access road.

The terminal area dispersion analysis was accomplished using the U.S. EPA CALINE model and the PAL model area source subroutine. CALINE is a line source dispersion model specifically designed to simulate roadways as individual line sources. Again, the CALINE/PAL model grid was developed from the most current terminal area plan. Using a coordinate system, the at-grade, lower level and elevated access/egress roadways were simulated. Excess emissions associated with the landside terminal kerb-sides were included as the PAL area sources.

### 17.1.3 Emission Factors

Emission factors for the primary sources of air pollution at the airport are applied to forecast activity levels, or operational volumes, in order to determine the amount of emissions generated. In order to avoid double counting, operational volumes were segregated between landing and takeoff operations. These source-specific factors and the applications to this analysis are discussed as follows.

*Aircraft*

Aircraft emission factors vary considerably according to the aircraft type; number of aircraft operations; and operational modes previously identified for landing and takeoff operations.

The primary source of aircraft emission rates are the aircraft engine performance data published in the U.S. EPA publication *Compilation of Air Pollutant Emission Factors*, or AP-42. AP-42 contains aircraft emission factors, by engine type, and by operational mode. For this analysis, the idle emission rates were used for taxi-in, taxi-out and delay periods and the approach emission rates were used for landing operations. Unpublished emission rates for aircraft engines not listed in the most recent version of AP-42 were obtained directly from the U.S. FAA. For B747-400 and MD-11 aircraft, where aircraft emissions rates were unobtainable, substitute emission factors were assumed based on similar aircraft. Aircraft engines in the year 2040 will be different and will likely operate more efficiently than the engines contained in AP-42. Therefore, the aircraft emission rates used in this analysis assume "worst case" conditions.

*Motor Vehicles*

Motor vehicle emission rates were computed from the most recent version of the U.S. EPA Motor Vehicle Emission MOBILE4 model. The latest model year for which emissions rates are available, 2020, was used. The model was programmed to account for the Hong Kong airport motor vehicle fleet mixes and Hong Kong design standards. For example, a high percentage of diesel vehicles was assumed and all applicable vehicles were designated to be in compliance with the Hong Kong APCO Gazette L.N. of 1991. On airport property, the airport fleet mix was further adjusted to reflect the inherent differences in trip purpose (i.e., terminal area, cargo, maintenance).

*Service Vehicles*

Aircraft service vehicle emission rates were obtained from the U.S. EPA and were based on service vehicle type (i.e., belt loader, container loader, tow tractor, etc.), time-in-service, and fuel consumption.

*Fuel Storage and Transfer Facilities*

Evaporative hydrocarbon emission rates were based on JP-1 (jet kerosene) characteristics (i.e., vapour pressure, molecular weight). Breathing losses during fuel storage and working losses during fuel transfer operations were computed independently.

### 17.1.4 Receptors

In order to obtain the most meaningful information from the dispersion modelling results, both existing and future development receptor locations were evaluated, on and off the airport site.

For the PAL model, pollution concentrations were predicted at 10 discrete receptor sites located around the perimeter and in the immediate vicinity of the airport. As shown previously on Exhibit 17.1, four receptors, designated as receptors No. 1 through 3 and Receptor No. 6, represent existing communities along the north-central and northeast coastline of Lantau Island, including Sha Lo Wan, San Tau, Tung Chung (also future new town) and Shek Lau Po. Receptors No. 4 and 5 duplicate NLD study receptors at sites where future reclamation/development will take place. Both of these sites are in close proximity to the NLE. Even though the airport site will be surrounded by water on three sides, the four remaining receptors, No. 7 through 10, were placed near the airport boundary in order to evaluate "worst case" conditions north, east and west of the airport site.

Using the PAL model, a "test-case" was conducted to evaluate the effect of airport-related emissions on both ground-level and elevated receptors in the vicinity of new development areas on northcentral Lantau Island. The results indicated that pollution concentrations decreased with height under simulated "worst case" meteorological conditions. Therefore, for the purpose of this assessment receptor heights were also simulated at ground level.

At the terminal, receptor locations designated T1 through T6 shown on Exhibit 17.2 were selected to represent areas of highest expected air pollution concentrations combined with frequent public use, including the terminal area access/egress roadways and kerb-sides along the upper and lower drives. The premise of this approach is that air pollution levels elsewhere in the terminal area will be lower than compared to these "worst case" locations.

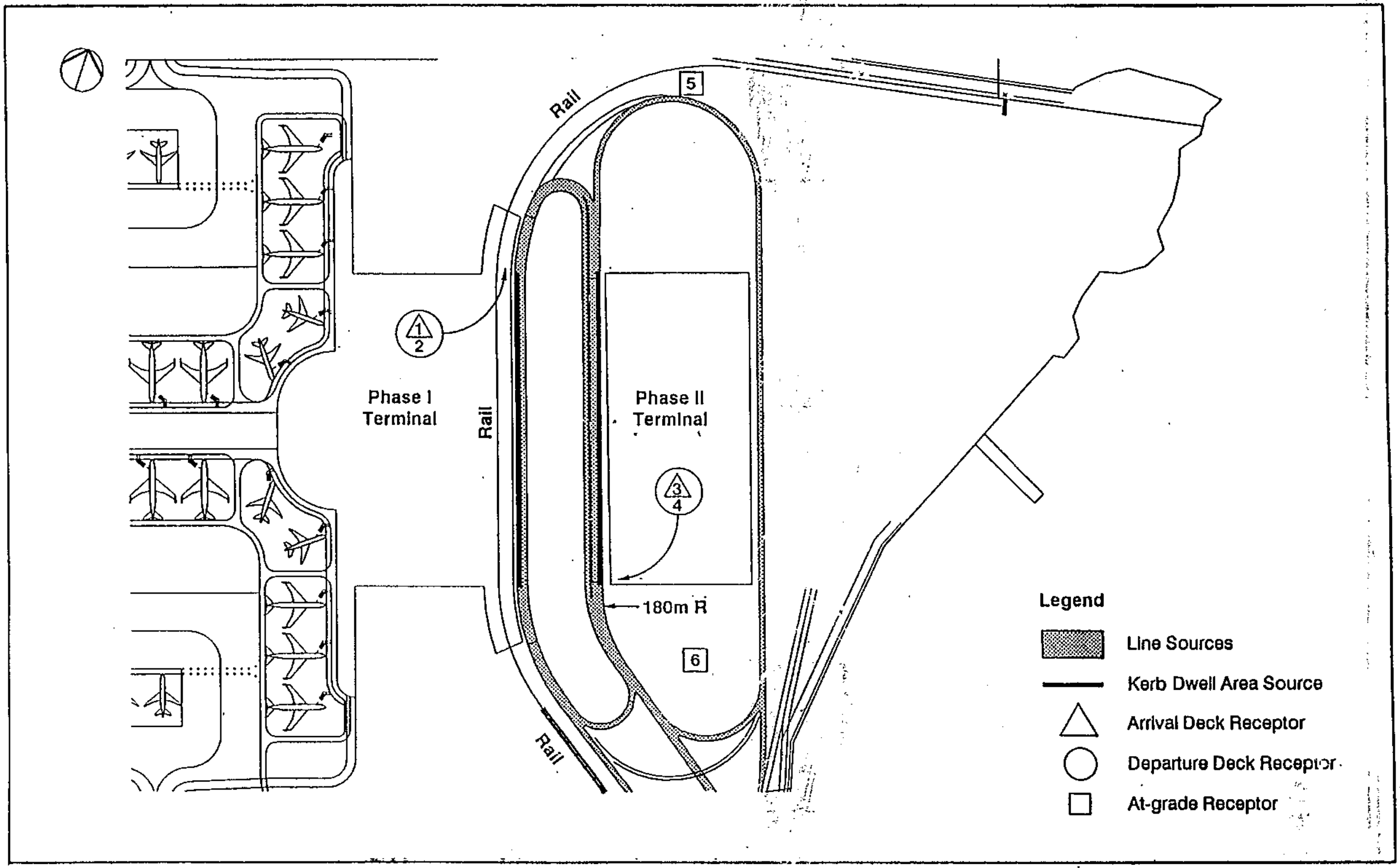
### 17.1.5 Meteorological Conditions

To more fully evaluate the potential air quality impacts resulting from the operation of the airport, the PAL model was simulated using both "worst case" and "most probable" meteorological conditions.

Because the airport site on Chek Lap Kok is located north of north-central Lantau Island, winds from 290° to 50° (WNW to NE) are considered "worst case" for any nearby populated areas. Based on four years of meteorological data collected at Chek Lap Kok, wind angles from these directions occur approximately 25 percent of the time. Other simulated "worst case" meteorological conditions include a 2m/sec wind speed, atmospheric stability Class D (neutral stability), an atmospheric mixing height of 500m and an ambient temperature of 13°C. For the purpose this analysis, wind directions from the 16 cardinal points of the compass were analyzed in order to also determine "worst case" conditions north, east and west of the airport. Finally, it was assumed that there was no variability in the wind direction, wind speed, atmospheric mixing height, stability class or ambient temperature over the one hour, 8-hour or 24-hour modelling periods.

By comparison, meteorological measurements from Chek Lap Kok indicate that the most prevailing wind directions are from 80° to 130° (ENE to SE) which occur approximately 44 percent of the time. For this analysis, a wind direction of 90° was used. Under these conditions, most of the airport emissions would be dispersed over water and away from the receptors on Lantau Island. Other "most probable" meteorological parameters used in the analysis included a 5m/sec wind speed, atmospheric stability Class D (neutral stability) and an atmospheric mixing height of 8?5m. Again, it was assumed that these meteorological conditions did not vary over the modelling time periods.

Local wind patterns in the vicinity of the main terminal are expected to differ from ambient conditions due to buildings, elevated roadways, etc. Therefore, the terminal area model "worst case" meteorological conditions also included a 1m/sec wind speed and the analysis of 36 wind angles (0° to 360° at 10° intervals). Because of the physical barriers to wind flow in the terminal area, "most probable" meteorological conditions were not evaluated.




*Terminal Area Source and Receptor Locations* **Exhibit 17.2**

### 17.1.6 Complex Terrain

Under "most probable" meteorological conditions, and when the wind is from the west and south, air emissions will be transported over water or the relatively flat surface of the airport site. Under "worst case" conditions, or when the wind is from the north, the mountainous terrain of north-central Lantau Island will be encountered. However, these foothills, mountains and valleys are leeward from the terminal area receptors and the receptors located at the site of the New Town and North Lantau villages. Therefore, the potential influence of complex terrain on the modelling results should not be significant in the areas where the greatest impacts are expected to occur.

## 17.2 Existing Environment

With the exception of the Advanced Works Contract (AWC), the site of the new airport is essentially undeveloped and does not contain any large scale sources of air emissions such as power source generation, waste incineration or processing of raw materials Air emissions associated with the AWC were discussed previously in the SIR and were limited to dust from blasting and excavation operations and exhaust from construction equipment. Currently, the only other nearby source of air emission is the Castle Peak Power Station located approximately 6 kilometers north of Chek Lap Kok.

Air quality monitoring data for Chek Lap Kok or Lantau Island is limited. The closest EPD air monitoring stations are located at the Tsuen Wan site on the mainland and the central/western Hong Kong Island sites, 18 kilometers northeast and 21 kilometers east of the airport, respectively.

A short-term air monitoring study was recently undertaken at Tung Chung in association with the North Lantau Development environmental assessment. The results, published in the *North Lantau Air Quality Survey*, indicate that the measured levels of $NO_2$, NO, $SO_2$, CO and TSP were well within the AQOs for these pollutants.

Overall, Hong Kong's climate, and that of the new airport site, is generally considered sub-tropical. The winter months are characterized by periodic surges of cold air from the north or east; spring months by cloudy skies, humid conditions and east-southeast winds; summer months by heavy rain and southwesterly winds; and the autumn months by sunny and dry conditions with variable winds.

Wind speed and direction, air temperature, precipitation, and cloud cover have been recorded by the Royal Observatory on Chek Lap Kok Island over the past several years. The average wind speed is 4.75 metres/second. Because of the persistent land-sea breeze, periods of calm are infrequent. The prevailing wind direction is from the east-southeast (80° - 130°) occurring approximately 44 percent of the time. The average air temperature is 22.8°C. Average rainfall is 1,405 millimetres (mm) per year and cloud cover occurs approximately 65 percent of the time. The average atmospheric mixing height is 819 metres and low level temperature inversions are not very common.

Because Chek Lap Kok is an island, much of the area surrounding the airport site is open marine estuary. Immediately south and southeast of Chek Lap Kok lies the north-central coast of Lantau Island where, just beyond the small, flat agricultural area of Tung Chung, the steep mountainous slopes reach heights of approximately 900 metres at the summits of Lantau and Sunset Peaks.

This partial natural topographic basin has the potential for affecting the dispersal of air pollutants when the winds are from the north, south or southeast over Chek Lap Kok. A wind tunnel study, also conducted in association with the North Lantau Development environmental assessment, revealed that zones of air recirculation may occur in this area of north-central Lantau Island. For example, when winds are blowing down the mountainous valleys from the south or southeast, recirculation is expected to occur at the base of the valleys in the vicinities of Tung Chung, Tai Po, Sha Lo Wan and San Tau. In contrast, when winds are from the north or northwest, these same topographic features may cause winds to accelerate up the valleys and more effectively ventilate these areas. Notably, winds from the south are only expected to occur less than 10 percent of the time and, under these conditions, air pollutants from the airport will be dispersed out to sea away from the north-central coastline of Lantau Island.

## 17.3 Air Quality Impacts

The operation of the new airport will involve several different sources of air emissions. These sources were identified as:

- Aircraft
- Ground support equipment
- Fuel storage and transfer
- Maintenance facilities
- Motor vehicles
- Fire training facility
- Space heating/food preparation
- Utilities

Using this information, combined with the 2040 design and operational elements of the airport Master Plan, the generation and dispersion of these air emissions has been evaluated. The year 2040 was selected because it was based on the highest number of aircraft operations, motor vehicle trips, fuel usage rates and available emission factors. Compared to earlier years with less activity, as in the case of 1997, the 2040 simulated impacts are considered "worst case" conditions.

The emission inventories enable the comparison of the relative contribution of airport-related air emissions to other sources of air pollution in Hong Kong. The inventory results also reveal the contribution of each primary emissions source associated with the airport including aircraft, ground support equipment, fuel storage and transfer, and motor vehicles. Using the PAL and CALINE atmospheric dispersion models, the impact of air emissions on ground-level concentrations of air pollutants in the vicinity of the airport terminal was also predicted.

### 17.3.1 Emissions Inventory

Tables 17.2, 17.3 and 17.4 contain the 2040 airport emission inventories for average year, average day and busy day conditions, respectively.

As shown in Table 17.2, the airport is predicted to generate 31,659 tonnes of CO, $NO_x$, HC, $SO_x$ and particulate matter annually by the year 2040. Aircraft and motor vehicles represent the two largest sources of air emissions contributing 49 and 43 percent of the annual total. By comparison, ground service vehicles and fuel storage facilities represent significantly smaller sources.

*Table 17.2 2040 Emissions Inventory - Average Year*[1]

| Source | CO | $NO_x$ | HC | $SO_x$ | Particulates | Total |
|---|---|---|---|---|---|---|
| | | | Emission (tonnes/year) | | | |
| - Aircraft (Total) | 7,329 | 5,167 | 2,470 | 340 | 144 | 15,450 |
| . Approach/Landing | 568 | 690 | 58 | 77 | 26 | |
| . Taxi-in | 2,119 | 107 | 780 | 32 | 28 | |
| . Delay | 2,304 | 108 | 793 | 33 | 28 | |
| . Taxi-out | 2,219 | 112 | 817 | 34 | 30 | |
| . Take-off | 19 | 1,167 | 4 | 38 | 6 | |
| . Climb-out | 100 | 2,983 | 18 | 126 | 26 | |
| - Motor Vehicles | | | | | | |
| . Off-site | 5,024 | 4,888 | 1,196 | 312 | 814 | 12,234 |
| . On-site | 703 | 447 | 151 | 30 | 77 | 1,408 |
| - Ground Support Equipment | 1,974 | 113 | 441 | 2 | 4 | 2,534 |
| - Fuel Storage and Transfer | - | - | 33 | - | - | 33 |
| Total | 15,030 | 10,615 | 4,291 | 684 | 1,039 | 31,659 |

*Source: Greiner-Maunsell, 1991*

*Table 17.3 2040 Emissions Inventory - Average Day*[2]

| Source | CO | $NO_x$ | HC | $SO_x$ | Particulates | Total |
|---|---|---|---|---|---|---|
| | | | Emission (kg/day) | | | |
| - Aircraft (Total) | 20,078 | 14,159 | 6,771 | 934 | 397 | 42,339 |
| . Approach/Landing | 1,557 | 1,890 | 160 | 212 | 72 | |
| . Taxi-in | 5,805 | 294 | 2,138 | 89 | 77 | |
| . Delay | 6,311 | 297 | 2,173 | 90 | 78 | |
| . Taxi-out | 6,079 | 308 | 2,239 | 93 | 81 | |
| . Take-off | 51 | 3,198 | 11 | 105 | 17 | |
| . Climb-out | 275 | 8,172 | 50 | 345 | 72 | |
| - Motor Vehicles | | | | | | |
| . Off-site | 13,764 | 13,392 | 3,277 | 856 | 2,232 | 33,521 |
| . On-site | 1,925 | 1,225 | 413 | 81 | 212 | 3,856 |
| - Ground Support Equipment | 5,409 | 309 | 1,209 | 5 | 10 | 6,942 |
| - Fuel Storage and Transfer | - | - | 90 | - | - | 90 |
| Total | 41,176 | 29,085 | 11,760 | 1,876 | 2,851 | 86,748 |

Notes: (1) Based on 375,500 annual aircraft operations.
(2) Based on 1,028 daily aircraft operations.
CO = carbon monoxide

$NO_x$ = nitrogen oxides
HC = total hydrocarbons
$SO_x$ = sulfur oxides

*Source: Greiner-Maunsell, 1991*

*Table 17.4* ***2040 Emissions Inventory - Busy Day*** [(1)]

| Source | CO | $NO_x$ | HC | $SO_x$ | Particulates | Total |
|---|---|---|---|---|---|---|
| | | | Emission (kg/day) | | | |
| - Aircraft (Total) | 21,601 | 15,233 | 7,285 | 1,005 | 425 | 45,549 |
| . Approach/Landing | 1,675 | 2,033 | 172 | 228 | 77 | |
| . Taxi-in | 6,245 | 316 | 2,300 | 96 | 82 | |
| . Delay | 6,790 | 320 | 2,338 | 97 | 84 | |
| . Taxi-out | 6,540 | 331 | 2,409 | 100 | 87 | |
| . Take-off | 55 | 3,441 | 12 | 113 | 18 | |
| . Climb-out | 296 | 8,792 | 54 | 371 | 77 | |
| - Motor Vehicles | | | | | | |
| . Off-site | 14,529 | 14,137 | 3,460 | 903 | 2,356 | 35,385 |
| . On-site | 2,022 | 1,281 | 438 | 86 | 225 | 4,052 |
| - Ground Support Equipment | 5,819 | 332 | 1,301 | 5 | 11 | 7,468 |
| - Fuel Storage and Transfer | - | - | 97 | - | - | 97 |
| Total | 43,971 | 30,983 | 12,581 | 1,999 | 3,017 | 92,551 |

Notes: (1) Based on 1,106 daily aircraft operations.
CO = carbon monoxide
$NO_x$ = nitrogen oxides
HC = total hydrocarbons
$SO_x$ = sulfur oxides

*Source: Greiner-Maunsell, 1991*

With respect to the aircraft, taxi-in, taxi-out and ground-based delay periods will generate most of the CO and HC emissions when the engines are in the idle, or low power mode. In contrast, the greatest amount of $NO_x$ emissions is shown to occur during the take-off and climb-out modes when aircraft engines are under high power.

With respect to motor vehicle emissions, the vast majority will be generated off-site by passengers, employee and cargo trips to and from the airport. Most will occur within the proposed NLE but will be indistinguishable from those emissions associated with other motor vehicles.

As previously shown in Table 17.3, the airport is predicted to generate 86,748 kg of emissions during an average day in 2040. The same general patterns of the relative contributions between sources identified for annual conditions in Table 17.2 also apply to average day conditions.

Compared to an average day, busy day airport-related emissions are expected to increase approximately seven percent to 92,551 kg/day as shown in Table 17.4. Otherwise, the same general percent contributions, by source, apply.

### 17.3.2 Dispersion Modelling Results

Based on the emissions inventory results, CO and $NO_x$ account for approximately 80 percent of the air emissions associated with the airport. By comparison, HC, $SO_x$ and particulates comprise the remainder and the airport represents a minor source of these emissions. As a result, CO and $NO_2$ were selected for the dispersion modelling analysis.

Atmospheric dispersion models were used to predict $NO_2$ and CO levels in the vicinity of the airport and in the terminal area. Both "worst case" and "most probable" meteorological conditions were evaluated in the PAL model of the airport. For the terminal area model, "worst case" meteorological conditions were simulated. In both cases, the results represent peak period airport operations.

*PAL Model*

Table 17.5 contains the "worst case" and "most probable" one and 24-hour $NO_2$ concentrations at the 10 receptors located in the vicinity of the airport. The results are presented in ug/m$^3$ and, for comparative purposes, the AQOs for $NO_2$ are also shown. The receptor locations were illustrated previously on Exhibit 17.1. For the purposes of this analysis, it was assumed that 20 percent of the nitrogen oxides from both aircraft and motor vehicles are converted to $NO_2$ in the vicinity of the airport and the NLE.

Under "worst case" conditions, the one hour $NO_2$ concentrations from the airport are predicted to range between 69 and 251 ug/m$^3$ at the ten receptors. The greatest impact is expected to occur at Receptor No. 4. The maximum 24-hour $NO_2$ concentrations from the airport are predicted to range between 36 and 124 ug/m$^3$ under "worst case" conditions. Again, the greatest impact from the airport is expected to occur at Receptor No. 4. Without background $NO_2$ concentrations or contributions from other sources, these "worst case" $NO_2$ levels are below the one and 24-hour AQOs when the wind is 2m/sec and from the north. At Receptors No. 4 and 5 the major source of reported $NO_2$ concentrations during peak hour is from motor vehicles travelling segments of the proposed North Lantau Expressway outside the airport boundaries. $NO_2$ levels at the remaining receptors are primarily from sources within airport boundaries or from aircraft approach and climbout emissions.

Under "most probable" conditions, or when the wind is 5m/sec and from the east, the highest one hour $NO_2$ concentrations from the airport are predicted to range between <1 and 74 ug/m$^3$. The greatest impact is expected to occur at Receptor No. 7 located near the airport's west boundary. The highest 24-hour $NO_2$ concentrations are predicted to range from <1 to 37 ug/m$^3$. Again the greatest impact from the airport is expected to occur at Receptor No. 7. Without background $NO_2$ concentrations or contributions from other sources, these levels are well below the AQOs for this pollutant.

Table 17.6 contains the "worst case" and "most probable" one and 8-hour CO concentrations at the ten receptors located in the vicinity of the airport. The results are presented as ug/m$^3$ and the AQOs for CO are also shown.

*Table 17.5*
*"Worst Case" and "Most Probable" One and 24-Hour $NO_2$ Concentrations (ug/m³)*

| Receptor No. | Receptor Location | Worst Case(1) One Hour Average | Worst Case(1) 24-Hour Average | Most Probable One Hour Average | Most Probable 24-Hour Average |
|---|---|---|---|---|---|
| 1 | Sha Lo Wan | 244 | 122 | 17 | 9 |
| 2 | San Tau | 97 | 49 | 18 | 9 |
| 3 | Tung Chung (New Town) | 87 | 44 | <1 | <1 |
| 4 | New Town next to NLE | 251 | 124 | 48 | 25 |
| 5 | North of Pak Mong | 118 | 62 | 43 | 22 |
| 6 | Shek Lau Po | 69 | 36 | <1 | <1 |
| 7 | W. Airport Boundary | 196 | 100 | 74 | 37 |
| 8 | N. Airport Boundary | 155 | 78 | 54 | 25 |
| 9 | N. Airport Boundary | 158 | 82 | 2 | 1 |
| 10 | E. Airport Boundary | 111 | 58 | <1 | <1 |

Notes: (1) Includes "worst case" wind angle for each individual receptor.
Assumes 20 percent of $NO_x$ is converted to $NO_2$.
Hong Kong Air Quality Objectives:
$NO_2$ - One hour average 300 ug/m³; not to be exceeded more than three times a year.
- 24-hour average 150 ug/m³; not to be exceeded more than once per year.

*Table 17.6*
*"Worst Case" and "Most Probable" One and 8-Hour CO Concentrations (ug/m³)*

| Receptor No. | Receptor Location | Worst Case(1) One Hour Average | Worst Case(1) 8-Hour Average | Most Probable One Hour Average | Most Probable 8-Hour Average |
|---|---|---|---|---|---|
| 1 | Sha Lo Wan | 2618 | 2270 | 100 | 87 |
| 2 | San Tau | 2371 | 2038 | 100 | 86 |
| 3 | Tung Chung (New Town) | 1587 | 1369 | <1 | <1 |
| 4 | New Town next to NLE | 2469 | 2232 | 268 | 231 |
| 5 | North of Pak Mong | 830 | 715 | 236 | 204 |
| 6 | Shek Lau Po | 1285 | 1105 | <1 | <1 |
| 7 | W. Airport Boundary | 2122 | 1836 | 444 | 401 |
| 8 | N. Airport Boundary | 2534 | 2191 | 208 | 178 |
| 9 | N. Airport Boundary | 2360 | 2049 | 2 | 1 |
| 10 | E. Airport Boundary | 2955 | 2561 | <1 | <1 |

Notes: (1) Includes "worst case" wind angle for each individual receptor.
Hong Kong Air Quality Objectives:
CO - One hour average 30,000 ug/m³; not to be exceeded more than three times a year.
- 8-hour average 10,000 ug/m³; not to be exceeded more than once per year.

*Source: Greiner-Maunsell, 1991*

Under "worst case" conditions, the one hour CO concentrations from the airport are predicted to range between 830 and 2,955 $ug/m^3$. The greatest impact is expected to occur at Receptor No. 10 located adjacent to the airport's eastern boundary. The maximum 8-hour average CO concentrations are predicted to range from 715 to 2,561 $ug/m^3$; the highest level occurring at Receptor No. 10. Without background CO concentrations or contributions from other sources, these "worst case" CO levels are well below the one and 8-hour AQOs for this pollutant.

Under "most probable" conditions, or when the wind is 5m/sec and from the east, the one hour CO concentrations from the airport are predicted to range between <1 and 444 $ug/m^3$ and the 8-hour concentrations are predicted to range between <1 and 401 $ug/m^3$, with the greatest impact expected to occur at Receptor No. 7. Without background CO concentrations or contributions from other sources, these levels are well below the AQOs for this pollutant under these conditions.

*Terminal Model*

The results of the terminal area dispersion modelling are presented in Tables 17.7 and 17.8. The terminal area receptor locations were previously shown on Exhibit 17.2.

Table 17.7 contains the "worst case" one and 24-hour $NO_2$ concentrations. As shown, the highest one hour levels are predicted to range between 152 and 175 $ug/m^3$. The highest 24-hour levels are predicted to range between 79 and 92 $ug/m^3$. Including the combined contributions from aircraft and motor vehicles, these levels are within the one and 24-hour AQOs for this pollutant.

Table 17.8 contains the "worst case" one and 8-hour CO concentrations in the vicinity of the terminal. As shown, the one hour levels are predicted to range between 5249 and 6033 $ug/m^3$ and the 8-hour levels are predicted to range between 4551 and 5041 $ug/m^3$. Including the combined contributions from aircraft and motor vehicles, those levels are within the one and 8-hour AQOs for this pollutant.

*Table 17.7*
*"Worst Case" One and 24-Hour $NO_2$ Concentrations in the Terminal Area ($ug/m^3$)*

| Number | Location | One Hour Average | 24-Hour Average |
|---|---|---|---|
| T1 | W. Terminal, N. End, Upper Level | 152 | 83 |
| T2 | W. Terminal, N. End, Lower Level | 152 | 80 |
| T3 | E. Terminal, S. End, Upper Level | 175 | 92 |
| T4 | E. Terminal, S. End, Lower Level | 175 | 86 |
| T5 | N. End of Terminal | 152 | 79 |
| T6 | S. End of Terminal | 175 | 79 |

Notes: Hong Kong Air Quality Objectives:
$NO_2$ = One hour average 300 $ug/m^3$; not to be exceeded more than three times a year.
24-hour average 150 $ug/m^3$; not to be exceeded more than once per year.

*Source: Greiner-Maunsell, 1991*

*Table 17.8*
***'Worst Case' One and 8-Hour CO Concentrations in the Terminal Area (ug/m³)***

| Number | Location | One Hour Average | 8-Hour Average |
|---|---|---|---|
| T1 | W. Terminal, N. End, Upper Level | 5249 | 4551 |
| T2 | W. Terminal, N. End, Lower Level | 5249 | 4551 |
| T3 | E. Terminal, S. End, Upper Level | 6033 | 5041 |
| T4 | E. Terminal, S. End, Lower Level | 5519 | 4775 |
| T5 | N. End of Terminal | 5249 | 4551 |
| T6 | S. End of Terminal | 5366 | 4667 |

Notes: Hong Kong Air Quality Objectives:
CO = One hour average 30,000 $ug/m^3$; not to be exceeded more than three times a year.
8-hour average 10,000 $ug/m^3$; not to be exceeded more than once per year.

*Source: Greiner-Maunsell, 1991*

## 17.4 Other Issues

Other potential air quality issues associated with the airport that were not addressed quantitatively in the emissions inventories or dispersion models include health effects, effects on vegetation, visible emissions, odor and fuel dumping.

### 17.4.1 Health Effects

Several of the air pollutants associated with the operation of the airport are known to cause adverse health effects in humans. The effect would depend, in part, on the type and concentration of pollutant, the sensitivity of the individual, and the exposure period. AQOs, discussed previsouly in Section 3.2, were developed taking into account the health effects of these pollutants on humans, including the most sensitive. Therefore, compliance with these goals should result in minimising the potential adverse effects on health.

### 17.4.2 Effects on Vegetation

Similar to the potential impacts on health, the effects of airport-related emissions on vegetation will depend on the pollutant, the plant and the exposure period. Meteorological conditions also play important roles. Compliance with the AQOs on the airport, in combination with the fact that most air emissions will be blown out to sea, will assure that the airport's contribution alone will not impact vegetation on North Lantau. However, in order to realistically evaluate the impact on vegetation, it will be necessary to estimate total pollutant concentrations, including contributions from the New Town, NLE, power plants, etc.

### 17.4.3 Visible Emissions

Water vapour is one of the primary components of jet aircraft exhaust. In some cases, this vapour is visible as a white cloud or as vapor trails coming from the ends of aircraft wings. This vapour is the condensation of atmospheric water droplets and is not considered as an air pollutant.

During takeoff and dimbout, aircraft exhaust contains relatively large particles of partially burned and unburnded hydrocarbons that, combined with exhaust gasses containing nitrogen dioxide, is visible as a dark plume. Except for the areas near the runway ends, aircraft altitude significantly reduces the ground level impact of these emissions through evaporation and dilution.

### 17.4.4 Odour

Kerosene-like odours may arise from the exhaust of aircraft and motor vehicles, aircraft maintenance facilities and fuel storage facilities. The detection of odours is somewhat subjective and is greatly influenced by local meteorological conditions and the sensitivity of the receptors. Under prevailing wind conditions, most odour producing components will be transported out to sea.

### 17.4.5 Fuel Dumping

Fuel dumping by airborned aircraft is only permitted under emergency landing conditions in order to reduce the weight of the aircraft and the potential for fire during impact. Under these circumstances, the aircraft would release the fuel at altitude and over water, thereby minimising the impact to land-based receptors.

## 17.5 Mitigation Measures

The generation of air emissions during routine airport operations is unavoidable. Aircraft, ground support equipment and motor vehicles will give rise to exhaust gases, some of which are considered air pollutants; fuel storage and transfer facilities are potential sources of evaporative hydrocarbons; and the wide array of airport support operations including maintenance and repair hangars, catering services and the fire training facility will produce emissions characteristic of those operations.

The primary legislative means for reducing the potential impact of these emission sources, with the exception of aircraft, is to require consistency with the APCO and compliance with the AQOs.

The emission inventory results indicate that aircraft and motor vehicles represent the two largest sources of air emissions at the airport. The PAL dispersion model results show that the greatest potential impacts will be limited to receptors located along the north-central coastline of Lantau Island. The results of the terminal area dispersion analysis reveal that aircraft and motor vehicle emissions are expected to substantially increase $NO_2$ and CO levels in the vicinity of the terminal.

Based on these findings, a variety of air pollution mitigation measures that are inherent to the new airport have been identified. These mitigation measures, pertaining to the location and layout, terminal area design, access and egress, and individual support facilities, are briefly discussed.

### 17.5.1 Location and Layout

Airport location and layout play important roles in the generation and dispersal of air emissions. Ground-based circulation patterns, travel distance and delay periods are directly related to the generation of both aircraft and motor vehicle emissions. The location of airport-related sources of air emissions with respect to each other and the prevailing wind patterns factor in the distribution and concentration of air pollutants. For example, the following design and layout features of the airport will help mitigate potential air quality impacts:

- Persistent land-sea breeze, prevailing easterly winds and infrequency of atmospheric inversions improve the natural dispersal characteristics of the airport site and will help transport air emissions out to sea.

- Adequate runway/taxiway operating capacities reduce aircraft delay periods and excess emissions.

- Remote location of airport site, away from heavily urbanised Kowloon and Hong Kong Island, minimises overall potential air quality impact to off-site receptors and helps reduce build-up of air emissions in combination with other sources.

- East-west runway alignments direct aircraft take-off, climb-out, approach and landing over water and thereby minimise potential impact of aircraft exhaust fallout on Lantau Island.

- Centralized midfield terminal locations minimise aircraft taxiing distances and thus reduce excess ground-based emissions.

- Midfield taxiways minimise crossfield taxiing distances and reduce excess aircraft emissions.

- Runway separation and balanced runway utilisation evenly distribute aircraft landing and take-off emissions, thus improving dispersion.

- West end locations of aircraft maintenance areas and the fire training facility, downwind from east-to-west prevailing winds, minimise both on-site and off-site impacts.

- Segregation of air emission sources including runways/taxiways, terminal complex, air cargo, aircraft maintenance and fuel farms helps prevent build-up of air emissions and improves dispersion.

- Southeastern location of main terminal complex, cargo village, and air cargo facilities on airport site minimise on-site vehicle distance travelled and reduced excess motor vehicle emissions.

### 17.5.2 Terminal Area Location and Design

Terminal area location partially determines the amount of emissions generated by taxiing aircraft and motor vehicles. The efficiency by which aircraft and motor vehicles access the terminal area is also directly related to excess emissions associated with gate delay periods and roadway congestion. The following aspects of the terminal area will help minimize the impact of air emissions.

- Location of main terminal complex close to eastern airport boundary maximises natural ventilation benefits of land-sea breeze.

- Segregated airside/landside main terminal complex configuration reduces co-mixing of aircraft and motor vehicle emissions.

### 17.5.3 Access/Egress

Motor vehicles travelling to, from and circulating about the airport site are a significant source of emissions. These emissions will be reduced through the following measures:

- Limited access, high speed access/egress roadways permit optimal motor vehicle operating conditions, minimise stop-and-go driving and reduce emissions.

- Segregated road, rail and ferry, and pedestrian access corridors in the main terminal area eliminates conflicts with motor vehicles and helps reduce excess motor vehicle emissions.

- Rail and ferry service to airport site reduce dependence on motor vehicles.

## 17.6 Monitoring and Audit

The analysis of potential air quality impacts has indicated that all AQOs will be met within the airport boundaries even under "worst case" meteorological conditions. Substantially elevated $NO_2$ levels are projected for the receptors along the shore of Sha Lo Wan, under "worst case" meteorological conditions, as a result of airport operations in the year 2040. If the recommendation to relocate residents in this area within the next two years is accepted and implemented, then no air quality monitoring should be required of the PAA.

During the periodic updating of the Master Plan a re-evaluation of the air quality impact assessment should also be made. If AQOs are projected to be approached or exceeded, primarily as a result of airport operations in the following five years, then a monitoring and audit programme should be implemented.

A permanent air quality monitoring station should be established by Government on North Lantau to monitor the combined impact of the North Lantau Expressway (NLE), New Town, airport and power plants on air quality in this area.

## 18.1 Assessment Methodology

The new airport reclamations were included in the North West New Territories two-layer mathematical models of wet and dry season tidal flows and sediment transport. These models form part of the WAHMO suite of models run by the Hong Kong Government and were used to simulate the tidal flows and siltation patterns which would follow construction of the airport reclamation. By comparing these simulations with those for existing conditions, it was possible to assess the impact the reclamations would have on flow patterns and siltation rates.

## 18.2 Hydraulic Impacts

The model tidal flow simulations were assessed in detail and it was found that:

(1) The proposed airport reclamations lie in an area of weak tidal flows and they would have little impact on large scale water movements, siltation patterns and water quality. Some local velocities around the reclamations, however, could increase to the extent that local erosion of the sea bed would occur. To the west of the reclamation and in East Tung Chung Bay, tidal water speeds would decrease and it was anticipated that siltation could occur.

(2) Tidal flows in the open channel between the airport reclamations and Lantau Island would be strong enough to prevent siltation and would be important in maintaining some flushing of East Tung Chung Bay. The tidal excursions in the channel would exceed the length of the channel and it is unlikely that water quality problems would arise assuming no direct discharges of effluent to the channel.

The changes to the local tidal flow patterns were in general small in themselves and, apart perhaps from the increased speeds around the northeast corner of the airport, would have little impact on vessel movements.

### 18.2.1 Siltation

Because of the relatively low tidal flows in the area of the reclamation, marine sediments have been deposited over a long period and, at present, water depths are relatively shallow and the bed is probably stable in the long term. The reclamation lies just to the south of the Chek Lap Kok Bank, which is a naturally shallow area susceptible to deposition of mud from suspension; this bank is also thought to be stable in the long term.

The WAHMO model of sediment transport, deposition and erosion was run to simulate existing conditions and those following the airport reclamations. The sediment transport model was run to simulate sedimentation processes for both tidal currents alone and under the action of tidal currents and wave disturbance.

Wet and dry season spring and neap conditions were simulated and it was found that, for existing conditions, without wave action, the area around Chek Lap Kok and the Chek Lap Kok Bank were subject to a low rate of net deposition of sediment from suspension.

With wave action, erosion rates from these relatively shallow areas were large with correspondingly larger deposition rates in some neighbouring shallow areas. Under wave disturbance, the areas susceptible to erosion and deposition depended on the particular wave direction simulated in relation to the local coastline and bathymetry.

However, it is thought that in the long term, existing sea bed levels are in a state of dynamic equilibrium. Long term steady rates of low net deposition in shallow areas are periodically interrupted by short term erosion under storm wave conditions and, depending on wave direction, the sea bed levels adjust locally. To within relatively small limits, however, sea bed levels over the larger area are thought to be stable at present.

The airport reclamation will change tidal flows locally and modify the local wave climate and both these changes could affect local siltation patterns and long term bed stability. The impact of the airport would be limited to within 3km of the reclamation, however the main operational impact would be the predicted siltation in the area to the west of the reclamation where water velocities were predicted to reduce. While this did not suggest an ultimate stable bed level, it is possible that this area will silt up to result in bed levels at least comparable to those immediately to the west of Chek Lap Kok at present. It was calculated that if siltation continued at the predicted rate, navigation could become a problem in 10-20 years depending on the type of vessel required to use these waters. Access may be required for marine rescue and fire fighting vessels.

If in the future, bed levels west of the airport rise and it is found necessary to dredge navigation channels, maintenance dredging could be a problem periodically. It was calculated that this whole area would experience siltation rates equivalent to 300mm per year. Siltatin rates in a navigation channel dredged through this predicted future shallow area, however, would be much higher. The whole area will be subject to deposition but, once neighbouring bed levels have reached a long term stable level, much of the sediment which might have deposited over the larger area will remain relatively mobile. Under the action of tidal currents and weak wave action, some of the newly deposited sediment will be reworked and will tend to settle in deeper areas such as artificially created navigation channels where tidal water velocities will be low. Low velocities in the navigation channel will also mean that, whereas deposition may only occur in the neighbouring areas for part of the tidal cycle, deposition could proceed virtually unhindered throughout the tidal cycle in the navigation channel. Under periodic storm wave conditions, bed mud in shallow areas can experience very rapid erosion forming fluid mud layers and very rapid siltation of any navigation channel could occur. In the absence of storm conditions, siltation rates of the order of several metres per year would not be unexpected and following storm conditions, the navigation channel could suffer several metres siltation in one event.

The WAHMO models also predicted some areas of net erosion. Unlike the predicted deposition zones, the areas predicted to experience erosion in future were restricted to the immediate vicinity of the seawalls. The erosion was caused by local accelerations in the flows and the resultant local scour may have implications on seawall design to ensure stability.

## 18.3 Mitigation Measures

The main operational consideration will be the predicted siltation to the west of the airport reclamation and the possible need to maintain navigable water depths at some time in the future. As previously discussed, it is thought that the bed levels at present are in a state of dynamic equilibrium maintained by long term steady deposition and periodic erosion during storm wave conditions. For this to be the case, the surface bed sediments must remain relatively mobile and unconsolidated and this has been found to be the case from field observations of surface bed mud densities.

Should bed levels to the west of the airport reclamation rise as predicted by the models, maintenance dredging for a navigation channel could become a problem and a navigation channel could become unusable after a storm. If it is essential to have access at all times, one way of preventing such siltation would be to dredge the whole shallow area rather than just a channel through what is predicted to become a naturally shallow area. This will increase maintenance dredging costs and volumes but would prevent the sudden loss of any navigation channel following a storm.

## 19.1 Assessment Methodology

During operation of the airport, the two main factors with potential to affect water quality will be the discharge of foul sewage and stormwater. The sources, pollutant loads, treatment and disposal of foul sewage and stormwater arising from the new airport are described in the following sections.

### 19.1.1 Foul Sewage Loads

The main sources of foul sewage at the airport have been identified and loads of the following parameters estimated: suspended solids (SS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total kjeldahl nitrogen (TKN), ammonia-nitrogen ($NH_3$-N), total toxic metals (TTM) and coliforms. The estimates have been made using per-capita load factors from the *Sewage Strategy Study* (SSS) combined with the appropriate forecasts for airport populations from the New Airport Master Plan.

Pollutant loads were estimated for the design years 2010 and 2040 using load factors from the SSS for the years 2011 and 2021 (which show little variation) respectively. Reductions in the load factors have been made in some instances to reflect the differences between typical domestic sewage and that generated at an airport. The estimates of total pollutant loads from foul sewage at the airport are presented in Tables 19.1 and 19.2.

The main sources of foul sewage at the airport will include:

- Terminal/Building/Airside
- Aircraft Catering
- Maintenance Hangars
- Aircraft Washing
- Vehicle Washing
- Aircraft Discharge
- Hotel
- Fire Training Facility
- Refuse Transfer Station
- Airport Related Activities.

*Terminal/Building/Airside*

Discharges from the airside will include sewage from the transient airport population (passengers and escorts) at the terminal and from the permanent employed population at the airport. The effluent loads for the transient population at the terminal will exclude contributions from typical "grey-water" activities, such as laundry and cleaning, and some of the pollutant loads have been reduced accordingly. The employed population includes passenger-related, cargo-related, airport maintenance and aviation industry employees (as defined in the Final First Interim Report - Civil Engineering) but does not include aircraft maintenance and catering employees which have been considered separately. The population employed in airport-related areas has also been considered separately.

*Table 19.1 Estimates of Sewage Loads from the Airport for the Year 2010*

| Source | SS (kg/d) | BOD (kg/d) | COD (kg/d) | TKN (kg/d) | $NH_3$-N (kg/d) | TTM (kg/d) | Coliforms (No./d) |
|---|---|---|---|---|---|---|---|
| 1. Terminal/Building/Airside* | 1221 | 1240 | 2587 | 246 | 146 | 6 | 1.7 x 10 |
| 2. Aircraft Catering | | | | | | | |
| Trade effluent+ | 503 | 503 | 1260 | 126 | - | 2 | - |
| Sewage | 119 | 119 | 245 | 23 | 14 | 1 | 1.2 x 10 |
| 3. Maintenance | | | | | | | |
| Shops and hangars trade effluent+ | 135 | 135 | 330 | - | - | 1 | 0 |
| Aircraft washwater | - | 111 | 282 | - | - | 2 | 0 |
| Sewage | 233 | 233 | 479 | 46 | 27 | 1 | 2.4 x 10 |
| 4. Aircraft Discharge | 489 | 513 | 1100 | 104 | 61 | 2 | 1.1 x 10 |
| 5. Hotel (400 rooms) | 38 | 50 | 101 | 7 | 4 | 0 | 3.0 x 10 |
| 6. Refuse Transfer Station+ | 30 | 30 | 75 | 6 | - | 0 | - |
| Total (Airport) | 2768 | 2934 | 6459 | 558 | 252 | 15 | 2.1 x 10 |
| Airport Related | 2549 | 3758 | 7474 | 397 | 207 | 13 | 1.5 x 10 |

*Table 19.2 Estimates of Sewage Loads from the Airport for the Year 2040*

| Source | SS (kg/d) | BOD (kg/d) | COD (kg/d) | TKN (kg/d) | $NH_3$-N (kg/d) | TTM (kg/d) | Coliforms (No./d) |
|---|---|---|---|---|---|---|---|
| 1. Terminal/Building/Airside* | 2117 | 2154 | 4500 | 429 | 255 | 10 | 3.0 x 10 |
| 2. Aircraft Catering | | | | | | | |
| Trade effluent+ | 1024 | 1024 | 2560 | 128 | - | 2 | - |
| Sewage | 238 | 238 | 490 | 47 | 28 | 1 | 2.5 x 10 |
| 3. Maintenance | | | | | | | |
| Shops and hangars trade effluent+ | 162 | 162 | 396 | - | - | 1 | 0 |
| Aircraft washwater | - | 196 | 497 | - | - | 4 | 0 |
| Sewage | 375 | 375 | 772 | 74 | 44 | 2 | 3.9 x 10 |
| 4. Aircraft Discharge | 953 | 1000 | 2143 | 202 | 119 | 5 | 2.0 x 10 |
| 5. Hotel (800 rooms) | 77 | 100 | 202 | 13 | 7 | 0 | 5.9 x 10 |
| 6. Refuse Transfer Station+ | 30 | 30 | 75 | 6 | - | 0 | - |
| Total (Airport) | 4976 | 5279 | 11635 | 899 | 453 | 25 | 3.7 x 10 |
| Airport Related | 2549 | 3758 | 7474 | 397 | 207 | 13 | 1.5 x 10 |

* Loads include sewage from a transient airport population and permanent employed population (excluding loads from catering and maintenance employees which are itemised in (2) and (3)).

\+ After pretreatment to achieve limits set by the *Technical Memorandum on Effluent Standards* (TMES).

*Source: Greiner-Maunsell, 1991*

*Aircraft Catering*

The large in-flight catering operations will give rise to a commercial effluent resulting from preparation of the meals and rinsing the meal-trays collected from the aircraft.

The major in-flight catering contractor (with over 80 percent of the total market-share) currently disposes of the food waste from the aircraft using a wet-water system, which produces a heavy wet waste requiring disposal. However, the smaller catering contractor uses a strip-bin system in which much of the left-over food is flushed away. The system adopted at the new airport will thus have a large bearing on the relative quantities of solid waste or effluent produced. For the purposes of this study it has been assumed that the current wet-water system will be adopted.

The effluent from catering operations may be expected to be similar in composition to that of a typical food industry waste, though not necessarily similar in terms of pollution loads due to the unique nature of airport catering operations. The effluent will have a high load of BOD, COD and SS, together with a significant load of oil and grease.

It is possible that part or all of the catering operations wastewater will be pretreated and used for irrigation of grassed and landscaped areas. Pretreatment requirements are discussed in Section 19.3.1.

*Maintenance Hangars*

A number of maintenance activities will generate trade effluents which will be discharged to foul sewer. These include plating shops and general maintenance workshops.

At the plating workshop chromium plating, anodising, chromating on magnesium alloy, cadmium plating and metal stripping are conducted. The liquid and slurry wastes arising from these operations classify as hazardous wastes and are currently exported for treatment. Waste sulphuric acid is currently neutralised on-site. The plating rinsewaters are discharged to foul sewer and will contain low but significant concentrations of toxic metals including chromium, cadmium, zinc, aluminium and nickel.

At the engine overhaul cleaning section the engines are cleaned and stripped using detergents and kerosene, followed by plasma stripping with acids, further cleaning with alkali and neutralisation with chromic acid. The rinsewaters from these operations, containing residues of detergent and metal acid wastes, are discharged to foul sewer.

Aircraft appearance work, currently carried out inside one of the hangars at Kai Tak, involves paintstripping and repainting. The paintstripper, containing dichloromethane and phenol, is applied to the aircraft and removed with rags. The mixture of paintstripper and paint flakes with rags is collected on cardboard placed under the aircraft and disposed as solid waste. The paintstrippers are acid-based and provide adequate preparation for re-painting so that no further treatment is required. After the stripping process the aircraft are thoroughly hosed down with water and then repainted.

The chemicals used for the different maintenance operations are presented in Table 19.3. They include paintstrippers, acids, commercial cleaners, kerosene and metal-plating solutions. Pretreatment requirements for discharge of maintenance effluents to foul sewer are discussed in Section 19.3.1.

*Aircraft Washing*

The term "aircraft washing" can describe anything ranging from a cosmetic wash of particular areas of the aircraft to a full scale wash. Aircraft wash procedures and facilities vary enormously between different airports and even between different airlines at the same airport. One airline at Heathrow airport has a specially-designed dedicated hangar with drainage to the foul sewer, whilst JAL in Tokyo have not only built a designated hangar but have designed and implemented a giant automated brush-roller system for washing aircraft.

The wide variation in aircraft washing procedures accounts for the correspondingly wide range of detergent and water consumption rates. Experience from UK airports indicates that water usage can range from [illegible],000-16,000 litres per aircraft (all sizes) whilst detergent usage may range from 0.5 litre for a small plane washed manually to 200 litres for a cosmetic wash of a large aircraft (B747). In addition washwater volumes and chemical usage for the different types of washes and aircraft is strongly dependent on the condition of the aircraft. Labour intensive methods for aircraft washing tend to employ far less water and detergent than, for example, using high pressure jets to remove detergent.

Washwater volumes are not metered at Kai Tak therefore assessment of the amount of contaminated water is difficult. It is estimated that approximately 22,500 litres of washwater are used per plane, with three to four bowsers of 1,000 gallon (4,500 l) volume used for spraying the upper parts of the plane and one used for manual washing of the underside. Although the total volume per wash may be high, the intermittent nature of the operation, with an average 1.3 planes currently washed per day, means that the volume of runoff from the aircraft standing area is fairly low at approximately $30m^3/d$.

At Kai Tak approximately 500 aircraft are currently washed per year using two aviation detergents Cee Bee 280 and CH 511C. There are generally two kinds of detergents; cosmetic shampoos and heavier formulations containing aromatic compounds for removing heavy grease and carbon deposits. Cee Bee 280 is a biodegradable shampoo with a pH of about 12 and no flash point. CH 511C is a highly concentrated compound of pH 13 which is 80 percent biodegradable and is used for extra heavy-duty cleaning. It is assumed that similar detergents will be used at the new airport.

All aircraft washing at Kai Tak is currently conducted on maintenance aprons in front of the hangars, with the washwater discharged to the stormwater system. At the new airport, however, aircraft washwater will be diverted to the foul sewer. The preferred solution is for washing to be carried out under cover in hangars, as outlined in the Second Interim Report - Civil Engineering. However, current airport layout plans show aircraft washing facilities located on open stands inside the maintenance areas positioned between the two runways. Preliminary designs for the aircraft washing facility provide a dedicated discharge to the foul sewerage system with automatic diversion to the storm drainage system in the event of a storm. This is discussed further in Section 19.3.

*Table 19.3 Chemicals Used during Maintenance Operations at Kai Tak*

| Operation | Process | Chemicals | Main Component |
|---|---|---|---|
| Plating Shop | 1. Chromium Plating | Chromic Acid<br>Sulphuric Acid | |
| | 2. Anodising | Sulphuric Acid | |
| | 3. Chromating on Magnesium Alloy | Ammonium Sulphate<br>Magnesium Sulphate<br>Potassium Dichromate<br>Ammonium Dichromate | |
| | 4. Cadmium Plating | Sodium Cyanide<br>Cadmium Oxide | |
| | 5. Metal Stripping | Sodium Cyanide<br>M-nitrobenzene Sulphonic Acid | |
| Engine Overhaul Cleaning Section | 1. Cleaning | Cee Bee J84A<br>Cee Bee J88<br><br>Cee Bee A214<br>Cee Bee 280<br>Ardrox 29<br>Ardrox BC-70<br>Ardrox 1871<br>Ardrox 2303<br>Kerosene<br>Dewatering Fluid | Sodium Hydroxide<br>Sodium Hydroxide, Potassium Permanganate<br>Dicholoromethane<br>Surfactants, Glycol |
| | 2. Plasma Stripping | Nitric Acid<br>Ferric Chloride Solution<br>Caustic Soda<br>Chromic Acid | |
| | 3. Paint Stripping | | |
| Aircraft Appearance | 1. Paintwork | MEK (Methylethylketone) | |
| | 2. Paint Stripping | CH8903<br>Cee Bee A202<br>Turco S351 | |
| Aircraft Washing | Washing | Cee Bee 280<br>CH511C | Surfactants, Glycol<br>Surfactants, Glycol |
| General Solvents | Cleaning, Degreasing | 1-1-1-trichloroethane<br>Trichloroethene<br>Perchloroethene<br>Paint Thinners<br>Acetone | |

*Source: Greiner-Maunsell, 1991*

### *Vehicle Washing*

The number of ground vehicles at the airport will be considerably greater than the number of aircraft. At one UK airport nearly 11,000 vehicles are washed every year, a process which consumes 17,000 litres of detergent. Vehicle washing services are required by a number of airport operations including baggage transport, catering, freight forwarders, fire services and car hire firms. Currently vehicles are washed manually at Kai Tak using detergents and a portable high pressure washer.

### *Aircraft Discharge*

Aircraft discharge refers to the toilet wastes removed from the aircraft by toilet trucks or "honey-wagons" and discharged via specially designed chambers to the gravity foul sewerage system. The toilet wastes will have a high solids concentration due to the limited flushing water available on the aircraft. Since this effluent is almost entirely "black-water", the loads of certain parameters have been reduced to account for the lack of "grey-water" contribution. Disinfection on board the aircraft has also been assumed to reduce the bacterial load by two orders of magnitude.

### *Hotel*

An airport hotel will give rise to a typical commerical effluent from associated catering and laundry facilities as well as domestic sewage from the hotel guests and employees.

### *Fire Training Facility*

In accordance with international aviation requirements a fire training facility or burn pit is provided for on-site training of all fire crews. Design of the facility has been detailed in the Final Report - Civil Engineering. It consists of a large open pit which is partially filled with water and fuel floated on the water's surface. Large aircraft fires are simulated using a fuel/water mix and extinguished as quickly as possible using a mixture of Aqueous Film Forming Foam (AFFF). The quantity of AFFF currently used during fire training is approximately 450 litres per month. After the exercise, unburned fuel is skimmed off the water via an overflow drain, separated in a fuel/water separator and stored in a fuel storage tank for reuse. The water is stored in a separate tank and used to refill the pit at the next exercise. Excess water from the burn pit will have an elevated BOD due to residual foam and traces of fuel, and will be discharged to foul sewer.

### *Refuse Transfer Station*

The conceptual design for solid waste disposal as discussed in Section 22 is for wastes from the secured airside to be collected by small collection vehicles and delivered to the airport Refuse Transfer Station (RTS). The proposed site for the RTS is adjacent to the catering facility, where much of the airport solid waste is generated, to minimise transportation. The airport RTS will comprise on-site static compactors and will be fully enclosed. The RTS will generate high strength liquor from the tipping and compaction of wastes, washdown water from the tipping hall, and vehicle washwaters from the refuse collection vehicle washdown facility. These wastewaters will be treated in a dedicated treatment plant and the treated effluent discharged to foul sewer.

*Airport Related Activities*

Airport-related activities refer to the areas designated as cargo village and business park, and may also include carparking and government offices. It has been assumed that any heavy airport-related industry such as manufacturing will be located at the industrial park on North Lantau and the areas within the airport boundary will be predominantly commercial industries, such as component assembly, packaging or import/export firms. Domestic sewage arising from the employed population for the area was estimated using the gross site area and plot ratio, multiplied by a factor for worker density typical of a business park development. Trade effluents are not anticipated, but the discharge of any industrial wastewaters generated by airport related activities would be required to comply with the *Technical Memorandum on Effluent Standards* (TMES) and would be expected to be discharged to foul sewer.

### 19.1.2 Storm Water Contamination

Stormwater runoff from much of the airport area will be free from pollutants, but there are a number of airport operations which could contribute to stormwater contamination, such as spillages of aviation fuel or the uncontrolled discharge of aircraft washwaters. Stormwater runoff from paved areas of the airport will be similar in nature to typical urban or highway runoff, which can contain organic material; solids; petroleum hydrocarbons from fuel/oil, tyres and bitumen; specific hydrocarbons such as Polyaromatic Hydrocarbons (PAHs); and heavy metals from lubricants, exhaust emissions and tyre degradation. In general, petroleum hydrocarbon residues are likely to be lower in airport runoff than road runoff due to the higher engineering standards and maintenance specifications for airport vehicles.

Potential contamination of stormwater runoff could arise from:

- Aircraft and Vehicle Washing
- Aircraft and Vehicle Maintenance
- Oil and Fuel Spillage
- Fire Fighting
- Chemical Spillage
- Horticulture
- Cooling Water Discharges.

*Aircraft and Vehicle Washing*

Both aircraft and vehicle washwater at Kai Tak are presently discharged to the stormwater system. However, a dedicated aircraft washing area is proposed for the new airport, with discharge to foul sewer. Similarly, a centralised vehicle washing facility is recommended with discharge to foul sewer. These are described in detail in Section 19.3.2.

*Aircraft and Vehicle Maintenance*

The main operations and chemicals used in the aircraft maintenance hangars and at the workshops were discussed in Section 19.1.2. Since all maintenance operations will be designed to be conducted inside the hangars and workshops there should be no potential contamination of stormwater. However, periodic audits may be necessary to ensure that all maintenance activities, for both aircraft and airport vehicles, are restricted to designated areas.

*Oil and Fuel Spillage*

Large quantities of fuel and oil will be stored at the new airport, for both aircraft and the various vehicles servicing the airport. Fuel will be brought in by barge and transferred to a centralised fuel farm. This will be split into two units for safety reasons, each with three days fuel supply. Fuel will be supplied to the aircraft from the fuel farms via an in-pavement hydrant system. The various vehicles servicing the airport will also consume significant quantities of fuel and several refuelling points will provide petrol and diesel.

Oil is used extensively at an airport for lubrication and general maintenance. The largest amounts will be used in the heavy maintenance areas in the hangars whilst smaller amounts of oil will also be required for minor maintenance in the workshop areas. Vehicle maintenance areas will also involve the use of significant quantities of oils and lubricants. Minor oil spillages are normally caused by human error or leakage from faulty equipment. Large oil spills are relatively infrequent. Being less volatile than fuel, oil spills tend to persist longer, until cleared up or dispersed into the stormwater drains.

Due to the extensive use of fuel at an airport, occasional spillages are inevitable. Incidents of aviation fuel spillage at Kai Tak over the last 18 months are detailed in Table 19.4. Potential sources include the following:

- Spillage of fuel during offloading of fuel barges via the fuel piers or transfer by pipeline to fuel farms.
- Spillage of aviation fuel during transfer of fuel from fuel farm to hydrants via in-pavement hydrant system.
- Spillage of aviation fuel during refuelling of aircraft.
- Spillage of aviation fuel on the runway during an emergency.
- Spillage of diesel/petrol during vehicle refuelling.
- Spillage or leakage of oil from poorly maintained vehicles or during maintenance.
- Leakage of oil on carparking areas.

The recommended fuel delivery system to the airport will involve the transfer of fuel from barges via a fuel pier located to the north of the airport site. A second fuel pier located further east will also be provided to act as a back-up in cases of emergency. Fuel will be transferred to the fuel farms via pipelines. The supply of fuel from the fuel farms via the in-pavement hydrant system will be controlled by one pumping station. The pipes will be double walled and a leak detection system will monitor the occurrence of any leakage.

*Table 19.4*
*Aviation Fuel Spillage Incidents at Kai Tak Airport for the past 18 Months (February 1990 – July 1991)*

| Date | Contaminated Area (in $m^2$) |
|---|---|
| 08.02.1990 | 9 |
| 14.02.1990 | 4 |
| 09.03.1990 | 25 |
| 16.05.1990 | 4 |
| 11.05.1990 | 25 |
| 29.06.1990 | 375 |
| 05.07.1990 | 15 |
| 15.06.1990 | 6 |
| 08.07.1990 | 150 |
| 13.08.1990 | 10 |
| 01.08.1990 | 900 |
| 15.09.1990 | 40 |
| 09.11.1990 | 12 |
| 06.01.1991 | 60 |
| 23.02.1991 | 4 |
| 23.02.1991 | Seeping |
| 06.04.1991 | 0.25 |
| 19.04.1991 | 25 |
| 29.04.1991 | 500 |
| 29.04.1991 | 3 |
| 05.07.1991 | 6 |
| 08.07.1991 | 6 |
| 24.07.1991 | 50 |
| 24.07.1991 | 9 |
| 26.07.1991 | 25 |
| Total | 2263.25 |

*Source: Greiner–Maunsell, 1991*

Spillage of aviation fuel during refuelling of aircraft is a more likely occurrence. In one study at a UK airport, it was found that over 50 percent of aviation fuel spillage events were due to poorly maintained shut-off valves on the aircraft. The next highest cause of spillage was faulty tankers. Although the number of incidents involving aviation fuel spillage may be low, the potential for large losses are high due to the large quantities handled. A hydrant refuelling system, operating at about 170 psi can dispense 135,000 litres of fuel to a Boeing 747 at a rate of 8000 l/min. Lower rates of fuel transfer are achieved using tankers but throughput is still high and even minor errors or failures can cause significant and potentially numerous spillages. Although the occurrence of large accidental spillages may be rare, experience from other airports would suggest that smaller losses .(up to 100 litres) occur on a not infrequent basis.

The frequency of spillage of aviation fuel on the runway during an emergency situation is difficult to predict but may involve large quantities of fuel. Due to safety concerns any fuel spillage must be rapidly dispersed. This usually involves the use of a chemical dispersant, in quantities of similar proportion to the size of the fuel spillage.

Spillage of petrol or diesel during vehicle refuelling should be no greater than at regular petrol stations and measures to prevent stormwater contamination should therefore be similar.

Further sources of pollution include site runoff from large carparking areas. The Buildings Ordinance (Cap. 123) Regulations specify oil interception for runoff discharged to drains or sewers from carparks associated with buildings. In the UK, interception is normally required for carparks with 30 carspaces or $500m^2$, whichever is the greater.

*Fire Fighting*

In the event of an emergency or accident, fire fighting operations on either the airside or landside could contaminate stormwater runoff with foam or dispersant chemicals. The main fuel dispersant used at Kai Tak is Shell Dispersant VDC, which is a blend of emulsifying agents in a glycol ether solvent. It is reported to be biodegradable and of low toxicity and is licensed for use by the UK Ministry of Agriculture Fisheries and Food. A synthetic firefighting foam concentrate "Light Water AFFF" is used for flammable liquid spills. Light Water AFFF is biodegradable, of low toxicity and can be treated in biological sewage treatment systems. Observed use of the foam is reported to show no adverse effects on aquatic life.

*Chemical Spillage*

A number of chemicals are likely to be used at the airport in addition to those used at the aircraft maintenance facility. Types of chemicals observed in use at UK airports include paint, primer, drain cleaners, battery cleaners, heavy duty cleaners, methylated spirits, organic solvents, thinners, bleach, disinfectant, degreasers, lubrication oil, creosote, brake fluids, battery acid, soldering fluid, herbicides and insecticides. Many of these are used in only small quantities but at various locations. Although large spillages may be rare, the cumulative effect of a large number of small isolated incidents, through accidents, carelessness or deliberate discharge, e.g. pouring waste chemicals down drains, may be significant.

*Horticulture*

Several pesticides are employed at Kai Tak. Two contact herbicides are used to control weed growth on the runway, a paraquat-containing foliage application and a soil application containing glyphosate together with a contact insecticide containing carbaryl. No data are available for the quantities of pesticides currently used at Kai Tak. Typical rates of application for agricultural pesticides range from 0.2-5kg/ha/y of active ingredient, however much higher rates of application are common for total defoliation, as applied to airfields. Although the formulations used are of relative low toxicity there still is potential for polluting adjacent areas. The degree of pollution will depend on the application rates, methods and weather conditions.

As grassed areas at the new airport will be established on new reclamation, and during phased construction large areas will be hydroseeded to reduce dust generation, it is likely that fertiliser application will be required. This has the potential to increase nitrate and phosphate concentrations in runoff.

*Cooling Water Discharges*

Cooling water supply will be via three seawater intakes at the northeast corner of the reclamation, on the northern seawall and in the sea channel. Preliminary estimates indicate a demand of 661,000$m^3$/d. After use, cooling water will be discharged via a number of outfalls. Initial plans show seven outfalls, with one discharging to the south into the sea channel. Cooling water from this outfall will be discharged at a rate of 600 l/s, which is equivalent to 0.3 percent of the daily flushing volume of the sea channel. Providing the discharge complies with the TMES, the flow can provide an additional source of flushing water to the sea channel.

## 19.2 Water Quality Impacts

### 19.2.1 Foul Sewage

Foul sewage from the airport will be treated at the sewage treatment works which is to be constructed at Siu Ho Wan to serve the New Town developments. This will initially provide preliminary treatment only, but may subsequently be upgraded to secondary biological treatment with nitrogen removal and effluent disinfection. The impacts of combined airport/new town sewage discharge through long outfalls sited near The Brothers have been determined by mathematical modelling and reported as part of the North Lantau Development Study in *Topic Report No.10 Environmental Assessment* (NLDS TR10). The modelling showed that some deterioration of water quality would be expected in East Tung Chung Bay as a result of the foul sewage discharge, particularly during the wet season.

The discharge of polluting loads to the foul sewer has a potential impact in terms of the effects of the discharge on the efficacy of the sewage treatment process and the effects of the discharge of the final effluent on the aquatic environment. In relation to the first impact, discharges made to foul sewer on the airport site will be required to comply with the TMES, which specifies acceptable effluent concentrations for various flow rates for discharge to either biological or non-biological sewage treatment facilities. Many of the discharges to foul sewer from the airport will be classified as domestic sewage and will not require a licence to discharge. Several discharges, however, such as the aircraft and vehicle washwaters, the discharges from the maintenance workshops and hangars, and the catering effluent, will classify as trade effluents and will need a licence to discharge, and possibly pre-treatment to ve compliance with the TMES. This will ensure the sewage treatment works does not eive shock loadings of pollutants nor effluents containing substances such as heavy etals or certain organics which can inhibit the aerobic biological sewage treatment process.

The discharge from certain of the maintenance operations, particularly electroplating and paint stripping operations, may be expected to contain high concentrations of heavy metals. These can have toxic effects on the secondary biological treatment process, especially if the effluent is nitrified, since the nitrifying bacteria are particularly sensitive.

Effluents with a potentially high oxygen demand include the aircraft and vehicle wash waters, discharge from the fire training pit and the catering operations effluent. The washwaters will contain all the residues from the washing procedures including detergents, oil, grease and solids. Detergent formulations contain organic compounds, such as glycols and surfactants, which exert a considerable oxygen demand.

The discharge from the in-flight catering operations may also be expected to have an adverse impact on the sewage treatment process due to the high levels of fats, oils and greases. These consist of mainly long chain fatty acids and glycerols whose insoluble nature causes them to form a scum on water unless emulsified by some physical or chemical means. This coating action can cause physical problems in sewerage systems and treatment plants and can also result in clogging of pipes, pumping stations and screens.

### 19.2.2 Contaminated Stormwater Runoff

Short term water quality impacts from contaminated stormwater will arise as a result of its organic load. Longer term, potentially chronic impacts may arise from toxic components such as heavy metals and organic micropollutants. The impacts of these are considered in relation to marine biota in Section 20.

Although assessment of the likely impact of airport stormwater is difficult due to the intermittent/accidental nature of the inputs, an evaluation can be made on the basis of reported stormwater quality for other airports and for general urban runoff, which is likely to be similar in nature.

Typical concentration ranges for pollutants in urban runoff are given in Table 19.5. Concentrations measured in stormwater runoff from two UK airports are also shown for comparison, and can be seen to be similar in quality to urban runoff. The urban runoff data are for European, US and Australian sources and are considered likely by Ellis (1985) to overestimate pollutant concentrations in Asian urban areas. However, they provide guidelines as to potential quality and permit an estimation of the potential impacts of stormwater discharge.

Based on the data in Table 19.5, Ellis (1989) has reported a range of area loading factors for SS, BOD, COD and $NH_4$-N for stormwater runoff as shown in Table 19.6. Unit area loadings reported by others such as Carleton (1990) fall within these ranges. The pollutant loads in stormwater from the total paved area of the airport of 990ha, based on the maximum loading factors above, are also shown in Table 19.6. These have been expressed as a proportion of the total point source (foul) load, and show that although the solids loading is relatively high, the organic and nutrient loadings are low in comparison.

*Table 19.5 Reported Pollutant Concentrations in Stormwater*

| | Marsalek 1990 | Perry 1989 | Carleton 1990 | Ellis 1986, 1989 | | | | | CES Ltd. 1990 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Urban Runoff | Urban Runoff | Urban Runoff | Storm Sewer Runoff | Highway Runoff | Roof Runoff | Comm. Area | Light Ind. Area | Airport Runoff | Airport Runoff |
| BOD (mg/l) | – | – | 47 | 7–22 | 12–32 | 2.8–8.0 | 5–17 | 8–12 | 2–73 | 1–30 |
| COD (mg/l) | – | 36–575 | 132 | 33–365 | 128–171 | 58–80 | 74–160 | 40–70 | 25–408 | 17–87 |
| Suspended Solids (mg/l) | – | < 15–3700 | 141 | 21–582 | 28–1178 | 12–216 | 230–1894 | 45–375 | – | – |
| $NH_4$–N (mg/l) | – | – | – | 0.15–3.6 | 0.02–1.6 | 0.3–3.0 | 0.02–4.0 | 0.15–0.9 | 0.3–6.0 | 0.1–0.6 |
| Oil (mg/l) | – | 6–23 | – | – | – | – | – | – | 0.25–27.8 | 0–33.4 |
| Lead (mg/l) | 0.1460 | 0.1–8.0 | – | 0.03–3.1 | 0.15–2.9 | 0.001–0.03 | 0.1–0.4 | 0.6–1.2 | – | – |
| Zinc (mg/l) | 0.4900 | 0.1–3.4 | – | 0.05–3.68 | – | – | – | – | – | – |
| Cadmium (mg/l) | 0.0015 | < 0.003–0.04 | – | – | – | – | – | – | – | – |
| Copper (mg/l) | 0.0030 | 0.007–0.03 | – | – | – | – | – | – | – | – |
| Chromium (mg/l) | – | 0.002–0.08 | – | – | – | – | – | – | – | – |
| PAH (µg/l) | 6.9500 | – | – | 0.03–0.2 | 0.36–6.0 | – | – | – | – | – |

*Table 19.6 Potential Pollutant Loads in Airport Stormwater*

| | SS | BOD | COD | $NH_4$-N | Pb |
|---|---|---|---|---|---|
| mean and (range) of pollutant loads for stormwater (kg/imp.ha y) | 487 (347–2340) | 59 (35–172) | 358 (22–703) | 1.4 (1–19.5) | 0.83 (0.09–1.91) |
| stormwater pollutant loads from 990ha of impermeable airport area, based on maximum loading factor above (kg/d) | 6350 | 466 | 1906 | 53 | 5.2 |
| proportion of ultimate foul sewage load for airport (%) | 70 | 4 | 8 | 6 | – |

*Source: Greiner-Maunsell, 1991*

In the design for the stormwater drainage system the northern half of the airside area is planned to discharge to open sea off the northern seawall. Runoff from the remaining areas will be discharged to East Tung Chung Bay, to the west of the airport near the mouth of the proposed sea channel, and, in the case of one catchment, directly into the sea channel. It was recommended on water quality grounds that direct discharge into the channel is avoided, but cost considerations make this impractical.

The potential impact of stormwater pollutant loading can be estimated as a "worst case", assuming that all the stormwater from the southern airport areas (four outfalls draining a paved area of 600 ha) were to be discharged into the sea channel. The predicted daily residual discharge from the sea channel has been calculated as 15 $Mm^3$ in Section 6.2.2 (Flushing Channel). Introduction of pollutant loads of 3846 kg/d SS, 283 kg/d BOD, 1156 kg/d COD, 32 kg/d $NH_4$-N and 3 kg/d Pb from the southern parts of the airport into a daily flushing volume of 15$Mm^3$ would result in concentrations of approximately 0.3 mg/l SS, 0.02 mg/l BOD, 0.08 mg/l COD, 0.002 mg/l $NH_4$-N and 0.0002 mg/l Pb.

This does not take into account potential pollution loads from the New Town development at Tung Chung, one of the main stormwater channels from which discharges directly into the channel. No data were given in the NLDS TR10 on potential stormwater loads. On a similar basis to the above and assuming a 75 percent impermeable area, a total New Town area of approximately 400 ha could generate up to 1920 kg/d SS, 140 kg/d BOD, 580 kg/d COD, 20 kg/d $NH_4$-N and 2 kg/d Pb. Cumulative concentrations in the daily flushing volume of the sea channel would be of the order of 0.38 mg/l SS, 0.03 mg/l BOD, 0.12 mg/l COD, 0.003 mg/l $NH_4$-N and 0.0003 mg/l Pb.

These figures assume instantaneous dilution in "clean" seawater; in practice it would be expected that pollutant concentrations would increase until reaching an equilibrium level. Two factors will tend to constrain the equilibrium level. Firstly, WAHMO water quality modelling carried out by EPD and reported in the NLDS TR10, indicates a retention time of approximately one day within the sea channel. In the case of BOD, approximately 30 percent of a five day BOD is exerted within the first day, thus the actual biochemical oxygen demand exerted by stormwater within the channel would be expected to be lower than the total load. Secondly, only a single outfall will discharge directly into the sea channel, while the other outfalls serving the southern part of the airport will discharge to the west and the east. Stormwater will thus be dispersed to an extent and the loads actually entering the channel will be lower than predicted.

The data above assume an even distribution of the stormwater pollutant loading over the year. Taken over a four month wet season the cumulative concentrations from the airport and Tung Chung New Town would be 1.1 mg/l SS, 0.08 mg/l BOD, 0.34 mg/l COD, 0.009 mg/l $NH_4$-N and 0.001 mg/l Pb. The BOD concentration can be compared with background water quality in East Tung Chung Bay, as predicted by WAHMO modelling, taking into account foul sewage from the airport and New Town discharged through a long outfall at The Brothers and discharges from the NWNT. Upper concentrations of 2.5 mg/l BOD were reported for East Tung Chung Bay in NLDS TR10. The BOD concentration resulting from potential stormwater discharges averaged over the wet season is equivalent to three percent of the background concentration.

In Section 7, an assessment was made of the impact of nitrogen loading from dredging on the potential for enhanced phytoplankton growth in East Tung Chung Bay. A nitrogen load of 3767 kg/month, calculated to arise from grab dredging, was found to represent an annual depth average concentration of 0.33 mg/l. This concentration was below the critical threshold region of 0.4-1.0 mg/l for stimulation of enhanced phytoplankton growth and was concluded to be unlikely to stimulate red tides. The cumulative nitrogen load estimated for stormwater from southern catchments on the airport and from Tung Chung New Town is 52 kg/d, which is equivalent to 1560 kg/month. This value is less than half of the dredging-related load and would not therefore be expected to cause enhanced algal growth in East Tung Chung Bay.

From the results of the above, it is considered that the typical organic and nutrient loads likely to be discharged in stormwater from the airport should be within the assimilative capacity of the receiving water body. Loading rates for heavy metals, using lead as an example since it is usually at higher concentration than other metals in urban runoff, are relatively low. Nevertheless, in view of the potential for impacts caused by spillages or accidents and the sensitivity of the receiving water body, it has been strongly recommended that stormwater discharges to the sea channel be minimized to the extent practicable. Although cost considerations have necessitated one catchment discharging to the sea channel, the major potential source of pollution within this catchment, one of the fuel farms, will have a separate drainage system discharging to the west of the reclamation. This will help to ensure that the stormwater runoff discharged to the sea channel will remain unpolluted.

## 19.3 Mitigation Measures

### 19.3.1 Pre-treatment Prior to Discharge to Foul Sewer

Requirements for pre-treatment of the various discharges to foul sewer in order to comply with the TMES are discussed briefly below. The responsibility for pretreatment will rest with the individual tenants and this should be reflected in the lease conditions specified by PAA.

*Catering Effluent*

Predicted concentrations of the effluent from the catering operations are shown in Table 19.7. These exceed the standards for discharge to foul sewer, and will therefore require pre-treatment. It is proposed that part of the treated flow is used for irrigation of grassed and landscaped areas, and for this a higher effluent quality will be required than for discharge to the foul sewer alone. It is presently proposed to remove oil and grease by dissolved air flotation and to treat the effluent to a 20 mg/l BOD, 30 mg/l SS standard in a biological aerated filter, which is a submerged fixed-film reactor with air passed up through the media. The plant is described in the Final Report - Civil Engineering.

Security measures will need to be taken to ensure that the pretreated effluent cannot be mistaken for a potable water supply. Measures which should be considered include artificial colouring of the effluent, use of special plumbing fittings and irrigation only at night time.

*Table 19.7 . Estimated Pollutant Concentrations in Catering Effluent*

| | SS | BOD | COD | TKN | Oil and Grease |
|---|---|---|---|---|---|
| Pollutant Concentration (mg/l) | 2300-2500 | 3200-3400 | 6000-6500 | 160-170 | - |
| Maximum Permissible Concentration in 2010 (mg/l)* | 800 | 800 | 2000 | 200 | 40 |
| Maximum Permissible Concentration in 2040 (mg/l)** | 800 | 800 | 2000 | 100 | 20 |

* For estimated flows of 630m$^3$/d.
** For estimated flows of 1280m$^3$/d.

*Sources: Greiner-Maunsell, 1991 and TMES*

*Maintenance Effluents*

At the metal-plating workshop a number of processes utilise hazardous and highly-toxic substances such as cadmium and chromium. The high specification required for corrosion protection of aircraft components means that these processes are difficult to substitute. The waste spent concentrates from plating operations are disposed of as chemical waste, but rinsing waters are discharged to foul sewer.

A number of chemical treatment technologies are available and are already widely employed in the metal finishing industry for the reduction of metal concentrations in final effluent. These generally involve precipitation of an insoluble metal compound, such as the hydroxide. Improved settlement units, filtration and different precipitation reagents have also been developed which achieve much lower metal solubilities than those achieved by metal hydroxide precipitation. Such treatment processes may need to be considered by the maintenance operators for compliance with the standards. Alternatively, operational procedures which could be used to reduce concentrations in the maintenance effluents are discussed in Section 19.3.3.

*Aircraft Washing*

Estimated pollutant concentrations arising from aircraft washing are shown in Table 19.8 compared to the maximum permissible concentrations under the TMES. The data are based on estimated aircraft washwater volumes combined with loads derived from annual detergent consumption figures for Kai Tak airport. Aircraft detergents have to conform to established technical specifications, which in many cases require large amounts of surfactants and the use of corrosion inhibitors like chromates, thus loads of these parameters are relatively high.

Prediction of effluent concentrations, for comparison with the standards, is subject to considerable uncertainty due to the broad values of wash-water consumption reported at Kai Tak. The estimated pollutant concentrations shown in Table 19.8 thus have to be interpreted with caution. Estimates of mean pollutant concentrations in aircraft washwater at UK airports are generally lower, at 1000 mg/l BOD (max 3000 mg/l), 500 mg/l surfactant (max 1300 mg/l) and 150 mg/l phosphate (max 300 mg/l). However, the detergent consumption reported for Kai Tak (particularly of the heavier detergents) is high compared to UK figures, and this may explain why the washwater appears to be more concentrated.

An initial period of effluent monitoring by the maintenance company undertaking aircraft washing to determine wastewater strength in practice would be recommended. Requirements for balancing facilities (whereby aircraft washwater could be diluted with storm runoff from the stands) or pretreatment facilities at the new airport will need to be reviewed by the maintenance company. Alternatively, detergent type and consumption rates could be assessed, and wastewater concentrations reduced by substitution of lighter formulations used in smaller volumes.

*Table 19.8 Estimated Pollutant Concentrations in Aircraft Washwater*

| | BOD | COD | Surfactants | TTM (as Cr) | $PO_4^{2-}$ |
|---|---|---|---|---|---|
| Pollutant Concentration (mg/l) | 2180 | 5530 | 1950 | 40 | 160 |
| Maximum Permissable Concentration (mg/l) | 1000 | 2500 | 150 | 10 | 50* |

* Total phosphorus

*Sources: Greiner-Maunsell, 1991 and TMES*

*Vehicle Washing*

Data on present detergent and washwater consumption for vehicle washing are unavailable. However, volumes which would be used in automatic washing facility, as recommended, are 200 litres water and 0.06-0.1 litres of detergent per vehicle. Assuming a similar detergent composition as used for light aircraft washing, plus a small volume of emulsified oil, potential pollutant concentrations in vehicle washwater are estimated to be of the order of 30 mg/l BOD, 100 mg/l COD and 20 mg/l surfactants. If reclamation systems are employed, concentrations could increase by a factor of ten. This suggests that vehicle washwater is unlikely to require pretreatment prior to discharge to the foul sewer.

*Hotel*

If a dry cleaning service is provided, dry cleaning fluids may need to be disposed of as chemical waste, rather than discharged to foul sewer.

*Refuse Transfer Station*

Tipping hall wash-down water, leachate and vehicle washwater from the RTS will be treated in a dedicated treatment plant located within the RTS boundary. The treatment system is likely to be a fill and draw system to suit the diurnal variations in leachate generation. The plant will be designed to comply with the requirements of the TMES and the treated effluent will be discharged to foul sewer. Impacts arising from the RTS are considered further in Section 22.

### 19.3.2 Stormwater Interception

The general layout of the stormwater catchments and drainage system is shown on Exhibit 19.1. Land uses within the catchments are shown in Section 2 on Exhibit 2.1. The system has been designed to minimise as far as possible discharges of stormwater into the sea channel, which represents a potentially sensitive waterbody with limited assimilation capacity. The sea channel will receive stormwater from the Tung Chung New Town, which will contain a certain pollution load, therefore discharges from the airport have been located elsewhere, as far as possible, to minimise the potential loads entering the sea channel.

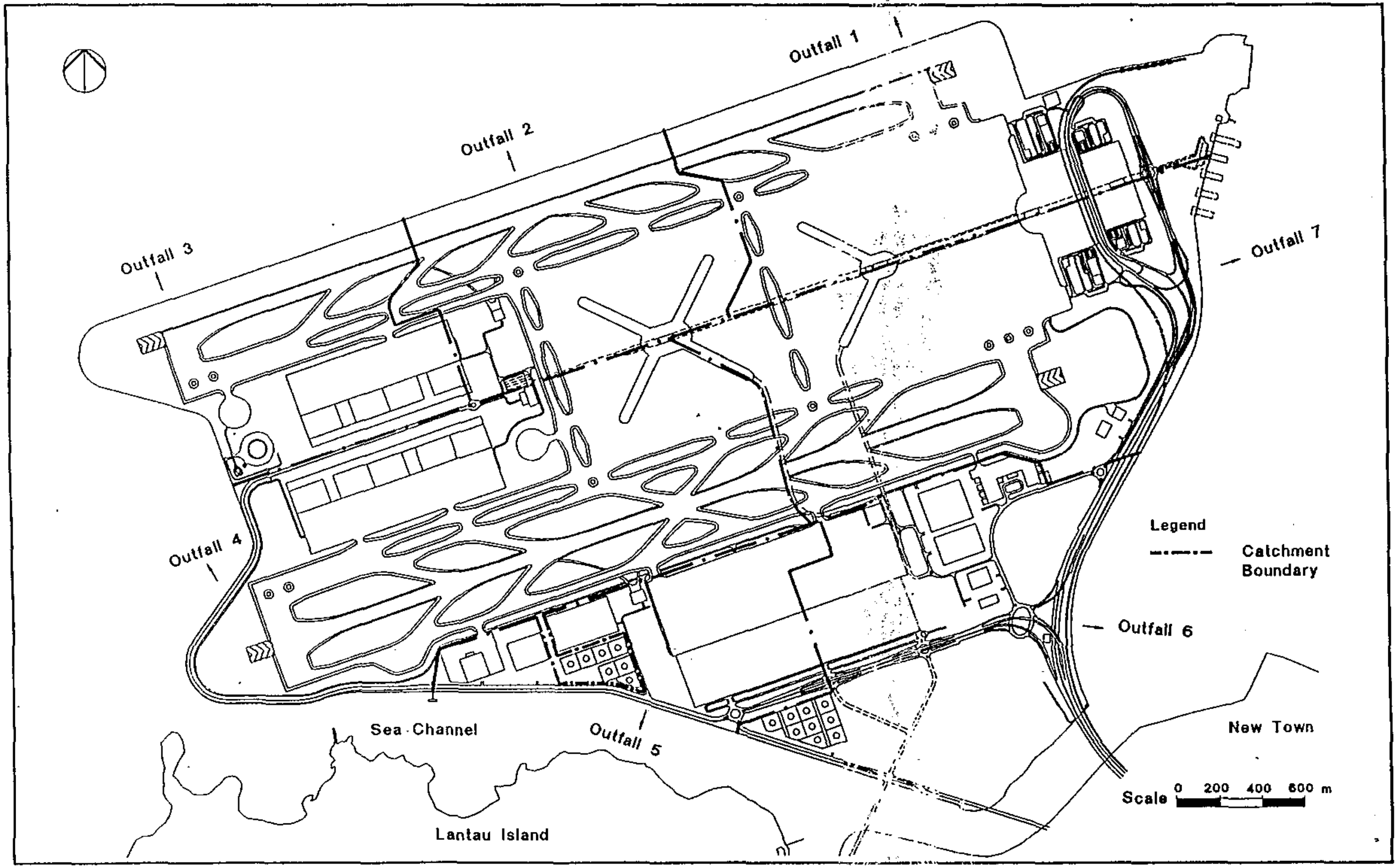
A summary table of the stormwater discharges expected in each of the catchments is given in Table 19.9. This details the various land uses, the nature of the runoff arising from each and the control measures proposed. The measures incorporated within the stormwater drainage system to reduce potential contamination are described in more detail below.

According to present practice, stormwater from potentially polluting areas, i.e. those where some form of treatment such as oil interception is applied, may be required to be licensed under the WPCO. Stormwater discharges which may become polluted in emergency situations, i.e. fire fighting, will not be required to be licensed. The discharge limits specified within the license conditions are likely to take account of the intermittent nature of the discharge.

*Oil/Fuel Spillage*

The fuel farm sites will be lined with impermeable liners and will be bunded to contain 110 percent of the volume of one of the tanks in case of major rupture. Spilled fuel retained by the bund would be pumped out and tankered off-site, as appropriate. All tanks will be fitted with level alarms and leak detection systems. Stormwater from within the bunded areas will be discharged via an oil interception system to be designed to achieve a discharge of <20 mg/l oil and grease. Stormwater runoff from the two fuel farms, although they are located at the southern boundary of the airport, will not be permitted to enter the sea channel but will discharge to the east and west of the reclamation.

The other main areas of concern with regard to fuel contamination of runoff are the apron areas where aircraft will be refuelled, including the large apron area adjacent to the satellite terminals and outside the cargo loading bays, and the aircraft maintenance areas (see Exhibit 2.1). It is proposed to drain these areas into two deep interception sewers which run parallel with the runways, but avoid the tunnels under the southern runway. The system proposed will allow for collection of any dry weather flow together with initial stormwater runoff. Pollutants which accumulate on the aprons will tend to be washed away in the first few minutes of any storm, thus the first 2-4 mm of rainfall from the apron area will be collected. The storage sewers will be designed with inlet controls to ensure the floating oil or fuel does not pass




*Stormwater Outfall and Drainage Catchments* ***Exhibit 19.1***

*Table 19.9 Summary of Stormwater Discharges*

| Outfall | Landuse in Catchment Area | Nature of Surface | Nature of Runoff/Source of Contamination | Pollution Control Measure |
|---|---|---|---|---|
| 1 | Runway | Paved | Emergency Fuel Spillage | Fuel spillage contained using penstocks |
| | Carpark | Paved | Fuel/Oil | Passed through bypass oil interceptor |
| | Aircraft Parking/Refuelling | Paved | Fuel/Oil | Passed through tilted plate oil separator |
| | Terminal Building | Roof | Clean | |
| | Fuel Pier | N/A | Emergency Fuel Spillage | Containment using absorbent boom |
| 2 | Runway | Paved | Emergency Fuel Spillage | Fuel spillage contained using penstocks |
| | Aircraft Parking/Refuelling | Paved | Fuel/Oil | Passed through tilted plate oil separator |
| | Compass Recalibration Pad | Paved | Clean | |
| 3 | Runway | Paved | Emergency Fuel Spillage | Fuel spillage contained using penstocks |
| | Fire Training Facility | Bunded | Fuel/Foam | Separated water discharged to foul sewer |
| | Aircraft Maintenance Facilities | | | |
| | – Aircraft wash bay | Paved | Detergents/Oil | Intercepted and discharged to foul sewer |
| | – Engine testing cell | Roof | Clean | |
| | – Aircraft parking | Paved | Fuel/Oil | Passed through tilted plate oil separator |
| | – Hangars | Roof | Clean | |
| | – Workshops | Roof | Clean | |
| [illegible] | Runway | Paved | Emergency Fuel Spillage | Fuel spillage contained using penstocks |
| | Aircraft Parking/Refuelling | Paved | Fuel/Oil | Passed through tilted plate oil separator |
| | Aircraft Maintenance Facilities | | | |
| | – Administration | Roof | Clean | |
| | – Aircraft parking | Paved | Fuel/Oil | Passed through tilted plate oil separator |
| | – Hangars | Roof | Clean | |
| | – Workshops | Roof | Clean | |
| | – Engine testing cell | Roof | Clean | |
| | – Aircraft wash bay | Paved | Detergents/Oil | Intercepted and discharged to foul sewer |
| 5 | Hangar Shops/Admin. | Roof | Clean | |
| | Airport Maintenance | Roof/Paved | Chemicals | Spillage/leakage prevented by bunded storage/proper handling procedures |
| | Ground Service Equipment Maintenance | Roof | Clean | |
| | Air Express Facility | Roof | Clean | |
| | Cargo Building | Roof | Clean | |
| | Fuel Farm | Bunded | Fuel Leaks | Passed through oil interceptor – discharged outside sea channel |
| | Aircraft Parking/Refuelling | Paved | Fuel/Oil | Passed through tilted plate oil separator |
| | Air Express Facility | Roof | Clean | |
| | Air/Sea Rescue | Roof | Clean | |
| | HK Aviation Flying Department | Roof | Clean | |
| | Rescue and Fire Fighting | Roof | Clean | |
| | Structural Fire Station | Roof | Clean | |
| 6 | Cargo Village | Paved/Roof | Fuel/Oil | Oil interception provided by tenants |
| | Aircraft Parking/Refuelling | Paved | Fuel/Oil | Passed through tilted plate oil separator |
| | Fuel Farm | Bunded | Fuel Leaks | Passed through oil interceptor |
| | Business Park | Paved/Roof | Oil | Oil interception provided by tenants |
| | GA Terminal/Apron | Roof/Paved | Clean | |
| | Cargo Building | Roof | Clean | |
| | Aircraft Catering | Roof | Clean | |
| | Refuse Transfer Station | Roof | Clean | |
| | Environmental Preserve | Grass | Clean | |
| | North Lantau Expressway | Paved | Similar to Highway Runoff | Passed through deep–trap gulleys |
| | Airmail Facility | Roof | Clean | |
| 7 | Terminal Building | Roof | Clean | |
| | Runway | Paved | Emergency Fuel Spillage | Fuel spillage contained using penstocks |
| | Aircraft Parking/Refuelling | Paved | Fuel/Oil | Passed through tilted plate oil separator |
| | Bus/Ferry Terminal | Paved | Similar to Highway Runoff | Passed through deep–trap gulleys |
| | Carpark | Paved | Fuel/Oil | Passed through bypass oil interceptor |
| | Structural Fire Station | Roof | Clean | |
| | HK Police | Roof | Clean | |
| | North Lantau Expressway | Paved | Similar to Highway Runoff | Passed through deep–trap gulleys |
| | Sea Rescue | Roof | Clean | |

*Source: Greiner–Maunsell, 1991*

back into the main flow. Each storage sewer will provide a storage volume of 5,500m$^3$ and the collected flow will be raised by a screw lift pump and discharged through a tilted plate separator to produce a discharge of <20 mg/l oil and grease. The treated flow will be discharged back into the stormwater system.

Waste fuel and oil collected from the interception systems will need to be disposed of off-site at approved locations. This will either be for oil recovery, or disposal at the Government Chemical Waste Treatment Facility. The interception sewers will permit settlement of solids in stormwater runoff. Micropollutants such as heavy metals and organics (PAHs) will tend to adsorb to particulate matter in stormwater and will be partially removed by sedimentation in the sewer system. The solids removed from the interception sewers during maintenance desilting should be disposed of to landfill.

Accidents or emergencies on the runways and taxiways could result in major spillage of oil or fuel and application of dispersants or fire fighting foams. It is proposed that a system of stoplogs should be used to contain any flow contaminated by fuel, oil or fire fighting materials. The relevant stormwater outfalls would be closed off at the seawall and stoplogs installed within the storm drainage system would be used to isolate the affected area, working from the outfall up the system towards the incident area. Contaminated flow from the contained section could be subsequently pumped out and disposed of via the oil interception system or off-site as appropriate.

Road drainage on the airside and landside will pass through deep-trap gulleys of approximately 200 litres volume. These will collect solids and, since they are designed as a water seal to prevent odour emission from the receiving sewer, will also retain floating oil. Unless regularly emptied however, this can be carried through into the storm sewer system. Regular maintenance is therefore critical to maintain their efficiency.

Car parks and lorry parks greater than 500m$^2$ will have proprietary bypass interceptors installed to collect the first flush of stormwater runoff and allow excess flows to pass directly to the storm drains. Regular maintenance will also be necessary for these interceptors.

As a further measure to reduce the potential discharge of oil or fuel from any part of the airport, it is recommended that absorbent booms are maintained for emergency use, in the event that a major spillage or leakage cannot be contained. Biodegradable dispersants and oil skimmers should also be stored on site for rapid deployment.

*Aircraft Washing*

As indicated in Section 19.1.1, it is recommended that dry weather flows and first flush stormwater from the aircraft washing stands are intercepted and discharged to foul sewer. The receiving sewer would be oversized, with a hydrobrake. Surcharging of the sewer in the event of a storm would activate a level sensor which would open a penstock to divert the stormwater flows to the storm sewer. The penstock would be closed automatically after levels subside. Alternatively, a syphon system could be installed at mid-depth to draw stormwater flows into the storm system once the level of the syphon crest was exceeded. It is important that the routing of stormwater overflow from the aircraft washing stands should avoid any oil interception systems, since residual detergents could emulsify and strip out accumulated oil. Degritting chambers would be provided to collect suspended solids; regular desilting would be required with disposal of solids to landfill. Aircraft washing stands should be scrubbed down after use to prevent surface accumulation of detergent residues.

*Vehicle Washing*

Similarly to aircraft washing, a centralised vehicle washing facility discharging to foul sewer would be recommended as a means of controlling the runoff of detergent wastewaters. A centralised, automated vehicle washing facility would be more efficient in term of water use than a number of individual facilities. Automated vehicle washing systems can be fitted with water reclamation systems and use of these should be considered to reduce water consumption. The water reclamation system recommended by the company providing some of the present vehicle washing services can reclaim 95 percent of the 200 litres of water used per wash and 50 percent of the 0.1 litre of detergent. The use of brush systems rather than water jets alone is more economical in terms of water and detergent use and would be recommended.

*Cooling Water Discharges*

Cooling water will be required to comply with the TMES. Parameters of most concern are temperature, which will be limited to <40°C and residual anti-fouling additives. If, as is likely, chlorine is used as a biocide, residual concentration in the discharge should not exceed 1 mg/l.

### 19.3.3 Operational Procedures

*Oil/Fuel Spillage*

During offloading of fuel from the fuel barges via the fuel piers, the recommendations of the *International Oil Tanker and Terminal Safety Guide* (IOTTSG) should be followed with special attention to the method of barge mooring and the condition of any flexible ship-to-shore connections. In the event of spillage or leakage all loading operations should be stopped immediately and absorbent booms deployed for containment of fuel spillages.

Removal of spilled fuel or oil from runway and taxiway areas is normally achieved by washing spillages down storm drains using detergent-based dispersants or water. Alternative methods would be preferable on environmental grounds, such as sand-bagging affected storm drains and removing spilled fuel or oil by vacuum suction or with solid absorbents. The feasibility of such methods is, however, dependent upon fire fighting and airport operational requirements, which would be expected to necessitate the quickest possible method of removal.

In the UK, large spills are washed down using water and residual fuel is scrubbed with detergent and removed by a vacuum suction device. Detergent-based dispersants are not permitted to enter the storm drains as they strip oil and fuel out of any interception systems on the stormwater system. Small spills are removed using absorbent materials such as sand or sawdust, or specialised textiles which can remove up to 20 times their own weight of hydrocarbons.

A similar system is recommended for use at the new airport, whereby large spills are washed off with water, but contained within storm sewer system. An emergency response plan should be developed, in accordance with Fire Services Department procedures, whereby the stoplogs on the stormwater outfalls are installed in the event of an emergency on the runways or taxiways to isolate the affected storm sewer run.

Consideration could be given to development of a computerised emergency response programme. The location of an incident would be input to the programme, which would undertake an analysis of the storm sewage system and indicate which stoplogs should be dropped to contain the spillage, and which should be raised temporarily to permit clean stormwater to bypass the contained section. Contaminated flow from the contained section could be subsequently pumped out and disposed of via the oil interception system or off-site as appropriate.

Non-emergency fuel spillage at other airports is frequently associated with poor maintenance of aircraft, fuel tankers and vehicles. As indicated previously, over 50 percent of fuel spills in a three month period at a UK airport were attributable to faulty shut off values on aircraft. . These faults can be easily rectified by adequate inspection and maintenance. PAA could consider a system of financial penalties for fuel spillage due to inadequate maintenance with penalties in proportion to affected ground area or costs of manpower and equipment required for clean-up. This would provide incentive for airlines and the maintenance companies to employ additional safety measures such as secondary shut-off values and leak detection systems.

Detailed records of the causes and extent of fuel/oil spillages should be kept for auditing purposes.

*Chemical Spillages*

Potential impacts from chemical spillages can be significantly reduced by implementation of proper storage and handling procedures.

Chemicals stored in tanks should be surrounded by bunding that can contain at least 110 percent of the volume of the tank, should a rupture or total leakage occur. Bunded areas should have an impermeable base or membrane liner as the ground (formed from marine sand) will be porous. Drums of chemicals, including paint, pesticides, solvents, lubricants etc., should be stored in bunded areas or in catch trays as a minimum. Where possible, chemicals should be handled and used in areas isolated from stormwater drains. A strategy should be developed for dealing with chemical spills, based on manufacturers' recommendations. As for fuel spills, clean-up procedures should involve the use of absorbents, such as sawdust or proprietary absorbent products, rather than washing spilled materials into drains.

It is recommended that a centralised recording system is established to maintain an inventory of the quantities and location of the different chemicals stored on site. All chemicals proposed for use by tenants and PAA operations should be reviewed by PAA environmental staff prior their adoption. This will be particularly important when moving to new products.

Good practice procedures should be defined for the correct handling, storage and use of chemicals, together with controls over disposal of waste chemicals and empty containers. These should be based on manufacturers' recommendations for specific chemicals and on additional guidelines such as those produced by the World Health Organisation and the UK Health and Safety Executive (*Control of Substances Hazardous to Health*). Procedures should be in accordance with the regulations of the Dangerous Goods Ordinance, Agricultural Pesticides Ordinance and the Draft Chemical Waste Regulation and Associated Codes of Practice, where appropriate. These procedures should be developed by PAA environmental staff in the form of an operations manual describing approved protocol, and made available to all tenants and airport staff involved in chemical handling.

*Horticulture*

The pesticides used at Kai Tak are of relatively low toxicity and application rates will be comparable with those for parks and gardens managed by USD. There are, however, a number of factors which will minimise the potential for pollution of adjacent areas. These include application during good weather only (i.e. in windless, dry conditions), careful disposal of empty containers and the use of foliage rather than soil applications to reduce the risk of leaching. Similarly, controlled application of slow release fertilisers should be employed to reduce potential leaching.

*Product Substitution*

The substitution of low impact products and procedures should be considered by PAA and airport tenants where practical. Some examples of this include the following;

Use of biodegradable detergents (containing no phosphates, EDTA or NTA) for aircraft/vehicle washing, ideally conforming to UK Ministry of Defence TS 10281 specification. Examples of detergents conforming to this specification are Nielsen Aircraft Cleaner 281, Basic CD' and Kent Trafficair Aviawash 2000.

Use of alkaline-based degreasers or steam cleaning for oily component cleaning during maintenance, rather than use of chlorinated solvents.

Use of alternative methods for chemical paint-stripping, such as high pressure jetting or aquastripping, as used by Lufthansa. Other stripping methods including cryogenics and plastic media blasting, and the production of low-solvent content paints and paints susceptible to stripping by lower impact agents are also currently under development.

Use of synthetic alternatives to mineral-oil lubricants, such as esters, which are easily biodegradable while retaining high performance. The European market in environmentally 'clean' engineering fluids, mostly lubricants, is growing despite the fact that synthetic lubricants are two to three times more expensive than mineral oils.

Use of waste minimisation techniques in the maintenance plating shops, such as:

- closed rinsing system, which combines evaporation and counterflow rinsing, thus reducing water consumption and allowing recovery of plating solution;

- ion exchange systems, for both product recovery and rinsewater reuse; used for acid recovery, metal salt recovery and final polishing of waste effluents

- electrolytic waste treatment, a well established technology which operates on the same principles as electroplating;

- electrodialysis, still under development, which permits the recovery of the metal plus the background electrolytic material by the passage of soluble ions through a semi-permeable membrane;

- membrane technologies, such as reverse osmosis, to filter out waste metals.

Application of ecological techniques, such as using naturally occurring species for seeding grassed areas which require less management and therefore less application of fertilisers and herbicides. This approach is being employed by one of the major airports in the UK.

## 19.4 Monitoring and Audit

### 19.4.1 Monitoring Requirements

Licensed discharges made to the foul sewer will be required by the regulatory authority to be monitored by the discharger. A suitable access area for confirmatory monitoring by the regulatory authority will also be required. It is understood that EPD will be the regulatory authority, whether the sewer system is publicly or privately operated, since the sewer system receiving the licensed discharges will be effectively communal. The general requirement for compliance with the TMES under the WPCO and monitoring of trade effluents should be included by PAA in lease conditions for all tenancies. Landside tenants will also be subject to the requirements of the WPCO and TMES.

Unpolluted stormwater discharges are not required to be licensed under the WPCO and there is no statutory requirement for monitoring. However, certain of the stormwater discharges may be required to be licensed, and in view of sensitive nature of the receiving waters it would be considered advisable to monitor at certain points through the storm sewer system on a regular basis. Interpretation of analytical data from analysis of stormwater is complicated, but monitoring at similar frequency at UK airports has been found adequate to highlight problem areas with the stormwater system.

Outflow from all the major oil interception systems should be monitored for oil and grease on a routine basis to check the separation efficiency. These include the tilted plate separators on the two main interception sewers, and the separators at the fuel farm and fire training pit. All oil separator units need to be regularly desludged to maintain efficiency; this is particularly important in the case of plate separators since the spacing between plates is usually about 25mm and regular cleaning is necessary to prevent accumulation and blockage.

Stormwater from the main outfalls should be monitored, sampling any dry weather flows and selected rainfall events for a range of parameters including BOD, COD, SS, oil and grease, heavy metals, pesticides and PAH. Monitoring should be carried out initially on a three monthly basis and the frequency reviewed after the first year's operation. Biological monitoring of heavy metals in barnacles and organics in caged green-lipped mussels in the vicinity of the outfalls should be carried out at a similar frequency to supplement the chemical analysis and provide an indication of bioaccumulation resulting from local discharges. The results should be audited and assessed for indications of elevated pollutant loads. Where this is observed, investigations should be made progressively further up the stormwater system to identify the potential source.

One of the major factors determining the quality of stormwater runoff is maintenance of the various interception systems. Although this will be the responsibility of maintenance staff, it is recommended that PAA environmental staff be given a mandate to monitor the maintenance operations. Regular visual inspection should be made of all oil interceptors on the storm drainage system, including bypass interceptors at vehicle refuelling stations and car/lorry parks and oil absorption equipment at the stormwater outfalls, to ensure that removal of accumulated oil and sludge is being carried out at sufficient frequency. Regular inspection of maintenance areas with heavy chemical usage should also be made to ensure that proper storage, handling and disposal procedures are being observed.

### 19.4.2 Audit Requirements

The main operations requiring auditing with respect to water quality will include fuel storage, spillage response, fire training, airport maintenance, aircraft maintenance and washing, vehicle maintenance and washing, catering, and solid waste handling. Auditing should involve a regular review by PAA's environmental staff of operational records and monitoring data for foul and stormwater discharges for these activities, and identification of the need for revised operational procedures and/or treatment methods to achieve compliance with statutory and guideline regulations. PAA should specify audit requirements for airside tenants in the lease conditions emphasising the need for all relevant data to be made available. Auditing of tenants' operations should be carried out by PAA so that any mitigation measures required to be imposed are consistent and coordinated.

## 20.1 Assessment Methodology

A marine ecological survey was carried out in November 1990 to characterise the areas that will be affected by both construction and operational phases of the airport development. A brief summary of the results of the sublittoral and littoral surveys is presented below.

## 20.2 Existing Environment

### 20.2.1 Sublittoral

The heterogeneity of the sediments in the sampling area as a result of tidal influence resulted in a diverse variety of biota in grab samples, with several species new to science being collected. These included the pycnogonid *Neopallene* sp. and the gastropod *Pseudoliotia* sp.

Trawl samples also produced long species lists of high diversity. A lack of echinoderms is probably a result of the low salinity of the area as a result of the summer flow from the Pearl River. Those species of relative abundance in the trawl samples included the predatory gastropod *Murex trapa* and the turret shell *Turritella bacillum*.

The trawl survey also included investigation of fish communities which, in line with previous work by others, showed a high diversity.

Dolphin sightings were investigated on the basis of reports from the World Wide Fund for Nature and the Agriculture and Fisheries Department. Thirty sightings of the Chinese White Dolphin, *Sousa chinensis* were reported between July 1980 and October 1991 with the frequency increasing during the last two years. The lack of sightings of young dolphins suggests that this area may be used for feeding rather than as a breeding ground.

### 20.2.2 Littoral

Sampling of local shores identified seven littoral communities in the area. These were rocky cliff, jetty, boulder, Zoysia bed, sandy shore, mangrove swamp and open shore communities. A high diversity was found on all shores, with some new faunal associations being observed.

The shore of Tung Chung in particular produced good examples of mangrove communities dominated by the relatively rare species *Bruguiera gymnorrhiza*. The sea grass *Zostera nana* was identified south of Tim Sam jetty and is of international conservation significance as only one other sea grass bed of this species is found in Hong Kong, at Lai Chi Wo beach.

The barnacle *Tetraclita squamosa* was used to establish baseline metal concentrations of copper, zinc and cadmium. Barnacles were collected from four sites around Tung Chung and Chek Lap Kok. Concentrations were found to be low by local standards and levels of nickel, chromium and cobalt were undetectable.

### 20.2.3 Post-Construction Environment

It is likely that most disturbed sublittoral communities will re-establish themselves following the construction phase. Over most of the affected area sediments are expected to remain of the same type and a similar bottom community will be able to colonise the area. Localised changes in tidal flow in some areas are expected to produce different sediment types and new bottom communities will form. An example of this is at the northeastern corner of the reclamation, where it is expected that the existing marine mud will be eroded down to alluvium, resulting in a high energy environment with a sand/gravel substrate. Several littoral and sublittoral areas will be permanently lost due to the reclamation including almost all of the shoreline of Chek Lap Kok.

## 20.3 Marine Ecological Impacts

Marine ecological impacts could arise as a result of the discharge of foul sewage and stormwater runoff.

Foul sewage from the airport development will be pumped to the sewage treatment works at Sui Ho Wan and treated prior to discharge through a long outfall terminating near The Brothers. Impacts arising from this discharge have been addressed in the NLDS TR10.

Potential contaminants in stormwater arising from sources such as oil/fuel spillages, aircraft washing and maintenance, runway runoff etc. have been identified in Section 19. The potential impacts on marine organisms which could be caused by various stormwater pollutants are summarised in Table 20.1.

It is difficult to estimate with any degree of certainty the concentrations of potentially toxic substances that will enter the receiving marine waters in stormwater runoff, particularly those arising from spillages. The degree of toxicity on discharge also varies with factors including the proximity of sensitive marine organisms to the point of discharge, the degree of dilution obtained (which is dependent on the water currents in the area), the salinity and temperature of the receiving water and the local sediment type. Contaminants such as heavy metals and organics tend to be adsorbed more strongly by organically-rich lower particle size fractions, and thus tend to accumulate in finer muddy or silty sediments.

While a proportion of contaminants may be transformed and removed from the aquatic system, e.g. by biological or photochemical oxidation of organics such as PAHs or biological methylation and subsequent volatilisation of heavy metals such as mercury, there is generally a tendency for accumulation in sediments. Infauna which burrow in fine marine sediments thus tend to have higher exposure to contaminants than pelagic species.

*Table 20.1 Effects of Pollutants on Marine Organisms*

| Pollutant | Effect on Environment | Effect on Marine Organisms |
|---|---|---|
| Organic Compounds | Exceedance of receiving water capacity to oxidise material; reduction in dissolved oxygen concentration as microbial growth enhanced. | Oxygen stress, suffocation, replacement of diverse communities with low diversity/high population communities tolerant of anoxic conditions. |
| Nutrients | Stimulation of heavy algal growth, including potentially toxic species; localised reduction in DO on collapse of bloom and microbial decomposition, release of toxins. | Oxygen stress, suffocation, toxic effects (e.g. paralytic shellfish poisoning, red tides). |
| Oil/Fuel, including PAHs | Interference in oxygen transfer through water surface; toxic effects on shellfish and fish (sub-lethal effects occur at 0.005–0.1 ppm PAH and lethal effects at 0.2–10 ppm PAH). | Oxygen stress, suffocation, disturbed cell and membrane function, intestinal tumours, death. |
| Heavy Metals (e.g. lead, zinc, cadmium, copper, chromium, mercury) | Bioconcentration leading to chronic/acute effects and transfer via foodchain to human seafood. | Metabolic interference, mutagenic/ carcinogenic effects, death. |
| Detergents | Toxic at high concentration, reduced capacity to survive low dissolved oxygen conditions at low concentrations. | Damage to cell membranes, death. |
| Pesticides | Bioconcentration leading to chronic/acute effects and transfer via foodchain (e.g. to seabirds). | Metabolic interference, tumour formation, death. |

*Source: Greiner-Maunsell, 1991*

The gradual accumulation of organic matter and toxic pollutants, if discharges are not controlled, can have an adverse effect on the community structure and composition - particularly evident in bottom infauna and epifauna. The effects of marine deterioration of this type have been well illustrated in Tolo Harbour. Species diversity will fall as diverse communities with specialist feeding types are replaced by a smaller number of generalists (e.g. the gastropod *Babylonia areolata*). Echinoderms, crustaceans, fish and cnidarians will all suffer and be eliminated. Eventually particular polychaetes (e.g. capitellids) will dominate infaunal communities, until all infauna are eventually replaced by microbial communities able to live in toxic and/or anoxic conditions.

## 20.4 Mitigation Measures

It is difficult to define "acceptable" levels of exposure of marine organisms to potential contaminants. Therefore the only approach is to ensure that runoff of all contaminants, including fuel oils and other petroleum-based substances, is minimised at all times and all possible measures are taken to avoid accidental spillages by good working practices. In addition, the application rates and methods of pesticides to runways should be restricted as far as possible in order to minimise the potential for runoff. Drainage systems serving potentially contaminated areas should preferably discharge into areas with strong tidal currents as opposed to sheltered areas such as the sea channel.

Mitigation measures for controlling contaminated stormwater discharge have been discussed in Section 19.3.2.

## 20.5 Monitoring and Audit

A monitoring programme of the sublittoral community was previously recommended in Section 8, to be undertaken bi-annually for six years after construction at sites immediately adjacent to the airport, and at borrow sites disturbed anthropogenically during the source of construction. This type of programme will also permit an assessment of operational impacts on sublittoral communities. In addition, monitoring should be extended to intertidal sites close to and remote from the airport to measure, for example, changes in population numbers of barnacles, oysters or gastropods.

Data should be compared against the baseline data collected in the 1990 survey. Two types of community changes would be expected. The first would be as a result of the sheltering effect of the reclamation. Existing exposed cliff communities containing the barnacles *Capitellum mitella* and *Tetraclita squamosa* and the limpet *Siphonaria sirius* would be expected to be replaced by an oyster (*S. cucullata*) dominated community. This would be the result of the construction changing the flow regime and wave exposure.

The second change which might be expected to occur would be in response to operation of the airport and New Town developments, i.e. as the result of pollution. Potential pollution changes may be indicated by oscillation or further decline in the numbers of e.g. oysters. Significant changes observed in the marine communities should be documented and checked for correlation with any potential causative factors such as water quality, which may be able to be mitigated.

## 21.1 Terrestrial Impacts

Operational impacts on the terrestrial ecology of Chek Lap Kok do not arise, since almost all of the flora and fauna will have been destroyed during the construction phase, as detailed in Section 9. Although there is recent evidence that heavy military jet air traffic can disturb nocturnal bird migration (Hilgerloh, 1990) this is not considered likely to occur at Chek Lap Kok. No significant off-site operational impacts are envisaged.

The only section of the island remaining will be the southern-most headland, which has been designated as an open space reserve. The reserve area is restricted to the headland knoll and the rocky shoreline along its southern boundary. The northern shoreline of the knoll will be incorporated into the reclamation for the airport development.

The headland knoll rises to a general elevation of 79.0 mPD with relatively steep slopes to the south and east. The main natural drainage swale falls to the northwest of the ridge, dissecting the broader slope area.

Although having some open secondary woodland on its northern slopes, the majority of the headland is covered in grassland and low scrub, with patches of bare soil on the steep slopes and the hilltop. The area has been extensively burned over the last year, although burned areas are now beginning to be recolonised.

The headland on its own is too small and dry to support any natural vegetation of conservation value. The area is visually important as it will form the "gateway" to the new airport, and its potential in this respect should be optimised. Thus it is recommended that it be landscaped to provide an area of aesthetic interest.

## 21.2 Landscaping

The landscape design intent for the southern headland area will be to reinstate a natural character through the replanting of indigenous plant species representing the natural landscape of Hong Kong. This will include the establishment of scrubland and woodland species and the retention of selective areas of open grassland.

The headland area is a visually prominent landform which will form a focal element to the proposed airport entrance road. The inclusion of a natural landscape character would relate the site to the backdrop of the Lantau Peak Ranges and evoke the natural character of Chek Lap Kok.

The retention of the knoll provides the only elevated part of natural ground within the airport development context. The headland represents a transitionary element between the proposed New Town and airport, and will therefore form a landscape buffer and a point of separation between these two development areas. The open space linkage will be continued through the New Town by a town park which will incorporate the existing headland northwest of Ma Wan Chung.

## 22.1 Waste Arisings

The main solid waste generating activities at the new airport have been identified and estimates made of waste arisings. The estimates were based either on figures obtained from the relevant airport industries for their current waste arisings at Kai Tak, or load factors for publicly-collected and privately-collected waste forecasts for the year 2000 obtained from the *Waste Disposal Plan for Hong Kong 1989.* Publicly-collected waste comprises mainly household or domestic waste, e.g. food waste, paper and plastics. Privately-collected waste comprises mainly industrial and commercial waste arising from all forms of commercial activity and major industries but excluding chemical and construction wastes. Reductions in the waste load factors were made, as appropriate, to reflect the differences between these general factors and the waste generated at an airport. Future waste arisings were estimated using the appropriate forecasts from the planning reports of the Master Plan Study. A summary of the total waste arisings by area is presented in Table 22.1.

*Table 22.1 Solid Waste Arisings*

| Solid Waste t/d by Area | Year 2010 | Year 2040 |
|---|---|---|
| Airport (Airside) | 176 | 375 |
| (Landside) | 17 | 32 |
| Airport Related Industry | 86 | 86 |

*Source: Greiner-Maunsell, 1991*

### 22.1.1 Domestic Waste

The main source of domestic waste will be from the transient and permanent airport population at the terminal building (excluding catering facilities). It has been assumed that this will be of a similar composition to publicly-collected waste but with a lower putrescible content.

### 22.1.2 Commercial Waste

Commercial waste sources will include airport administration areas and offices, non-catering wastes removed from the aircraft, catering waste from the terminal and canteens, hotel waste and waste from the airport-related areas. Waste from administrative areas has been assumed to be of a similar composition to privately-collected waste and will include paper waste and food waste from office canteens.

Catering waste will comprise putrescible material plus packaging. The hotel waste has been assumed to be typical of commercial waste, whilst waste obtained from the airport-related areas has been assumed to be of a similar composition to privately-collected waste.

### 22.1.3 Industrial Waste

Industrial waste sources will include the aircraft maintenance and cargo areas. Current maintenance activities include cleaning and testing of engines and components, together with line (cosmetic) and base (major) maintenance of the aircraft. Although only some of the maintenance activities may be transferred initially, due to the high costs of removal, it has been assumed for the purpose of this assessment that all maintenance activities will be relocated to Chek Lap Kok.

There will also be a plating workshop generating some hazardous waste as considered in Section 23. The aircraft maintenance waste composition is variable but will be largely metal and wood together with paint stripping wastes composed of rags, cardboard and paint flakes. Adoption of new technologies in the future may alter the composition of solid waste arisings but this will largely affect the arisings of hazardous waste. Cargo waste will be largely composed of low density, high volume packaging (plastic sheeting, cardboard and wooden pallets).

### 22.1.4 Putrescible Waste

Putrescible waste will arise from the in-flight catering services as a result of waste from flight-meal preparation at the airport, together with left-over food from flight meals unloaded from the aircraft. Whilst this will include some food packaging waste it will be insignificant compared to the food waste in terms of tonnage. It has been assumed that present catering operations at Kai Tak, which involve a significant degree of primary food processing, will continue at the new airport.

### 22.1.5 Miscellaneous Solid Wastes

Miscellaneous sources of waste which may require segregation and separate treatment include small intermittent arisings from customs and quarantine facilities. Currently, small quantities of counterfeit goods seized by customs are incinerated at Kai Tak, although the majority of waste is auctioned off or donated to charity or corrective services. Quarantine facilities will also give rise to some excremental waste. It has been proposed that the existing quarantine facilities remain located in Kowloon and Hong Kong Island and only temporary hostel facilities be provided at Chek Lap Kok. This will give rise to small quantities of difficult waste requiring separate treatment.

There will also be intermittent arisings from maintenance desilting of storm sewers. Since the silt may be contaminated by pollutants in the stormwater runoff, it is recommended that it is disposed of to landfill after drainage, rather than being dumped at sea. Maintenance desilting is likely to be carried out every two to three years depending on the rate of accumulation of solids within the storm sewer system.

## 22.2 Background to Strategy

The strategy for management of solid wastes at the airport is broadly consistent with Government policy. This involves collection and delivery of wastes to Refuse Transfer Stations (RTS) serving the main urban areas, transfer to larger containers and shipment to major strategic landfill facilities by barge. Waste from the airport will, in common with the waste from the North Lantau Developments, be transferred to the Western New Territories (WENT) landfill. An RTS will be located at Siu Ho Wan on North Lantau and will receive wastes from the New Town developments. While this RTS could also accommodate direct delivery of wastes by refuse collection vehicles from the airport, an additional RTS facility is to be provided at the airport site. The principal benefit of this arrangement would be in relation to security, since collection vehicles operating airside would not be required to pass through security checks on crossing the airside/landside boundary. The airport RTS will therefore accept waste from airside operations and from the airport facilities located landside. Containerised waste will then be taken to Siu Ho Wan for transfer to barge.

Alternative strategies which were considered but rejected involved direct haul to the site at Siu Ho Wan (rejected on security grounds), a totally independent airport RTS with barge facility (rejected mainly on grounds of cost and operational constraints) and a mini-RTS with transfer of containers to Siu Ho Wan. The latter option as originally conceived involved filling of containers directly at collection points with the RTS acting as a centralised consolidation point for loading into high capacity vehicles. The currently preferred option is a development of that concept and is considered preferable from an environmental standpoint for several reasons:

- frequent collection of waste and transfer of containers to landfill within at most 24 hours reduces the length of time spent by waste at collection points, thereby reducing the tendency to putresce and create odour and other environmental nuisance;

- filling of containers at collection points is unlikely to achieve the degree of compaction possible at a centralised facility and payloads will not be maximised;

- a greater number of containers might be required since at least two would be needed for each collection point; and

- double handling of containers would tend to increase the potential of nuisance from noise and other impacts.

The overriding security requirement is for solid wastes to be transferred across the airside-landside boundary without a concomitant movement of vehicles and personnel. The transfer operation must therefore at least facilitate the tipping of waste from collection vehicles, the transfer of this waste to other vehicles operating landside only and transfer to the RTS at Siu Ho Wan. This would preclude the use of conventional refuse collection vehicles to effect the transfer of waste from the airport to Siu Ho Wan.

## 22.3 Preferred Strategy

### 22.3.1 Collection

Collection from airside collection points would be effected by a dedicated fleet of vehicles. Landside collection could be by RSD vehicles or private contractor.

### 22.3.2 Transfer

Wastes collected from the airport site will be taken to an RTS on the airport site. The proposed location is to the north of the open space reserve, as shown on Exhibit 2.1. The RTS will incorporate the following functional requirements:

- a secure reception area for wastes generated and delivered airside;
- a non-secure reception area for wastes generated landside;
- a non-secure compaction area for compaction of waste into containers;
- a storage area for full containers awaiting transfer; and
- parking, cleaning and maintenance areas for collection and transfer vehicles;

From a design standpoint, maximum operational flexibility is being retained at this stage. Effectively, this makes provision for wastes to be taken from the non-secure landside areas of the airport either to the airport RTS or to the North Lantau Development RTS at Siu Ho Wan.

The proposed RTS is similar in concept to the existing Kowloon Bay RTS. It will consist of a two-storey building and associated access roads and ramps. Collection vehicles will enter the RTS site, pass over a weighbridge and onto an up-ramp into the first floor level tipping hall. The waste will be tipped into pushpits from which it will descend to the ground floor where it will be compacted into containers. The access roads, up ramps and first floor tipping hall are provided in duplicate to allow segregation of airside and landside collection, delivery and tipping operations, but the ground floor compaction operation and all aspects of container handling are common. The principal benefits of this arrangement relate to airport security, but there are some environmental benefits. These include minimising the number of collection vehicles on internal landside roads which are accessible or visible to the public. Moreover, since collection vehicles tend to cause more odour nuisance and have a higher potential for leakage of offensive liquors than transfer vehicles, there are perceptible benefits from minimising vehicle miles travelled by the former.

### 22.3.3 Disposal

Containerised waste from the airport RTS will be transferred to the Siu Ho Wan RTS. From there the containers will be transferred to the WENT landfill for disposal.

## 22.4 Potential Environmental Impacts

### 22.4.1 Impact on Disposal Facilities

The total waste arisings from the airport when fully developed will be equivalent to less than two percent of total municipal waste arisings in the Territory. The impacts of these arisings are therefore not significant in a regional context.

### 22.4.2 RTS Location and Land Use Considerations

Refuse transfer stations attract a "bad neighbour" image, even though it is possible to design facilities with a high quality external finish and integrated pollution control systems to minimise external impacts. Siting of an RTS in close proximity to sensitive uses may result in adverse visual impact and odour nuisance. It is also necessary in many cases to consider the routing of collection and transfer vehicles since these also have potential for adverse aesthetic impact and odour nuisance.

### 22.4.3 Air Quality

The principal air quality impact associated with refuse handling is that of odour. Although no statutory or planning guideline criteria exist in respect of quantitative limits on odour levels, in general a limit of two odour units should apply at the site boundary of any potentially odorous facility. There is no minimum period of exposure below which transient odour levels can be permitted to exceed the limit. Consequently, this has important implications for odour mitigation.

Dust generation is often regarded as a potential adverse impact associated with refuse handling, but operational experience in Hong Kong reveals that for the most part, refuse has a reasonably high moisture content throughout the year and does not generate significant dust levels. Nevertheless, the possibility exists that individual consignments of waste may be particularly dusty and provision for mitigation should be made.

### 22.4.4 Noise

Activities generating noise at transfer stations include:

- collection and transfer vehicle movements;
- pushpit and compactor plant;
- vehicle and plant maintenance;
- station ventilation plant; and
- wastewater treatment plant (e.g. pumps, blowers, compressors).

Assuming 24-hour operation of the RTS, representing a "worst case" for illustrative purposes, noise levels at source are likely to be in the range up to 95 dB(A). This is representative of the maximum combined sound power level of the ventilation system design for the Kowloon Bay RTS.

### 22.4.5 Water Quality

Wastewater arisings at the RTS will include:

- liquors from incoming refuse;
- washwater from the tipping and compaction areas;
- vehicle washwater; and
- domestic wastewater for staff rest rooms and canteens etc.

Arisings are difficult to predict because they depend partially on the nature of the incoming waste and on the quantities of washwater used. The quantities of liquor generated from tipping and compaction of refuse will depend on short term variations in weather and on long term seasonal factors. Liquors vary in quantity and quality particularly at times of the year when fruit and vegetables are in season. The high proportion of food preparation wastes to be accepted at the airport RTS will make it particularly susceptible to such factors.

It is anticipated that total arisings from refuse liquors and tipping and compaction area washwater would be of the order of 10 - 20 $m^3$ per day.

The composition of wastewaters also varies, but will certainly exceed standards for discharge to foul sewer without treatment.

## 22.5 Mitigation Measures

### 22.5.1 Air Quality

Dust and odour emissions at the transfer station should be controlled by total enclosure of the tipping, compaction and containerisation operation within the transfer station building. A ventilation system should be incorporated and designed such that all exhausted air is scrubbed and filtered to remove particulates and volatile organic materials capable of generating odour nuisance. The wastewater treatment plant should also be located within the transfer station building, or it should be fitted with a separate odour control system.

Various methods of odour control exist. The preferred method involves an active adsorbent, typically granular activated carbon, impregnated with an oxidising agent. Chemical odour masking or control sprays are not recommended because of the potential chemical handling problems and frequently only disguise rather than eliminate odours.

Odour nuisance from refuse collection vehicles, both airside and landside, will be minimised by adoption of the preferred strategy because total vehicle miles travelled by such vehicles will be minimised, they will not travel through centres of population and they will be cleaned each time they pass through the transfer station. Odour nuisance potential from container vehicles is much less, and since the main route to the facility at Siu Ho Wan is directly via the North Lantau Expressway, impacts will be negligible.

### 22.5.2 Noise

The extent to which noise control to meet statutory requirements is necessary depends on the area sensitivity and the proximity of sensitive receptors. The airport RTS is located so far from such receptors that no statutory control need be applied. Nevertheless, a degree of noise control is desirable in view of the relative proximity of the business park and other office uses, such as those associated with the customs building.

Total enclosure of the tipping, compaction and wastewater treatment facilities within a steel clad building will achieve noise reductions of the order of 30 dB(A). Furthermore, for occupational health and safety reasons restrictions will be placed on sound power levels of plant and equipment to protect the hearing of operatives. These measures combined will be more than sufficient to reduce noise immediately outside the facility to an acceptable level of about 60 - 65 dB(A) for a "worst case".

Noise from collection and container vehicles on the airport site will not cause unacceptable impacts because there will be no sensitive receptors. Elsewhere, the peak hour vehicle movements should be considered in the assessment of road traffic noise impacts. It is unlikely that the additional heavy goods vehicle movements on the North Lantau Expressway will influence the projected noise level to a significant degree.

### 22.5.3 Water Quality

Liquors arising from compaction of refuse are totally unsuitable for discharge direct to a receiving water or untreated to sewer. On site pretreatment of these liquors will therefore be required. Since the principal design criteria of flow and load cannot be predicted with the same precision and accuracy as for domestic sewage, conventional sewage treatment systems are considered inappropriate because they provide insufficient flexibility and are relatively complex to operate.

The preferred system for treatment would be a single stage fill and draw or batch reactor to provide biological oxidation and secondary sedimentation in the same tank as part of a flexible operating sequence.

The influent liquors will probably require amendment with nutrients. Despite the high levels of ammonia ultimately generated in landfill leachate in Hong Kong, reduction of organic and oxidised nitrogen does not appear to occur to any significant degree in liquors from new waste. Consequently, liquors tend to be deficient in both nitrogen and phosphorus. This problem can be overcome partially by combined treatment of liquors with other wastewaters, but this is not recommended unless trials demonstrate the feasibility from a biological and practical standpoint.

The system should be designed to provide treatment to the appropriate TMES standard, permitting discharge of the pretreated effluent to foul sewer. It is unlikely that sufficient treatment could be provided in a single stage system to generate effluent of sufficient quality for direct discharge to sea.

## 22.6 Compatibility with the North Lantau RTS

Since the preferred strategy for solid waste management at the airport relies to some degree on the availability of container handling and barging facilities at Siu Ho Wan, a certain degree of compatibility must be ensured. It is therefore necessary to consider contractual liabilities and programme issues at future stages of development. The planning, feasibility study and engineering design stages of both the Siu Ho Wan and airport transfer stations must therefore consider the following:

- if the programmes for development of both stations are compatible, the contract for design, construction and operation of the Siu Ho Wan station by the private sector could include the airport station;

- if the stations must be designed, built and operated under separate contracts, the particular specifications must ensure compatibility of the containers to be used at the airport with handling and barging facilities at Siu Ho Wan;

- in the unlikely event that transfer facilities are not operational at Siu Ho Wan by the time the airport is commissioned, use of a standard container design for the airport transfer station will ensure that road transportation of containers to WENT is possible.

The delivery of containerised waste from the airport to the RTS at Siu Ho Wan is considered as one of the possible options. Future consultancy study on this subject (for EPD or PAA) should address and evaluate other options in terms of economics, operational compatibilities, contract options and liabilities before arriving at a conclusion.

A high degree of cooperation between the EPD and the Provisional Airport Authority will be required to ensure that the above issues are properly addressed. This requirement should be reflected in the terms of reference of the feasibility, outline design and financial studies which normally precede calls for tenders from the private sector.

## 23.1 Assessment Methodology

Airports are generally not considered significant sources of potentially hazardous materials, chemical wastes or Dangerous Goods. Nevertheless, several airport support services involve materials potentially classifiable as hazardous. Without proper management, use and disposal, these materials can pose health risks and become environmental contaminants. The sources, nature and general characteristics of these materials are summarized in Table 23.1 and are briefly discussed below. This information is based on existing conditions at Kai Tak Airport, the new airport Master Plan Study, and what is known about other major airports worldwide. Both existing and pending legislation pertaining to hazardous materials and chemical wastes in Hong Kong were previously discussed in Section 3.5 (Environmental Legislation and Guidelines - Waste and Hazardous Materials). Sections 19 (Water Quality) and 22 (Solid Waste) also contain information that deals with hazardous materials at the airport.

### 23.1.1 Sources and Characteristics

*Aircraft Maintenance*

The maintenance, repair and servicing of aircraft will occur at a number of sites at the airport, although most of it will be conducted at the west midfield support area located between the two runways. Other similar, but smaller, aircraft maintenance facilities are planned for the general aviation area, Hong Kong Flying Services Department and the commercial heliport. Aircraft maintenance facilities will consist of maintenance hangars, aprons, engine test cells and a wide variety of production workshops and stores.

With respect to hazardous materials, routine servicing of aircraft engines (i.e. fluid changes, lubrication, etc.) gives rise to waste fuel, used oil, synthetic lubricants and other petroleum-based solvents. Traditionally, these waste materials are collected and stored on-site in drums or tanks by the maintenance contractors until they are transferred to the fuel farm for recycling or off-site disposal.

Aircraft washing gives rise to wastewater containing detergents and cleaning solvents that may be considered hazardous. Current plans are to collect the washwater in the foul sewer system for treatment prior to discharge.

Sewage from the aircraft chemical toilets and holding tanks contains formaldehyde or other similar disinfection chemicals. It is estimated that by 2040, approximately 1,400 $m^3$/day will be transported to a sewage treatment facility.

The repair of aircraft airframes, engines and other components generates a number of hazardous materials which require special storage and disposal. These repair services involve metal stripping, cleaning and plating. Liquid and slurry waste materials contain acids, alkalides, cyanides, chromium, lead and other metals. Air emissions contain hydrocarbons, chromium, cyanide and other potentially toxic or corrosive substances in the form of vapors, mists and particles. Depending on the operation, these wastes are either collected and reused on-site or transported off-site for recycling or disposal. Prior to use, the raw materials are contained as Dangerous Good stores.

*Table 23.1 Potential Sources of Hazardous Materials and Chemical Wastes*

| Sources | Materials/Wastes* | Characteristics | Control Plan/Method |
|---|---|---|---|
| Aircraft Maintenance | - Waste fuel, used oil.<br>- Synthetic lubricants, hydraulic fluids.<br><br>- Detergents and cleaning solvents.<br>- Sewage and chemicals.<br>- Acids, alkalines, metals.<br>- Paints, resins, solvents. | - Generated during aircraft engine and aircraft system servicing and repair.<br><br>- Contained in aircraft washwater.<br>- Collected from aircraft chemical toilets<br>- Used in metal plating, hardening and anodizing.<br>- By-products of aircraft painting operations. | - Collect, drum storage, remove off-site for proper disposal.<br><br>- Collect in foul system and treat.<br>- Dispose in sewage treatment facility.<br>- Reuse or dispose off-site.<br>- Collect and reuse or dispose off-site. |
| Fuel Storage and Transfer | - Aviation fuel, JP-1 and petrol. | - Stored at fuel farms; transferred through pipe lines or tank trucks. | - Inventory control, secondary containment, storage vessel and pipeline design standards. |
| Ground Support Equipment | - Used oil, hydraulic fluids, solvents, paint, spent batteries. | - Generated during servicing and repair of engines, components, etc. | - Collect and store for reuse or off-site disposal. |
| Air Cargo | Hazardous materials and dangerous goods. | - Very small percentage of air cargo and kept in small quantities. | - Segregate, store, label, package and handle according to Chemical Waste Management Regulation and Dangerous Goods Ordinance. |
| Fire Training Facility | - Wastewater containing fuel and fire fighting foam. | - Generated during fire training drills. | - Separate on-site, reuse or discharge to foul system. |
| Airport Maintenance | - Fuel, oil, herbicides, insecticides, fertilizers, paint. | - Used and stored on-site for routine airfield maintenance. | - Proper labeling, application and disposal. |
| Utilities | - Diesel fuel<br>- PCB's<br>- Fluorescent tubes<br>- CFC's | - Fuel for emergency generators.<br>- Contained in electrical transformers.<br>- Contain toxic metals.<br>- Contained in air-conditioning systems and used to extinguish fire. | - Fuel tank design standards.<br>- Phased out of use.<br>- Segregate from solid waste for disposal.<br>- Minimise use and recover. |
| Isolation Pad | - Hazardous cargo. | - Very small percentage of air cargo. | - Isolation from normal airport operations. |
| Roadways and Aprons | - Hazardous loads. | - Fuel trucks. | - Confined to perimeter roadways and not permitted in tunnels. |

*Note: The quantities of materials/wastes can vary widely as they are dependent on

(1) the final design of facilities, processes and operations;

(2) the owner/operator's internal policies regarding the type of material used; and

(3) future market and regulatory constraints.

*Source: Greiner-Maunsell, 1991*

Other activities that generate hazardous waste include aircraft painting and paint stripping. Painting operations give rise to organic solvents, resins and paint waste, in liquid, solid, and gaseous forms, which are also recycled or collected for off-site disposal. Paint stripping wastes consisting of paint stripper, paint flakes, rags and cardboard are also produced and are currently disposed of as solid waste.

*Fuel Storage and Transfer*

Jet A-1 for jet-engine aircraft, aviation gasoline (avgas) for piston-engine aircraft and petrol/diesel for ground support vehicles and boats will be stored at various locations around the airport site. Although these fuels are not classifiable as chemical wastes, they are considered hazardous.

Aviation fuel is typically stored in above-ground tanks of 10,000,000 litre capacity (27.6 m dia. x 16.67 m ht.). Based on projected demand forecasts, the two fuel farms, located at the south side support area, will have the combined capacity to store a six-day supply of approximately 150,000,000 litres of Jet A-1 by 2040. These facilities will consist of 16 tanks, pumping systems, a tanker truck loading station and administrative offices. In most cases, distribution mains (pipelines) and in-pavement hydrant systems will be used to deliver the jet fuel to the aircraft. Storage for avgas, petrol and diesel is not anticipated for the airport tank farms but will be provided at the general aviation facility and at the individual airport tenants, as necessary.

As the storage of fuel which has a flash point of less than 21°C does not exceed 10,000 tonnes, the two large tank farms are not considered Potentially Hazardous Installations (PHIs). However, any accidental fuel spill or leak can cause significant soil, groundwater or surface water contamination. Therefore, these fuel facilities and fuelling operations will be managed in ways to minimise their threat to the environment. For example, at the fuel farms, close supervision and record keeping, adequate storage volume and secondary containment, or bunding, will help prevent losses from leaks, spills and overfilling. Fuel transfer lines, valves and hydrants will meet design and performance specifications for leak tightness and loss detection.

At other, smaller facilities both above and below ground tanks must also be designed, installed and managed by the other airport tenants in accordance with these same criteria. Finally, spill containment and clean-up plans will be in place to deal with accidental releases of fuel as discussed in Section 19.1.2.

The supply of Jet A-1 to Chek Lap Kok is likely to involve various combinations of supply by barge or pipeline, either over land or under water. All of the options involve an off-loading fuel pier located off the northern edge of the airport. This location was chosen to reduce the risk of conflicts with aircraft and marine vessels and reduce potential environmental impacts to Tung Chung Bay. In addition, there will likely be restrictions on the transport of avgas, petrol and diesel fuel across the Lantau Fixed Crossing. Thus, it is anticipated that this supply would be by road tanker using the existing ferry transport to Lantau.

*Ground Support Equipment*

The maintenance, repair and servicing of aircraft ground support equipment will also be conducted in equipment maintenance buildings located in the western midfield support area of the airport. Similar to the aircraft maintenance materials described previously, the used oil, cleaning solvents and other hazardous wastes associated with repair, painting and/or servicing of these vehicles will be collected and reused on-site or transported off-site for disposal.

*Air Cargo Storage*

Air cargo will be handled on the cargo apron, in the cargo buildings and at the cargo village located at the south side of the airport. Most of the cargo, both imported and exported, is contained in boxes, bins or supported on pallets. In addition, the cargo is examined upon arrival and is transferred to the general, perishable or special cargo areas, as necessary. Very little air cargo transported in aircraft, or temporarily stored at the airport, is classifiable as hazardous material, chemical waste or dangerous goods. However, to the extent necessary, the WDO Chemical Waste Management Regulation and the Dangerous Goods Ordinance previously discussed in Section 3.5 will dictate the requirements for the labelling, packaging, handling and storage of these materials.

*Fire Training Facility*

The fire training facility, located on the western end of the airport, is composed of a burn pit, support equipment and a vehicle maneuvering area. This facility will be used intermittently by RFF personnel for fire training exercises. After the drills, the fuel/water/fire-fighting foam mixture will be drained from the lined burn pit, treated in a fuel/water separator and stored on-site for reuse. Excess wastewater and stormwater will be disposed of in the foul sewer system and treated before discharge.

*Airport Maintenance*

The airport maintenance facilities consisting of equipment maintenance shops, materials yards and storage areas will be located in the southwest section of the airport. Fuel, oil, herbicides, insecticides, fertilizers, paint, paint strippers and other similar materials will be stored at this location until used. As indicated in Section 19.1.2, proper labelling, storage, application and disposal will help minimise potential environmental impacts associated with these materials.

*Utilities*

Electric power will be supplied to the airport by the local power company. However, in some cases, select support facilities critical to sustaining airport operations will also be served by back-up diesel-powered generators which will require small fuel storage tanks.

Electrical transformers containing Polychlorinated Biphenyls (PCBs) are being phased out of use so it is unlikely that the on-airport substations will contain this material.

Fluorescent tubes used for strip lighting contain potentially toxic metals such as mercury, cadmium and lead. These tubes will be segregated from the solid waste stream and disposed of separately.

Chlorofluorocarbons (CFCs), used in air-conditioning systems and as fire extinguishers, are regulated under the Ozone Layer Protection Ordinance and their use in Hong Kong is restricted for all but essential purposes.

*Isolation Pad*

The isolation pad, located on the western end of the runways, is far removed from normal airport operations and will provide a place to park aircraft under threat of hijack, bombing, hazardous cargo or any other potentially hazardous material.

*Roadways and Aprons*

The internal network of surface roadways and tunnels will permit airport-related vehicles to shuttle throughout the airport without leaving the site. As a precaution, special use vehicles carrying hazardous loads (e.g. fuel trucks) will not be permitted in the tunnels and will use the runway loop roadways, the internal surface road system or select tower-controlled taxiways.

It is unlikely that the other primary airport support facilities will involve hazardous materials, chemical wastes or Dangerous Goods in amounts large enough to warrant special consideration in the Master Plan. These facilities include the passenger terminals, airport management offices, in-flight catering kitchens, air traffic control tower, postal service facilities, police station, communications center and the RFF/Sea Rescue Facilities. Minor exceptions may include small fuel storage tanks for fleet vehicles or emergency generators.

## 23.2 Existing Conditions

Historical land uses on Chek Lap Kok essentially preclude the chance that the island has been used for the production, storage or disposal of large quantities of potentially hazardous materials, chemical wastes or Dangerous Goods. A cursory field survey of the airport site by Greiner-Maunsell investigators confirmed that there are no existing large-scale industries, fuel facilities, waste disposal areas or other visible sources of these materials or wastes. At one time, explosives were likely stored somewhere in the northern section of Chek Lap Kok Island during the creation of the existing "test quarry" and seawall.

Currently, the only potentially hazardous materials at the airport site are limited to those associated with the Advanced Work Contract. These materials include fuel and other petroleum-based products for the construction vehicles and equipment. Explosives are also stored on-site in limited quantities for the land reclamation program. These materials were discussed in greater detail in Part B of this document.

The existing and pending ordinances, regulations and guidelines pertaining to hazardous materials, chemical wastes and Dangerous Goods have been discussed in Section 3.5.

## 23.3 Mitigation Measures

As previously stated, the airport is not considered a significant source of hazardous materials, chemical wastes or Dangerous Goods. These substances are primarily limited to the maintenance and repair of aircraft and ground support equipment, fuel storage and transfer facilities and other similar airport support services. However, mitigation measures have been developed in order to minimise the potential environmental impact of these hazardous materials and chemical wastes at the airport. Many of these measures have been developed as water quality mitigation measures which are described in Section 19.3.

### 23.3.1 Elimination, Substitution, Minimisation, Abatement

Wherever possible, waste minimisation policies should be adopted to prevent or reduce the arising of hazardous chemical waste in accordance with the Elimination/ Substitution/Minimisation/Abatement (ESMA) principles. If the use of a particular hazardous chemical cannot be eliminated due to the operational or financial constraints, then effective substitutes should be considered. If effective substitutes are not available then the use of the chemical should be minimised through reuse or recycling. Only as a last resort should other abatement measures be considered.

For example, the elimination of the use of paint strippers for aircraft is currently under consideration by several European operators. Alternatives to wet chemical paint stripping include a method based on high pressure jets of water. Other alternatives include plastic media blasting and cryogenic stripping, although there are concerns that these methods may affect the structural integrity of the aircraft. In addition, there is still need for treatment of the fuselage with an acid-based etching compound to ensure the surface is the correct porosity for repainting. Substitution of paint-strippers for those with a lower environmental impact is also currently being examined. Alternatively, the use of paints with a low solvent content, which subsequently require less paint stripper for removal, may be considered.

The opportunity for recycling is enhanced where large centralized facilities, such as an airport, exist. Recycling of waste aluminium from the maintenance operation is already practiced. Waste solvents may be recovered from liquid waste streams by distillation; however, it is understood that the majority of waste oils and solvents currently disposed of at Kai Tak Airport are subsequently sold for recycling or reuse by a disposal contractor licensed under the WDO.

Further potential for minimisation exists through the recovery of metals from electroplating wastes using technologies such as ion exchange or electrolytic treatment of rinsewaters. This has the two-fold benefit of reducing loads to the foul sewer and reducing the quantities of hazardous waste requiring disposal. Air emissions are effectively recovered under hoods or with other pneumatic devices. Carbon adsorption, air stripping and dilution air are other effective methods for reducing ground level concentrations to acceptable levels.

CFCs and halons will be recovered from air-conditioning plants and fire fighting equipment by the respective contractors during regular maintenance and decommissioning. Several alternatives to the use of PCBs in transformers exist and it is recommended that no PCBs be used in transformers at the new airport. Substitutions for CFCs in aerosols are also recommended or the substitution of pump-action containers for aerosols.

### 23.3.2 Stormwater Interception

Given the dependence of the stormwater drainage system on the control and containment of environmental contaminants, this system has been designed with safeguards. Although the final layout and design details of the system are still being developed, stormwater catchment boundaries have been established which segregate potentially high risk areas that may give rise to pollutants entering the storm drain. These areas include the fuel tank farm, aircraft fuelling sites, fire training facility and areas of industrial land use.

The fuel farm will be bunded so that if a leak, spill or tank failure occurs, the fuel would be contained and not enter the storm drain or contaminate the soil, surface water or groundwater. Strict monitoring to fuel throughput and inventory records will further minimise undetected releases. Under normal circumstances, stormwater from within the bund will either evaporate or pass through the fuel/water separator prior to discharge to the storm sewer.

At the aircraft refuelling areas, hydrants will have secondary containment and a separate stormwater/fuel interceptor system to collect any accidental spills together with the initial stormwater run-off which may contain trace amounts of fuel or oil.

At the fire training facility, the fuel/water foam mixture will be contained within the impervious liner of the burn pit. After the drill, the mixture is treated in a fuel/ water separator and the recovered fuel is stored for reuse in storage tanks. Contaminated water will be disposed of in the foul sewer system for treatment prior to discharge.

### 23.3.3 Accidents and Emergencies

As an additional precautionary measure, mechanical gates and stoplogs will be located at all of the outfalls and at other select points along the airport storm drainage system as previously discussed in Sections 19.3.2 and 19.3.3. These will be used primarily to isolate the drainage system from the inflow of tidal water. However, in the unlikely event of an emergency, these structures can be used to isolate pollutants such as aviation fuel in the system and prevent them from being discharged to surface waters. Manholes and sumps will also be provided at various intervals along the length of the drainage system so that isolated sections can be drained of pollutants or contaminated water by the use of submersible pumps. Finally, both forced ventilation and water flushing can be achieved through these manholes to help reduce the build up of potentially dangerous fumes.

### 23.3.4 Atmospheric Discharges

The potential sources of air emissions associated with the airport have been identified. In summary, the two primary sources of air emissions, aircraft and motor vehicles, will be controlled through design and operational elements of the runways, taxiways and access roadways. Emissions from fuel storage and transfer facilities generally remain well contained within their tanks and distribution mains. Aircraft maintenance facilities involved in the repair, servicing and painting of aircraft airframes, engines and other components will generate a variety of air emissions that are considered hazardous.

For example, chrome plating and metal anodizing operations give rise to sprays, mists and vapours containing chromium and cyanide or are otherwise highly toxic and corrosive. Aircraft painting operations that involve resins, organic solvents and paint also generate vapours and grit that are objectionable. Depending on the operation, spray and evaporative losses associated with metal works are minimised by recapturing the material under hoods or other similar enclosures. Airborne particles, including paint wastes, are collected under vacuum or with other pneumatic equipment. Recovered materials are either reused on-site or temporarily stored for off-site disposal.

Unrecoverable air emissions are removed from the air stream either by air stripping or carbon adsorption technologies. In other cases, the introduction of dilution air or the utilisation of high stacks reduce ground level concentrations of air emissions to acceptable levels.

### 23.3.5 On-Site Storage

The time period, accumulated quantity and characteristics dictate the method of on-site storage required for hazardous materials and chemical wastes before it is used or transported off-site for treatment, recycling or disposal.

Most airport facilities will generate less than 100kg of hazardous or chemical wastes in a calendar month. Some airport operations such as ground support and airport maintenance will generate between 100 and 1,000kg per month. Other airport facilities that operate aircraft maintenance and repair shops may generate 1,000kg or more every month. These sources have been discussed previously.

All airport facilities will be required to designate areas within the facilities where hazardous materials, chemical wastes or Dangerous Goods are to be stored. In accordance with the WDO and the Dangerous Goods Ordinance, these areas will be bunded, constructed of impervious materials, and have the capacity to contain 120 percent of the total volume of the containers. Indoor storage areas must have sufficient ventilation to prevent the build-up of fumes and be capable of evacuating the space in the event of an accidental release. Outdoor storage areas must be covered with a canopy or contain provisions for the safe removal of rainwater. In both cases, storage areas must not be connected to the foul or stormwater sewer systems.

Storage vessels in which hazardous materials or chemical wastes are temporarily stored on-site must meet the following criteria:

- Comply with the Waste Disposal Ordinance and the Dangerous Goods Ordinance.
- Each unit must be clearly labeled as containing hazardous materials or chemical wastes.
- Storage must not cause the material to generate any extreme heat, explosions, fire, fumes, dusts or gases.
- The stored materials must not cause corrosion, erosion or structural failure of the vessel.

For example, chrome plating and metal anodizing operations give rise to sprays, mists and vapours containing chromium and cyanide or are otherwise highly toxic and corrosive. Aircraft painting operations that involve resins, organic solvents and paint also generate vapours and grit that are objectionable. Depending on the operation, spray and evaporative losses associated with metal works are minimised by recapturing the material under hoods or other similar enclosures. Airborne particles, including paint wastes, are collected under vacuum or with other pneumatic equipment. Recovered materials are either reused on-site or temporarily stored for off-site disposal.

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### 23.3.5 On-Site Storage

The time period, accumulated quantity and characteristics dictate the method of on-site storage required for hazardous materials and chemical wastes before it is used or transported off-site for treatment, recycling or disposal.

Most airport facilities will generate less than 100kg of hazardous or chemical wastes in a calendar month. Some airport operations such as ground support and airport maintenance will generate between 100 and 1,000kg per month. Other airport facilities that operate aircraft maintenance and repair shops may generate 1,000kg or more every month. These sources have been discussed previously.

All airport facilities will be required to designate areas within the facilities where hazardous materials, chemical wastes or Dangerous Goods are to be stored. In accordance with the WDO and the Dangerous Goods Ordinance, these areas will be bunded, constructed of impervious materials, and have the capacity to contain 120 percent of the total volume of the containers. Indoor storage areas must have sufficient ventilation to prevent the build-up of fumes and be capable of evacuating the space in the event of an accidental release. Outdoor storage areas must be covered with a canopy or contain provisions for the safe removal of rainwater. In both cases, storage areas must not be connected to the foul or stormwater sewer systems.

Storage vessels in which hazardous materials or chemical wastes are temporarily stored on-site must meet the following criteria:

- Comply with the Waste Disposal Ordinance and the Dangerous Goods Ordinance.
- Each unit must be clearly labeled as containing hazardous materials or chemical wastes.
- Storage must not cause the material to generate any extreme heat, explosions, fire, fumes, dusts or gases.
- The stored materials must not cause corrosion, erosion or structural failure of the vessel.

- Incompatible materials and wastes must not be placed into the same vessel unless first rendered nonignitable, nonreactive or nonflammable.

- Continuously fed tanks must have a waste-feed cutoff or bypass system.

In addition, airport facilities must ensure that all involved employees are trained in proper waste and chemical handling procedures. Accidental spill and emergency plans must also be developed and include communications and alarm systems, evacuation procedures, fire control equipment, water supply and containment materials.

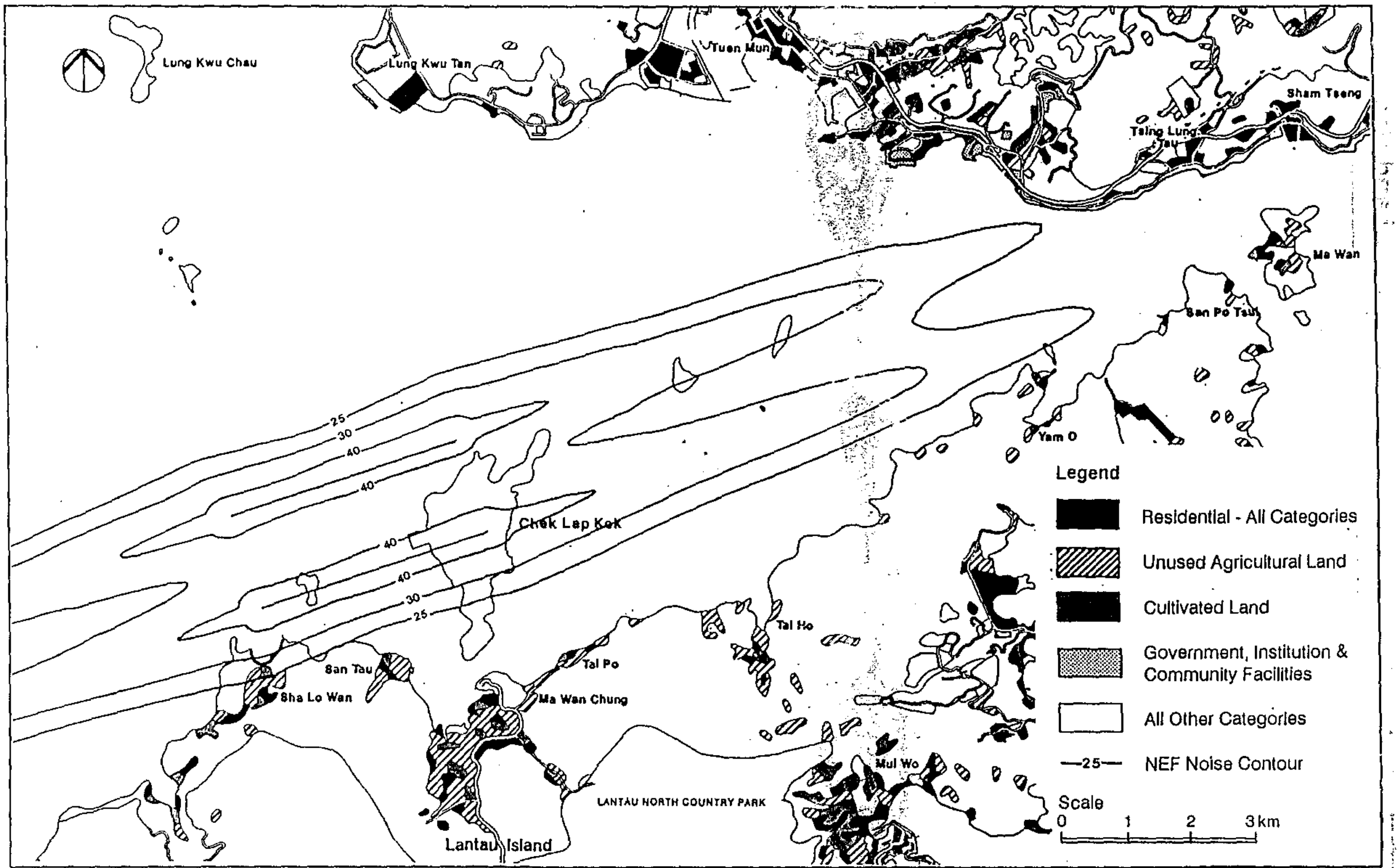
### 23.3.6 Off-Site Disposal

When the Waste Disposal Ordinance Chemical Waste Regulations are adopted, the off-site transport and disposal of hazardous and chemical waste will have to be carried out by qualified contractors licensed by EPD. In this way, the people and equipment involved in the movement, storage and receipt of hazardous or chemical wastes from the airport are properly trained and designed for the job.

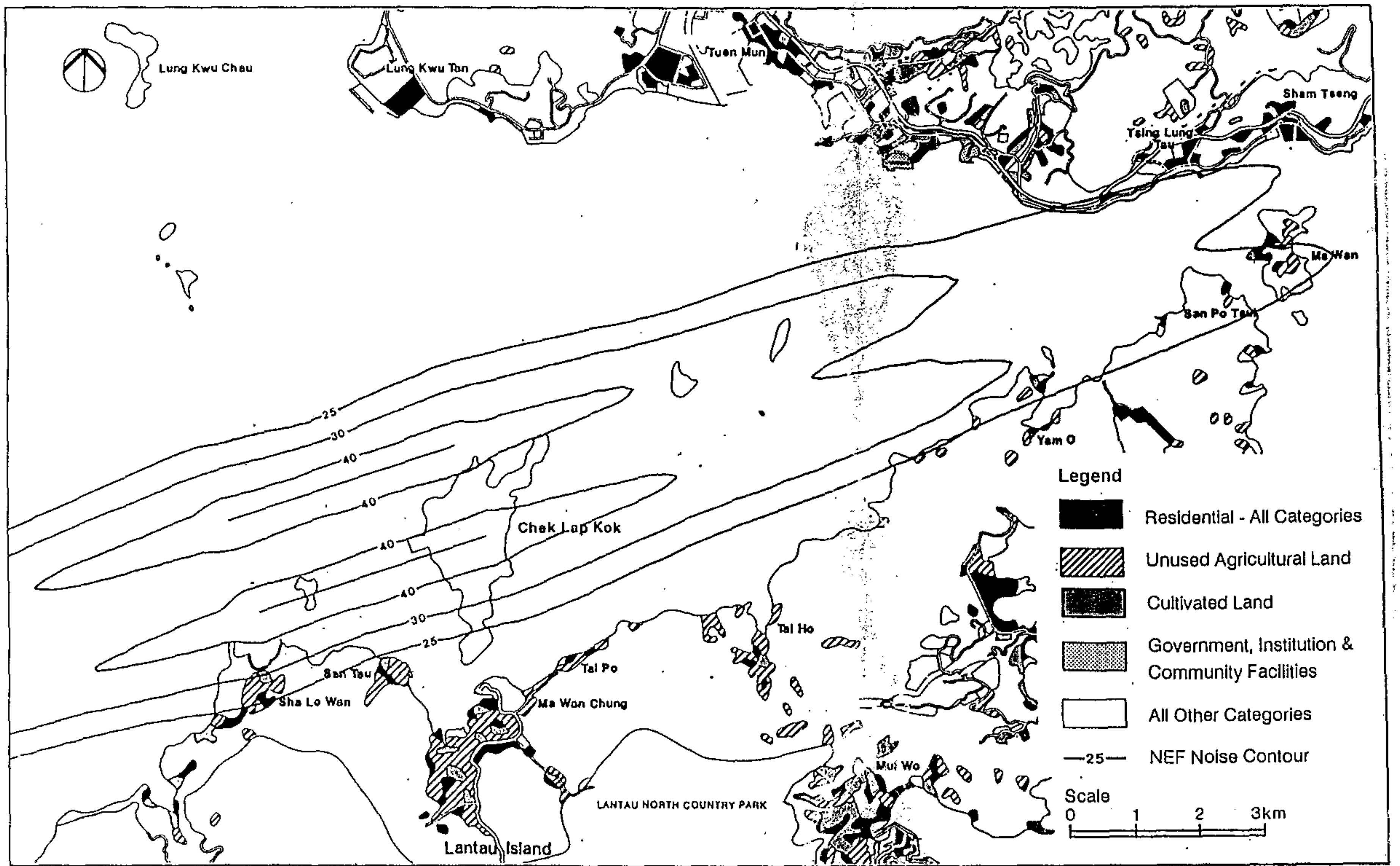
Under the Chemical Waste Regulations, a manifest must accompany the waste whenever it travels and each individual involved in the shipment, treatment, and disposal must accept responsibility. When the waste reaches its final destination, the airport facility owner or operator will obtain copies of the manifests to confirm that the original quantity of material was transported and disposed of in a manner consistent with the Chemical Waste Regulations. Moreover, chemical waste producers will be required to be registered with EPD. After 1992, the new Chemical Waste Treatment Facility (CWTF) at Tsing Yi will be operational and will be able to receive wastes from the airport.

Impacts on land use due to the operation of the new airport come in two forms. There are indirect impacts due to development pressure in the vicinity of the new airport, along the access routes, and on Hong Kong in general as more capacity for aircraft operations is introduced. There will also be massive redevelopment in Kowloon as height restrictions and noise impacts are removed as a result of airport operations moving from Kai Tak. These secondary impacts must be addressed as specific developments are proposed and details are submitted to Government for approval.

The direct operational impacts on off-site land use consist primarily of noise impacts. The existing land use within the year 2000 NEF contours is shown on Exhibit 24.1. Only a small portion of the 25 NEF contour is not over water. In the area of Sha Lo Wan, on North Lantau, there is limited residential development and cultivated land within the contour. Most of the land is either vacant or unused agricultural land. It is recommended that the residents within the contour be relocated, and that this area be converted to a noise compatible land use. The projected year 2030 contours, as shown on Exhibit 24.2, covers a larger, but still relatively small land area. The village of Sha Lo Wan, residential areas on Ma Wan, and scattered residences along the North Lantau coast and along Castle Peak Road are projected to fall within the 25 NEF contour. The noise projections for the year 2030 are conservative (tend to over-estimate impacts) and no firm recommendations on altering existing development are made at this time. New development within the 25 NEF contour should be compatible with elevated noise levels. Firm recommendations on existing development should be reviewed as noise contours are updated in five year increments.




*Existing Land Use within Year 2000 NEF Noise Contours* ***Exhibit 24.1***




*Existing Land Use within Year 2030 NEF Noise Contours* ***Exhibit 24.2***

The socioeconomic impacts associated with the operation of the new airport are anticipated to be significant, and mostly positive. Economic studies have been conducted in the process of developing a comprehensive Port and Airport Development Strategy (PADS) which are summarised in the *PADS Final Report (1989)*. Detailed classified studies have also been conducted regarding the individual projects, including the new airport. The airport is considered essential to allow Hong Kong's economy to continue to expand rapidly. It will generate increased revenues due to its capacity to handle substantially more aircraft operations than Kai Tak, and will also be able to accommodate additional airport tenants and other on and off-site airport related development. An inventory of the types of land uses that are dependent on the airport, and which can expand with increased airport capacity, can be found in *Study of Industrial and Commercial Enterprises that Need Relocation with the Airport (SICENRA) - Final Report (1991)*. Direct positive economic impacts to Hong Kong include increased spending by airport and airline employees, passengers, and on and off-site, airport dependent, facility employees. Increased revenues generated by the airport will include additional airline landing fees, surcharges on passenger tickets, cargo revenues and airport tenant lease payments. Indirect positive economic impacts will include the respending of dollars, as well as the increased payment of property taxes from airport related development. The direct and indirect positive impacts as a result of the new airport will strengthen the economic vitality of the region.

Potential negative social impacts due to airport related development leading to the disruption of village life on North Lantau is being limited by restricting urbanization to well defined areas. Details on proposed North Lantau Development and recommended development constraints are described in detail in NLDS reports.

The impact resulting from the operation of the new airport at Chek Lap Kok on the gazetted archeological sites is essentially restricted to visual and noise intrusion and should be minimal. Only one frequently utilised site at Sha Lo Wan is located within the 25 NEF contour. Other recognised sites are not considered to be impacted.

The impact to the Tin Hau Temple located along the shoreline at Sha Lo Wan is unavoidable and cannot be readily mitigated. The temple is not, according to the Village Representative (VR), utilised by other than local residents except for major Public Holidays. Therefore, as has been previously proposed in Section 16 (Noise), the relocation of the temple is recommended if it is verified by further studies that the noise and visual impact of the new airport will impair its utilisation.

Efforts to minimise impacts on archaeological sites which might result from the New Town, NLE and other airport related developments are described in the individual environmental impact assessment documents for these projects.

## 27.1 Assessment Methodology

The discussion of the visual impact of the new airport at Chek Lap Kok comprises a brief consideration of the airport site's visibility and concludes with recommendations for mitigation where appropriate.

The premise throughout this assessment is that the consideration of the visual impact is to identify areas where screening and/or building massing will be beneficial in reducing any negative aspects of the visual impact. The underlying assumption of the airport location is taken as predetermined. The purpose of this visual impact assessment is to identify mitigation measures and design issues which should be incorporated in the development of the airport design.

Notwithstanding the scale of the development, the excitement of an airport as an object for observation needs to be taken into account in the visual impact assessment.

The impact assessment has been conducted by on site observation and review of the conceptual layout drawings for the airport. The extent of impact is assessed by discussing the visibility of the site, and from where it is viewed. Views are divided into distant, middle and near views, and appropriate mitigation measures are referred to in each instance.

## 27.2 Existing Environment

### 27.2.1 Visibility

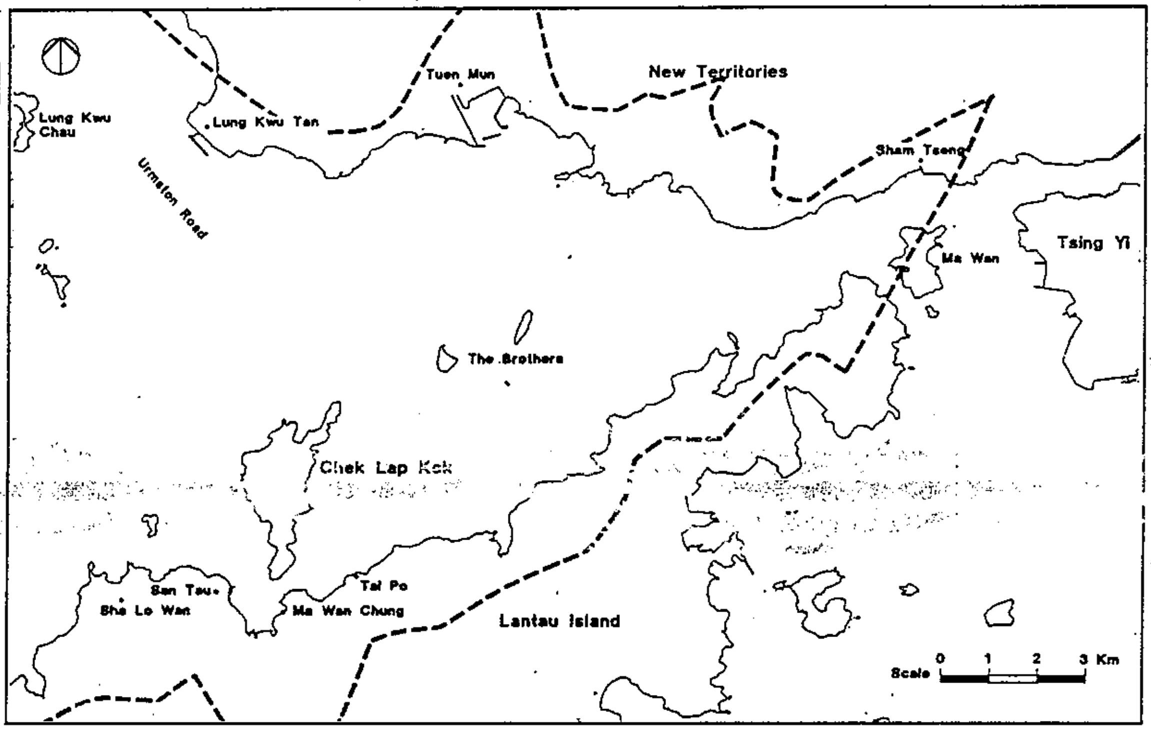
The visibility of the airport site can be assessed by pin-pointing the position of the island of Chek Lap Kok and its surroundings.

Chek Lap Kok is the largest island located off the north coast of Lantau Island and is therefore a significant landmark in the channel north of Lantau. It has a broad area of visual influence with views being restricted to the south by the Lantau Peak Ranges and to the north by the western New Territory Ranges. The area of visual influence throughout the channel north of Lantau Island is uninterrupted as there are only two other islands in the eastern section of the channel, The Brothers, which are quite small and comparatively low in elevation. The zone of visual influence is shown on Exhibit 27.1 on the following page.

### 27.2.2 Distant Views

Distant views of Chek Lap Kok are obtained generally from the southwestern New Territories from Tap Shek Kok in the far west to Tsuen Wan. Views along the Tuen Mun Highway, and from the villages along the western section of Castle Peak Road, will reach as far as the airport site. Elevated parts of the mountains behind will also provide unrestricted views across the channel north of Lantau to the site.

The closest populated area obtaining distant views of Chek Lap Kok and its environs is Tuen Mun. The township is situated between Castle Peak and the So Kwun Wat range and extends northwards within a relatively flat valley. The location combined with extensive building development along the town foreshore area restricts the views from the town centre area. The elevated buildings along the foreshore, however, obtain distant views to Chek Lap Kok and Lantau Island.




*Zone of Visual Influence of The Airport and Related Developments* *Exhibit 27.1*

Views would also be obtained from the recreation and housing developments west of Tuen Mun. The elevated southern ranges of the western New Territories obtain views of the channel north of Lantau and Chek Kap Kok. Views would be obtained from as far away as Tai Lam and Tai Mo Shan Country Parks where walking tracks allow access to elevated vantage points.

The distant views from the southwestern New Territories would in general locate Chek Lap Kok as a foreground element against which the elevated hills of Lantau Island rise behind. Sunset Peak and Lantau Peak, being the highest of the Lantau hills, rise to an elevation of 869 and 934mPD respectively. Chek Lap Kok has a highest elevation of 121mPD and a north to south orientation. The views from Tuen Mun locate the island as quite a low narrow land mass merging with Lantau Island as a single land area.

The existing small fishing villages and log pond areas have distant views, partially restricted by the coastline, back to the island of Chek Lap Kok. The eastern coast of Chek Lap Kok is about the only part which is visible.

The main ferry route between Hong Kong Island and Tuen Mun allows distant views of Chek Lap Kok and the north Lantau peninsula. Weekend routes between Tuen Mun and Sha Lo Wan on north Lantau provide more direct views of Chek Lap Kok Island.

### 27.2.3 Middle Views

Mid range views of Chek Lap Kok and surrounding areas are obtained from elevated points along the Lantau Island ridgeline. The range extends along the length of the island. The highest hill-tops of Lantau and Sunset peaks bound an open valley with a north aspect that drops to the coastline and villages of Tung Chung.

The valley area in which Tung Chung nestles allows quite open middle range views to the island of Chek Lap Kok and distant views to the south coast of the New Territories. Tung Chung and the valley behind contains the most populated area along the North Lantau coastline from where the airport site can be distinguished.

The Lantau ridgeline west of Hung Fa Ngan is mostly Country Park and is frequented by visitors on walking trips. There are a few small villages located within the western part of Lantau which have restricted views of Chek Lap Kok due to the elevated knoll to the west of Tung Chung. However the airport reclamation will be in their direct line of vision. These villages include Sha Lo Wan and Sai Tso Wan.

East of Tung Chung, the island of Chek Lap Kok is visible from the coastal areas between Tung Chung, Ngai Kwu Long and Luk Keng.

### 27.2.4 Near Views

The most direct views of Chek Lap Kok and the sea to the west are obtained from the near villages on the north coast of Lantau. The largest populated area is Tung Chung located in a valley enclosed by the elevated ranges of Lantau and Sunset Peaks. Ma Wan Chung is the largest village located along Tung Chung Wan. The view from Ma Wan Chung is partially obscured through an elevated knoll area directly to the north of the village. The knoll prohibits visual links between Ma Wan Chung and Chek Lap Kok. Other villages located along the Lantau coastal edge include Sha Lo Wan, San Tau, Tai Po and Pak Mong. These small villages have the most direct views of Chek Lap Kok and incorporate coastal frontage aspects.

## 27.3 Visual Impact of Airport and Related Developments

### 27.3.1 Distant Views

The airport, New Town and North Lantau Expressway will be visually prominent to distant views. This will depend to some extent on local weather conditions.

The construction phases of these developments will be quite pronounced throughout the area of visual influence within the channel north of Lantau Island. The proposed airport site and related developments will be under construction over several years and will therefore dramatically change the visual outlook throughout the channel.

Once constructed, during the operational phase, the airport will be visible from all the locations described previously. The dominant features will be the buildings which rise above the level of the reclamation. Building massing and a cohesive design approach to buildings will therefore be an important aspect for all views of the airport. Views from elevated positions will also distinguish the flat nature of the reclamation and the straight edges of the reclamation.

### 27.3.2 Middle Views

The airport and related development at Chek Lap Kok will have a pronounced effect on the mid range views from the northwestern section of Lantau Island, and the coastal areas to the east of Tung Chung. As described for the distant views, the buildings and reclamation edge will be the major components of the views.

The open views from the North Lantau approach will extend to the southwestern New Territories. The airspace above the channel will include aeroplane activity relating to flight take off and landing which will be a visual feature from the approach route.

The most significant middle range views of the proposed airport and related development will be obtained from the approaches of the rail and road routes along North Lantau. The open space reserve, which remains as the remnant of Chek Lap Kok Island, will be visible from these approaches as a headland close to the coast.

### 27.3.3 Near Views

The existing villages will incur varying levels of visual intrusion, all of which would be considered substantial.

The proposed construction of the airport and related development will significantly alter the visual outlook from the existing island villages remaining. The construction, programmed over several years, will result in the complete redevelopment of Chek Lap Kok and the development of a New Town site that will incorporate the existing villages of Tung Chung. The airport and New Town will be serviced by the North Lantau Expressway, which will traverse the lower reaches of the North Lantau coastline between Tung Chung and the northeastern tip. The view of the airport from the road and adjacent railway will be significant and will be viewed by a large number of people; the travellers. The most significant near views will be obtained from the approach points of the road route through the New Town development and on the immediate approach road to the terminal.

## 27.4 Mitigation Measures

### 27.4.1 Distant Views

Views of an airport can be considered positive in many respects. Witnessing aircraft taking off and landing is in itself a spectacle of interest. The runways and aircraft hanger areas are necessarily low in building proportions to perform their function.

The visual interest from long distance views will therefore be achieved by the massing arrangements of the buildings. The design of the terminal in particular will be significant in creating a cohesive and dramatic focus of the views of development from all vantage points. Cargo and freight handling facilities and buildings which are likely to be more disparate in their distribution would be best treated in muted tones, to minimise their visual impact, so that views focus on the aircraft and terminal.

The edges of the reclamation confined by the sea walls will also be distinguishable from long distance views. Detailing of the sea walls, and making opportunities to reduce rigid lines would be beneficial in the creation of a less stark landform.

There is minimal mitigation considered possible to alleviate distant views of the airport development apart from that mentioned above. It may be desirable in some places to consider, for example, the inclusion of off site planting within Country Parks and the foreshore developments along the southwestern New Territories.

### 27.4.2 Middle Views

Where visual mitigation for mid range views may be considered necessary, such as within selected areas of the Country Park, off-site planting could be implemented. This would address selective screening of high impact views of the airport and related development.

Selective screen planting may also be desirable along the approach route to screen adjacent development and emphasise the flight activity within the open channel area. This is being considered and assessed by concurrent studies.

In the open space reserve the retention and augmentation of the indigenous vegetation can have a significant screening effect on some middle range views. This will provide both a visual link to the vegetated knolls in the town park of Tung Chung and provide a green back drop to some middle range views from within the Tung Chung valley.

### 27.4.3 Near Views

The views of the airport from the road and train by the pending traveller can be optimised by selective screening, but still allow glimpses of the airport, aircraft, the views out to sea and of the surrounding countryside. Rear views of airport service buildings and cargo related developments are best screened, so that the views maximise the drama of the surrounding landform and the expression of the main airport buildings, such as the terminal and associated commercial developments.

Screening along the approach road can achieve this by allowing views out to the east on the seaward side, whilst using mounding and dense planting to effect screening of the airport related facilities, such as the business park and fire and police stations, which are proposed for these areas.

Ground modelling to achieve more effective screening can be incorporated along the road edge on the airport side. Planting design will need to blend the more urban character of the actual airport with the proposed New Town within the broader natural landscape surroundings. Planting should aim to create a lush character, framing the views of the terminal.

The open space reserve comprising the southern headland of Chek Lap Kok will become a focal point within the approach to the airport. The landform and vegetative cover of this area will effectively screen the airport services and cargo area from near views. This will be the culmination of the roadside mounding and planting.

The visual connection between the reserve and the vegetated knolls retained as part of the New Town development will be obvious from certain angles. This will assist in both linking the town with the airport whilst providing some visual separation.

Views from the villages, particularly west of Tung Chung, will extend over the remaining channel between Lantau's north coast and the reclamation to the sea wall and the cargo handling areas. Screen planting along the roads would help to mitigate the views from the villages of the rear views of the airport cargo buildings.

### 27.4.4 Airport Views

The views from the flight approach will introduce the visitor to the natural scenery of the Lantau area.

The view from the railway or road in a southeasterly direction towards North Lantau will be the first impression that visitors have of Hong Kong. Screen planting principles described above which allow views through to the sea, countryside and New Town, but screen the airport associated developments west of the approach road will be important in creating a strong visual link between the surrounding natural landscape, the new development at Tung Chung, and the anticipation of the urban area of Hong Kong.

# Part D

## Summary

## 28.1 Noise Impact

### 28.1.1 Summary of Construction Impacts

An analysis of construction noise impacts has shown that unmitigated 24-hour site formation activities will produce noise levels which will clearly be unacceptable at Noise Sensitive Receivers (NSRs) along the North Lantau coast to the south of the airport site. Mitigation measures were therefore designed, with the assistance of the Environmental Protection Department (EPD), to bring noise levels down to more acceptable levels. With all practical mitigation implemented at the construction site, approximately 350 NSRs will still be exposed to noise levels in excess of EPD designated Basic Noise Levels.

Impacts from dredging activities and Building and Infrastructure Contracts (BICs) activities generate lower noise levels at the closest NSRs, and these activities can be more readily constrained, and noise mitigated, so as to make them acceptable.

### 28.1.2 Recommendations

In order to minimise the noise leaving the airport construction site and to mitigate noise levels at the NSRs the following mitigation measures should be implemented:

(a) Preserve the southern tip of Chek Lap Kok to act as a natural noise barrier.

(b) Construct a southern berm to +10mPD and sufficiently in advance of the main reclamation to break line of sight between sensitive receptors and noise generating plant. The portions of the berm required to shield BIC activities will be retained until unmitigated noise from those activities will no longer exceed Base Noise Levels.

(c) Develop the Chek Lap Kok excavation plan so that all prudent measures are taken to shield Tai Po from noise generating plant.

(d) Specify the use of rock drills that have a sound power level of 110 dB(A) or less.

(e) Provide funding for the acquisition and operation of air conditioners for approximately 73 NSRs. With air conditioners in use, a portion of the dwelling unit can be closed and the walls can provide insulation from external noise.

If these mitigation measures are implemented the analysis shows that EPD established Allowable Noise Levels for all NSRs can be complied with. To assure compliance with Allowable Noise Levels the following measure should be taken:

(f) Compliance monitoring should be conducted by the Engineer and if the Allowable Noise Levels are exceeded the Contractor should be required to adjust the use of his plant.

### 28.1.3 Summary of Operational Impacts

Noise Exposure Forecast (NEF) contours for 25, 30 and 40 values were generated for the years 2000 and 2030. Based on existing (year 1991) development, in the year 2000 only approximately 14 NSRs, all along the shore of Sha Lo Wan on North Lantau, will be within the 25 NEF contour. In the year 2030 approximately 500 NSRs are projected to be within the 25 NEF contour. These NSRs are primarily located in and around the village of Sha Lo Wan and on the island of Ma Wan, with a few being scattered along the north coast of Lantau and along Castle Peak Road. Approximately 14 of these NSRs, all along the shore of Sha Lo Wan, are projected to be within the 30 NEF contour in the year 2030. The total number of NSRs projected to be impacted is exceptionally small for a major international airport - primarily because such a large proportion of the contours is over open water.

A very positive impact resulting from the transfer of operations from Kai Tak to the new airport is the removal or substantial reduction of very undesirable noise impacts from large areas of Kowloon. The noise environment of several hundred thousand residents will be substantially improved as a result of the new airport operation.

Maintenance hangars and aprons are located in the western midfield area. Maintenance run-ups will be performed at a specially designed, bunded, run-up pad which will be approximately 1600m further removed from the nearest NSR than the end of the closest runway. Run-ups for maintenance are therefore not considered to have any significant impact on the North Lantau noise environment.

### 28.1.4 Recommendations

Throughout the master planning process noise impacts have been an important consideration in developing and selecting alternative facility locations and configurations. In the Phase 1 screening process runway configurations and alignments were favoured which minimised noise impacts. Later, the midfield location of aircraft maintenance facilities was selected from several alternative locations, all of which would have been closer to NSRs. Additionally, a noise/blast barrier is proposed to shield the maintenance run-up pad from NSRs, and thus noise from this type of activity is even further reduced.

(a) For those NSRs which fall within the 25 NEF, year 2000 noise contour, relocation by Government is recommended. All of these NSRs are also impacted by construction noise and are to be provided mitigation for these impacts. Rather than providing some mitigation for construction noise and then additional mitigation for operational noise, it is recommended that residents of these NSRs be compensated just once by means of permanent relocation. All new construction of NSRs within the 25 NEF, year 2030 noise contour, should be prohibited.

(b) A portable noise meter, capable of interfacing with a computer system, should be acquired by PAA for validating modelled contours and for collecting site specific data if a complaint is received.

(c) The Master Plan and associated operational forecasts should be updated prior to the programmed airport opening in May 1997. Subsequent to the opening of the airport the Master Plan and operational forecasts should be updated in five year increments. During each revision of the Master Plan, operational noise should be modelled based on a revised forecast. This should be done using the then current noise model which will have new, and likely quieter aircraft in the data base. During each of the noise modelling updates, 25 NEF contours should be projected for the existing year and the fifth year into the future. If newly impacted NSRs are identified within these contours then mitigation measures should be developed and implemented.

## 28.2 Air Quality

### 28.2.1 Summary of Construction Impacts

Excavation and land reclamation activities associated with the new airport site at Chek Lap Kok will have a temporary impact on local air quality with particulate matter (dust) having the greatest impact. Blasting, excavation, loading, transport and the placement of fill material are the primary sources of dust associated with a project of this magnitude. Concrete/asphalt plants are also potential sources of air emissions.

In order to determine the potential impact of dust in the vicinity of Chek Lap Kok and Lantau Island, an assessment was conducted using an atmospheric computer dispersion model and the general design principles of the site excavation/ reclamation plan. Both "worst case" and "most probable" meteorological conditions were examined in order to more fully evaluate the potential effects of this project.

The highest predicted "worst case" one hour Total Suspended Particulates (TSP) levels are expected to occur immediately following blasting operations. For example, during Quarter 1 the maximum blast-related TSP levels are predicted to range from 308 to 1,286 $ug/m^3$ at the 13 receptors located along the north-central coastline of Lantau Island. During Quarter 2, the maximum blast-related TSP levels are predicted to increase to the range of 616 to 5,882 $ug/m^3$ at these same receptors in response to a corresponding increase in production rates and the work site moving further south on Chek Lap Kok. However, as the project progresses to Quarter 3, TSP levels following a blast are expected to decline significantly, ranging from 111 to 509 $ug/m^3$ by Quarter 7, as the elevation of Chek Lap Kok is lowered. Measured one-hour TSP values in excess of 500 $ug/m^3$ exceed the EPD-recommended Dust Suppression Measures Guidelines for construction activities.

By comparison, the highest predicted "worst case" one hour TSP levels associated with the excavation/reclamation process are within the EPD Dust Suppression Measures Guidelines level of 500 $ug/m^3$ for TSP.

The Hong Kong Air Quality Objectives (AQOs) and EPD 24-hour TSP Dust Suppression Measures Guidelines level of 260 $ug/m^3$ could be exceeded by the highest predicted "worst case" 24-hour TSP levels at two receptors in Quarter 2 and at one receptor in Quarter 3. However, there are no predicted exceedances of the 24-hour TSP AQO or the EPD guideline in Quarter 1 or Quarters 4 through 7.

Finally, the "worst case" 24-hour Respirable Suspended Particulates (RSP) levels which include contributions from both blasting and the excavation/reclamation operations are predicted to be well within the 24-hour AQO for RSP of 180 $ug/m^3$. No one hour AQO or EPD guideline exists for RSP.

Under "most probable" meteorological conditions, or when the wind is from the east across Chek Lap Kok Island, the dispersion of TSP and RSP is towards the west and the dust plume will likely remain distributed over water and the land reclamation area. The highest predicted one hour TSP impacts at the 13 receptors on Lantau Island are well within the EPD one hour TSP Dust Suppression Measures Guidelines level of 500 $ug/m^3$. Similarly, the highest predicted 24-hour TSP impact at the 13 receptors on Lantau Island will not be more than one $ug/m^3$ under the "most probable" meteorological conditions. Again, this is well within the 24-hour AQO and EPD guideline of 260 $ug/m^3$.

The RSP modelling results, under "most probable" meteorological conditions, also indicate that the potential impact to receptors on Lantau Island will be minor when the wind direction is from the east.

The creation of dust during the airport site preparation project is unavoidable. Fortunately, the remote location of the project site and the prevailing wind patterns will limit the potential impacts at receptors on Lantau Island. Based on the computer modelling results, the greatest potential impacts are limited to the initial construction period and when the wind is from the north over Chek Lap Kok. In particular, under these "worst case" conditions, the dust plume created by the blasting operations could unavoidably contribute heavily to elevated TSP levels along the coastline of North Lantau Island in the vicinity of Tung Chung, Sha Tsui Tau and Ma Wan Chung.

### 28.2.2 Recommendations

(a) As a control measure, TSP monitoring should be conducted by the Engineer at the closest downwind receptors on Lantau Island. The monitoring should be undertaken to measure compliance with the AQOs for TSP and RSP, and the EPD Dust Suppression Measures Guidelines, which will be defined as the Air Quality Requirements (AQRs) for the Site Preparation Contract (SPC) and BICs.

(b) The SPC Contractor should at all times be required to minimise dust nuisance resulting from his non-blasting activities and shall keep available adequate plant including water bowsers and spray bars for this purpose, and in the absence of suitable rainfall any exposed area should be wetted down as far as is practicable to meet the AQRs. The Contractor should also be required to properly manage, to the extent possible, the blasting and excavation operations during periods of "worst case" meteorological conditions so as to minimise the generation of dust.

(c) If AQRs are exceeded despite these mitigation measures, the Contractor should be required to identify the source of the dust generation and implement operational controls for activities, other than blasting, such as:

Should these reccos be implemented even if AQR is met?

i. Adjust his method of working to minimise the generation of dust.

ii. Limit, to the extent possible, the surface area of potentially erodible earth material exposed by clearing, grubbing, excavation, and fill operation.

iii. Place dust collectors on drill rigs.

iv. To the extent practicable: 1) treat material, which when handled is causing the AQR to be violated, with water or watering agent sprays prior to being loaded into a vehicle; and 2) for stockpiles of sand and aggregate, use water sprays to dampen stored materials and when receiving raw material as necessary.

v. Where dusty materials are being discharged to vehicles from a conveying system at a fixed transfer point, a three-sided roofed enclosure with a flexible curtain across the entry shall be provided where necessary.

vi. Where necessary fit conveyor belts with windboards and conveyor transfer points and hopper discharge areas with enclosures to minimise emission of dust, and enclose all conveyors carrying materials which have the potential to create dust and install belt cleaners.

The SPC Contractor is likely to establish his principal site of operations in the vicinity of the Advanced Works Contract reclamation, but the BIC Contractors may well carry out activities at locations closer to sensitive receptors. For cement handling and batching in close proximity to sensitive receptors the following clauses should be mandatory:

(d) Store cement or pulverised fuel ash delivered in bulk in closed silos fitted with high level alarm indicators. Fit all air vents on cement silos with EPD approved fabric filters provided with either shaking or pulse-air cleaning mechanisms.

(e) For dry mix batching have the truck batching aperture shrouded and fitted with water suppression sprays.

### 28.2.3 Summary of Operational Impacts

The two principal sources of air emissions associated with the new airport are aircraft and motor vehicles. Other sources include aircraft support equipment, fuel facilities, maintenance areas and a variety of other smaller sources.

Based on the design and operational elements of the airport Master Plan, the generation of air emissions associated with the primary sources of air pollution at the airport and the associated North Lantau Expressway (NLE) access facility was estimated for 2040 conditions. The results indicate that aircraft are predicted to generate 15,450 tonnes/year (42,339kg/avg. day) of emissions; motor vehicles, 13,409 tonnes/year (36,736kg/avg. day); ground support equipment 2,534 tonnes/year (6,942kg/avg. day) and fuel facilities, 33 tonnes/year (90kg/avg. day).

The results of the PAL model dispersion analyses indicate that, under "worst case" meteorological conditions, the highest one and 24-hour levels of airport and NLE related nitrogen dioxide concentrations are 251 and 124ug/m$^3$, respectively, at a receptor in close proximity to the expressway. The highest one and 8-hour carbon monoxide levels are predicted to range between 2955 and 2561ug/m$^3$. Under "most probable" meteorological conditions, the nitrogen dioxide levels are expected to range between <1 and 74ug/m$^3$ over the one hour period and range between <1 and 37ug/m$^3$ over the 24-hour period. Contributions to pollution levels on North Lantau from on-airport activities are projected to be well within AQOs in the year 2040 for all receptors except those along the shore of Sha Lo Wan (244ug/m$^3$ for "worst case" meteorological conditions).

The results of the terminal area dispersion model indicate that, under "worst case" meteorological conditions, the highest one and 24-hour nitrogen dioxide levels are 175 and 92ug/m$^3$, respectively. The highest predicted one and 8-hour carbon monoxide levels in the vicinity of the terminal are 33 and 41ug/m$^3$, respectively. Including the combined contributions from aircraft and motor vehicles, these levels are well within the AQOs for these pollutants.

### 28.2.4 Recommendations

(a) Airport activities, other than expressway traffic, are projected to have a significant impact in the year 2040, only during "worst case" meteorological conditions (less than 25 percent of the time) on residences along the shore of Sha Lo Wan. It has already been recommended, based on noise impacts, that the residents in this area be relocated and replaced with less sensitive land use. The results of the air quality analysis further supports this recommendation.

(b) For the analysis of landside terminal air quality it was assumed that design features, as represented in the current Master Plan, will be implemented. The location of the main terminal complex close to the eastern airport boundary maximises natural ventilation benefits of land-sea breezes, and the segregated airside/landside main terminal complex configuration reduces co-mixing of aircraft and motor vehicle emissions. These air quality enhancing features should be incorporated into the final design, or a revised air quality assessment should be made to assure that compliance with the AQOs can be achieved without them.

## 28.3 Tidal Flow and Water Quality

### 28.3.1 Summary of Construction Impacts

The recalibrated Tidal Flow Model from the Government's Water Quality and Hydraulic Model (WAHMO) suite was used to simulate effects on tidal flow of the airport reclamation configuration. The model runs excluded a flushing channel between the reclamation and North Lantau, in order to assess "worst case" conditions. It was found that the reclamation had insignificant impact on flows remote from Chek Lap Kok. Significant local effects observed were 100 percent increases in water speed in the channel between West Brother Island and the northeastern corner of the reclamation, which would result in local erosion. Flows were predicted to reduce to the west of the reclamation and in East Tung Chung Bay, which could result in increased local siltation and potential decreases in water quality should the area be subject to additional pollutant loading.

Potential effects of maintaining a flushing channel were assessed. The analysis suggested that East Tung Chung Bay, east of Chek Lap Kok, is relatively well flushed by the flows presently entering the bay south of Chek Lap Kok Island. Provided existing flows with peak speeds of approximately 1.0 m/s are maintained, water quality and siltation patterns following construction of the airport should not change significantly, unless new pollutant loads are introduced. It will therefore be important to ensure that no pollutant flows are discharged to the channel.

The recalibrated WAHMO tidal water quality model was used to assess water quality impacts of the airport reclamation configuration, again without a flushing channel to simulate "worst case" conditions. The only significant effects observed were increases in chlorophyll a in East Tung Chung Bay indicative of increases in algal growth. Hong Kong's inshore waters are known to have the potential for development of algal blooms known as red tides, some of which contain toxic phytoplankton. The reduction in flushing of the East Tung Chung Bay which would result from an airport reclamation continuous with the North Lantau shoreline would therefore have potential adverse impacts.

Potential impacts arising from dredging and dumping operations at the airport, borrow areas and disposal sites were simulated using sediment dispersion and transport models. It was found that:

i. Dredging at the airport site would have a small impact (generally less than 10 mg/l) on far-field suspended solids concentrations when taken in the context of the natural background variability. Tidal currents at the site are such that much of the sediment would be re-deposited locally and probably re-dredged.

ii. Dredging of overburden in the Urmston Road just off Castle Peak Power Station resulted in the sediment losses being dispersed over a large area as a result of the large tidal excursions in this area. Locally, concentrations would increase by the order of 10 mg/l in a narrow plume close to the dredger with lower concentration increases over a wider area. At the power station intakes, it is unlikely that the dredging would result in concentrations exceeding the 150 mg/l limit assigned by China Light and Power to the cooling water intake, except on the few occasions when it is exceeded naturally.

iii. Overflowing of barges during dredging for fill would result in the greatest rate of sediment input to the water column. Sites were examined at Deep Bay, Urmston Road and The Brothers. In all cases, the sediment losses were dispersed over a large area at low concentration. Dredging of fill at the Urmston Road site off Castle Peak would increase suspended solids concentrations by the order of 30 mg/l, which would double the mean concentration in the lower layers of the water column. Concentrations in the upper layer, from which cooling water would be abstracted, would increase by approximately 5 mg/l and would not be expected to cause adverse impact at the power station.

iv. Dredging for fill in the Urmston Road and Deep Bay borrow areas was predicted to give increases of generally less than 10 mg/l in the vicinity of oyster beds in Deep Bay. This is insignificant compared to maximum concentrations (31-210 mg/l) experienced under ambient conditions.

v. Combined, simultaneous cycles of dredging overburden, fill and dumping spoil in individual pits within The Brothers and Deep Bay borrow areas were predicted to give increases of over 10 mg/l suspended solids in some areas but this would not be expected to result in significant adverse impact.

vi. Spoil dumping in disused borrow pits at the entrance to Deep Bay was simulated and it was found that, again, the sediment losses were rapidly dispersed over a large area at low concentration and no significant adverse impact on sensitive receivers would be expected.

Sampling and analysis of marine mud at Chek Lap Kok, The Brothers, Urmston Road and Deep Bay borrow areas showed no significant contamination with heavy metals and from this it was inferred that East Sha Chau would be similarly uncontaminated. On the basis of an empirical model relating inorganic nitrogen and chlorophyll a concentrations, nutrient loading from sediments disturbed by dredging at Chek Lap Kok would not be expected to cause enhanced algal growth.

### 28.3.2 Recommendations

(a) A flushing channel which would maintain tidal flows and water speeds similar to those at present was previously strongly recommended to PAA and was approved. It is understood that this concept was endorsed by the Development Progress Committee of Government on 9th May 1991. Implementation of the channel will prevent potential siltation and enhanced phytoplankton growth in East Tung Chung Bay.

(b) A water quality monitoring programme should be implemented by PAA and carried out by the Engineer. Monitoring should be undertaken at the airport site and borrow areas to determine background conditions, assess compliance during the works and as a final check on water quality once the scheme has been completed. Water quality monitoring stations should be sited to reflect the position of sensitive receivers. Background monitoring at all gazetted areas should commence as soon as possible after the contract is awarded.

(c) Contractors should be required to provide portable sewage facilities for construction workers and to make appropriate arrangements for sewage collection and disposal.

(d) C.. ıctors shoulc' be required to provide silt traps at concrete-batching and as. .lt plants to collect, settle and recycle water used for dust suppression purposes and vehicle washing.

### 28.3.3 Summary of Operational Impacts

WAHMO modelling of sediment transport, deposition and erosion was carried out to simulate existing conditions and those following airport reclamation. The sediment transport model was used to simulate sedimentation processes for both tidal currents alone and under the action of tidal currents and wave disturbance.

It was concluded that the impact of the airport would be limited to within 3km of the reclamation. The main effects predicted were low net deposition in shallow areas to the west of the reclamation and net erosion at the northeast corner of the reclamation, caused by local acceleration in flows. The bed levels to the west of the reclamation are considered likely to remain in a state of dynamic equilibrium, maintained by long term steady deposition of sediments and periodic erosion by wave action during storm conditions.

On the basis of the current land use plans, the main sources of foul sewage at the new airport will be the airside terminal complex, aircraft catering operations, aircraft discharges, aircraft maintenance and washing operations, vehicle maintenance and washing operations, an airport hotel, airport-related activities such as a business park and cargo village, a refuse transfer station and a fire training facility. Total pollutant loads entering the foul sewage system estimated for the year 2010 are 0.67 tonnes/day biochemical oxygen demand, 1.39 tonnes/day chemical oxygen demand, 0.53 tonnes/day suspended solids and 0.95 tonnes/day total kjeldahl nitrogen. Foul sewage will be pumped to the main treatment works at Siu Ho Wan on North Lantau for treatment and discharge. Effluent from an on-site treatment plant serving the catering facility may be partially reused for irrigation purposes.

Stormwater quality at the new airport is likely to be generally comparable with that of urban runoff containing solids, organic matter, nutrients and micropollutants such as heavy metals and petroleum hydrocarbon residues. However, airport stormwater can be additionally liable to intermittent contamination as a result of oil/fuel spills, fire fighting, chemical spills, pesticide application or the uncontrolled discharge of trade effluents e.g. workshop/maintenance wastewaters or aircraft washwater. All commercial and industrial trade effluents will require to be licensed under the Water Pollution Control Technical Memorandum on Effluent Standards, once the North Western Water Control Zone is gazetted.

An assessment of the impact of possible pollutant loads from the southern part of the airport reclamation discharged into the sea channel suggested that pollutant concentrations are likely to remain relatively low due to the flushing effect of tidal water movement along the sea channel. However, discharge of stormwater to the sea channel is being minimised due to the potentially sensitive nature of this water body. Only one catchment will drain to the sea channel, while runoff from the fuel farm within this catchment will be discharged to the west of the reclamation.

### 28.3.4 Recommendations

(a) The sea channel, which is a PAA approved feature of the Master Plan, should be retained and protected to ensure that East Tung Chung Bay is properly flushed.

(b) Dredged navigation channels approaching the west of the reclamation should be broad and shallow in section rather than deep and narrow, since periodic wave action under storm conditions may cause narrow navigation channels to become unusable.

(c) PAA should provide dedicated aircraft washing bays with interception and discharge of runoff to foul sewer, and an automatic bypass to the storm sewer system under storm conditions. Tenants may need to consider flow balancing and/or pretreatment of washwater to comply with the Technical Memorandum on Effluent Standards, or substitution of lighter detergent formulations used at lower application rates.

(d) PAA should provide or specify in lease conditions centralised vehicle washing facilities, preferably with brush washing and water recycling, to be used by tenants undertaking vehicle washing.

(e) PAA should develop a standardised spill response for fuel or oil spills, involving the use of vacuum suction or absorbent materials for small spills on non-critical areas and water dispersion and containment in the storm sewer system for large spills on critical areas such as runways. An emergency response plan should be developed for the latter, using a computer programme of the storm sewer system to identify appropriate containment locations.

(f) PAA should provide oil interception systems for the removal of oil and fuel from stormwater. These should include tilted plate oil interceptors serving the main apron areas where refuelling occurs, and interceptors at the fire training facility. Requirements for oil interceptors at the fuel farm and bypass interceptors at carparks and vehicle refuelling stations should be specified in lease conditions as appropriate. PAA should maintain oil booms for emergency deployment at the main stormwater outfalls.

(g) PAA should consider a penalty system for fuel and oil spills associated with poor maintenance of aircraft, vehicles and refuelling systems. Detailed records of all spills should be kept for auditing purposes.

(h) PAA should ensure regular and effective maintenance of storm drains and oil interception and removal installations. PAA environmental staff should be given a mandate to monitor the maintenance operations.

(i) PAA should maintain a centralised inventory of chemicals and review new chemicals before adoption. An operations manual should be developed by PAA environmental staff detailing good practice procedures for the storage, handling and use of chemicals, and clean-up strategies for chemical spills, once land use and design details have been finalised. Tenants should be required through lease conditions to adopt these good practice procedures.

(j) PAA should highlight the requirements for monitoring licensed trade effluents in lease conditions, and should undertake monitoring of stormwater quality including discharges from oil interception systems and the main stormwater outfalls. Monitoring data for both foul and stormwater discharges should be audited on a regular basis by PAA environmental staff to check compliance with standards and the need for improved pollution control measures.

## 28.4 Marine Ecology

### 28.4.1 Summary of Construction Impacts

A marine ecological survey of the seabed around Chek Lap Kok and The Brothers showed heterogeneous sediment types and associated fauna. The bottom invertebrate community was a good example of that expected in Hong Kong coastal waters, with high species diversity, although a reduced echinoderm diversity was attributed to low salinity. Species new to science were collected including the pycnogonid *Neopallene* sp. and the gastropod *Pseudoliotia* sp. This was indicative of the paucity of information on Hong Kong's sublittoral fauna rather than of particularly special sublittoral habitats. Fish diversity was high and, similarly to the benthic invertebrate species composition, comparable to that reported in a similar study ten years ago. Records of dolphins in the North Lantau, Deep Bay and Pearl River Estuary show 51 sightings of the Chinese White Dolphin (*Sousa chinensis*) between 1980-1991, of which 42 were live and 9 dead.

Shorelines of the Chek Lap Kok and Tung Chung area comprise rock cliff, jetty, boulder, *Zoysia* bed, sandy shore, mangrove and open shore communities. The littoral flora and fauna of these communities are diverse and compare favourably with that of other Hong Kong shores. A new species of predatory gastropod, *Cymia trigona*, was recorded on oyster clumps. Valuable habitats include mangrove, containing the relatively rare *Bruguiera gymnorrhiza* on Chek Lap Kok, and a mangrove and eel grass (*Zostera nana*) community south of Tin Sam jetty on North Lantau. This is of international conservation importance because there is only one other *Zostera* bed in Hong Kong at Li Chi Wo beach, which together with the beds at Tin Sam form the most southerly beds in China; the nearest sites elsewhere are 1,500km north. The World Wide Fund for Nature Hong Kong have recommended that this site is designated as a Site of Special Scientific Interest.

The impact of airport construction on marine biota will be the destruction of benthic fauna in the immediate vicinity of dredging, reclamation and dumping operations, and disturbance to fauna in the surrounding areas through the dispersion of suspended sediments. The benthic communities in the North Lantau area are already acclimatised to periods of high suspended solids and sediment deposition due to the effects of the Pearl River discharge, and are known to recolonise naturally depopulated areas. Once disturbance in the areas affected by construction has ceased, recolonisation would be expected to occur fairly rapidly, with similar communities developing in areas where the substrate type is maintained. In others, i.e. borrow areas from which the original marine mud overburden is removed to expose sand, different communities will develop. Given the heterogeneity of North Lantau sediments, however, it is not considered that this will be detrimental to the sublittoral marine ecosystem as a whole.

Shoreline communities on Chek Lap Kok will be almost entirely destroyed during construction. The seawalls of the reclamation will offer some scope for recolonisation by rocky shore fauna, but in lower diversity due to the lack of microhabitat variation. The formation of a flushing channel will permit retention of shoreline communities on North Lantau, although changes to wave exposure and localised tidal flushing may cause the present rock cliff and sandy shore communities to be replaced over time by sheltered rocky communities dominated by oysters or by comparatively depauperate muddy shore communities. The mangrove and *Zostera* beds at Tin Sam may be adversely affected by dredging, through coating of mangrove aerial roots with silt, and alteration of the nutrient levels, to which *Zostera* is sensitive.

### 28.4.2 Recommendations

(a) Bi-annual surveys of sublittoral communities affected by the airport and by new PADS construction projects should be carried out by Government for six years after completion of construction. Inspection of the mangrove and eel grass community south of Tin Sam jetty should be carried out on a quarterly basis during airport construction to assess dredging impacts.

(b) The southern seawall of the airport reclamation should be progressively constructed in advance of the dredging works to contain sediment dispersion as far as possible and to protect the North Lantau shoreline.

(c) Water quality monitoring stations should be established by PAA within the proposed channel, one north of Tin Sam jetty between the dredging area and the mangrove/eel grass community and one at its western end off the sandy shore, to provide data on turbidity generation in this area. Remedial measures should be implemented by the Contractor if suspended solids levels become unacceptably high in relation to measured background concentrations.

(d) Disturbance of the sea bed outside the airport footprint, channel excavation, marine borrow areas and marine mud disposal areas should be avoided wherever possible.

(e) Should surveys of the existing *Zostera* beds indicate deterioration, consideration should be given by Government to the possibility of transplanting *Zostera* turfs from Tung Chung Bay to any new mudflats engineered for mangrove replanting adjacent to PADS developments along the North Lantau Coastline.

(f) Where practicable, marine borrow areas should be worked individually, and backfilled while the next area is being worked. This will reduce the extent of disturbance at any one time to marine communities. Recolonisation of affected areas depends on a supply of animals from unaffected areas, and may be significantly slower and less successful if large surface areas of seabed are destroyed simultaneously.

(g) Where practicable, worked out borrow areas should be backfilled to the original level, with at least 5m of uncontaminated marine mud at the surface, to permit recolonisation to begin within as short a time as possible.

(h) Contractors should be advised of the possible presence of dolphins in the area and of the need for their protection.

### 28.4.3 Summary of Operational Impacts

Impacts on marine flora and fauna could arise as a result of the discharge of foul sewage or contaminated stormwater runoff. Foul sewage from the airport and related developments will be pumped to the treatment works at Siu Ho Wan and treated prior to discharge through a long outfall terminating near The Brothers. Impacts arising from this discharge have been considered under the North Lantau Development Study.

Potential sources of stormwater contamination include, *inter alia*, oil and fuel spillages, chemical spillages, uncontrolled discharges from aircraft and vehicle maintenance and washing, and runoff from aprons, runway and taxiways. Polluted runoff may cause short term effects such as intermittent decreases in dissolved oxygen due to heavy loading of organic matter during storm conditions, or longer term chronic effects from gradual bioaccumulation in marine organisms of micropollutants such as heavy metals or chlorinated hydrocarbons. Persistent accumulation of organic matter and toxic pollutants, if permitted, could cause an adverse effect on marine community structure and composition; in the "worst case" replacing a highly diverse faunal community with large numbers of pollution tolerant organisms such as polychaetes, or microbial communities able to live in toxic and anoxic conditions.

### 28.4.4 Recommendations

(a) Mitigation measures as recommended in Section 28.3.4 should be adopted in order to minimise stormwater contamination. Stormwater drainage from potentially contaminated areas should be discharged to dispersive receiving waters, wherever practicable, as opposed to sheltered areas .such as the sea channel.

(b) Monitoring of sublittoral communities as recommended for the construction phase, i.e. by carrying out bi-annual benthic surveys for six years after completion, should also be used to determine operational impacts. Monitoring should be extended to intertidal sites on North Lantau and control sites remote from the airport at Tai O and South Lantau, measuring changes in representative species such as oysters and barnacles on shore transects, to determine impacts on littoral communities.

## 28.5 Terrestrial Ecology

### 28.5.1 Summary of Construction Impacts

A study of the terrestrial flora and fauna .of Chek Lap Kok identified the island's wetland habitats as the most valuable. These contain mangroves, including the relatively rare *Bruguiera gymnorrhiza* which has a restricted distribution in Hong Kong. The fresh water areas are home to Romer's Treefrog (*Philautus romeri*). This rare species is endemic to Hong Kong and is only known to occur in three sites in the world: Chek Lap Kok, North Lantau and parts of Lamma Island. Several wet valleys also support large populations of the protected pitcher plant, *Nepenthes mirabilis*. This species is protected and is fairly common on granite seeps elsewhere in Hong Kong. The dry hill slopes are generally species-poor, but one protected species, *Gardenia jasminoides* and one species recently removed from the protected species list, *Phoenix hanceana*, were found in the hill-slope grassland. Protected species of orchids would also be expected, although these are not rare. Apart from birds and bats, the only protected animal species known to occur on the island is the Chinese Pangolin (*Manis pentadactyla*).

Monthly observations of birds on Chek Lap Kok indicate that the island supports a relatively rich avifauna, with a total number of 101 species recorded to date. Of these, only one (*Seicercus burkii*) is rare in Hong Kong. All of the birds recorded on Chek Lap Kok are protected under Hong Kong legislation. The birds of prey and shorebirds are listed under the "Bonn Convention", an international convention which aims to protect migratory species.

The impact of airport construction will be to destroy almost all the terrestrial flora and fauna and to displace all the island's avifauna. The southern headland, which is to be retained, is too small and dry to preserve any significant proportion of the island's biota. Shorebirds may be attracted to new reclamation areas to roost, but as building and infrastructure development proceeds, they will again be displaced.

Off-site impacts of airport construction may involve terrain cuts on northeast Lantau and Tai Lam Country Park in the southern New Territories. Although of little special ecological value, the access and works involved in terrain cuts could have adverse aesthetic impact until the areas are restored to a natural state.

Off-site impacts may also arise from the siting of obstruction lights on Sunset and Lantau Peaks and on peaks in southern Tai Lam Country Park, and terrain cuts for the siting of electronic equipment on The Brothers Islands, Lung Kwu Chau, Sha Chau, Tai Lam Kok (Brothers Point) and hillsides on northeast Lantau.

There are ecologically sensitive Sites of Special Scientific Interest (SSSI) near the summits of both Sunset and Lantau Peaks which could be adversely affected by installation of lights unless construction and maintenance works are strictly controlled. Impacts will be significant on West Brother, which is densely vegetated and provides bird habitat; Lung Kwu Chau which is a Site of Special Scientific Interest due to the past presence of nesting sea-eagles and which has a protected plant species *Pavetta hongkongensis*; and Sha Chau which provides a roost for cormorants. Impacts at Tai Lam Kok and northeast Lantau, providing the latter is accessed by helicopter only, will be small.

### 28.5.2 Recommendations

The loss of habitats, flora and fauna on Chek Lap Kok cannot be mitigated directly. However a number of measures to compensate for this loss are recommended, as follows:

(a) A detailed field investigation of Romer's Treefrog on Lantau and Lamma Islands should be implemented and a laboratory breeding population of *P. romeri* captured from Chek Lap Kok should be established. Information obtained from the field and laboratory studies will provide data on the habitat requirements of the species which are essential for the development of a conservation and habitat management strategy. (This recommendation has already been implemented and is on-going.)

(b) Creation of new mangrove habitats outside the seawalls of the North Lantau Development or other PADS developments should be implemented by Government once schemes are finalised and appropriate areas can be identified. Alternatively, mangroves could be recreated in already disturbed coastal areas on North Lantau, such as the disused salt pans at Tai O. Creation of mangrove communities in existing natural shoreline areas is not recommended as it would risk damaging coastal environments which could otherwise be preserved.

(c) Enhanced protection of *Nepenthes mirabilis* populations and mangroves outside Country Parks should be provided by Government.

(d) Representative freshwater wetland habitats elsewhere within the Territory should be protected by Government by their inclusion within the Country Parks system.

(e) A management strategy for woodland habitat on North Lantau should be developed and implemented by Government to improve conditions for wildlife. This should include enhancing natural woodlands by additional fringe and corridor planting and planting of urban landscaping areas with native species.

(f) PAA should ensure that disturbance to areas identified for off-site terrain cuts, if any, are minimised by restricting the extent of access clearance wherever possible and restoring cut areas by reshaping the terrain and planting with native species.

(g) The extent of disturbance to Sunset and Lantau Peaks should be minimised and strictly controlled, with equipment brought in by helicopter or on foot. The location of equipment and extent of any excavation should be discussed with Agriculture and Fisheries Department before work proceeds and maintenance staff should be made aware of the ecological sensitivity of the sites.

(h) After levelling of the Brothers Islands, the centre of West Brother Island should be excavated and reinstated with low stature vegetation. Additional areas of woodland should be planted on North Lantau to compensate for that lost on West Brother.

(i) Lung Kwu Chau should be removed from the SSSI list, since sea-eagles no longer nest there. Construction work should be restricted to September-October to avoid disturbance to cormorants and nesting Reef Egrets. The southern part of this island should be off limits to construction workers. If practicable, disruptive activities such as blasting should be restricted to September and October.

(j) Spoil removed from the top of Sha Chau should be disposed of to the west of the island, over the existing eroded shoreline. The northwestern part of the island should be off limits to construction workers. If practicable, disruptive activities such as blasting should be restricted to September and October.

(k) Permits to allow the destruction of birds' nests should be obtained under the Wild Animals Protection Ordinance prior to construction works commencing. Strict controls should be exerted to prevent fires and fuel/oil spillage at the remote sites.

### 28.5.3 Summary of Operational Impacts

Operational impacts on the terrestrial ecology of Chek Lap Kok will not arise, since almost all of the flora and fauna will have been destroyed during the construction phase. No significant off-site operational impacts are envisaged. The only section of the island remaining will be the southern-most headland, which has been designated as an open space reserve. Although having some open secondary woodland on its northern slopes, the majority of the headland is covered in grassland and low scrub, with patches of bare soil on the steep slopes and the hill top. The area has been extensively burned over the last year, although burned areas are now beginning to be recolonised.

The headland on its own is too small and dry to support any natural vegetation of conservation value and it is thus recommended that it is irrigated and landscaped to provide an area of aesthetic interest. The area is visually important as it will form the "gateway" to the new airport, and its potential in this respect should be optimised.

### 28.5.4 Recommendations

(a) The natural character of the southern headland should be preserved through the replanting of indigenous plant species. This should include the establishment of scrubland and woodland species and the retention of selective areas of open grassland.

## 28.6 Solid Waste and Hazardous Materials

### 28.6.1 Summary of Construction Impacts

The excavation of Chek Lap Kok will require stripping the existing vegetation. It is anticipated that remaining vegetation will weigh approximately 25,000 tonnes. Construction wastes are expected to be generated at an average rate of 42,000 tonnes/year resulting in an additional 210,000 tonnes of material.

Domestic waste will be generated at a rate of approximately 0.3 tonnes/day during 1992-93, rising to an estimated 2 tonnes/day for the later construction years.

Potentially hazardous materials and chemical wastes associated with construction activities at the new airport site are primarily limited to those required for the fuelling, servicing and repair of earth moving and construction equipment. The raw materials used to make explosives associated with blasting activities will not be stored in quantities in excess of exempted quantities for a Potentially Hazardous Installation.

Plans are to isolate the storage and handling of fuel and other petroleum-based fluids in specially designed zones of the contractor staging areas. In this way fuel storage, hazardous material and waste disposal vessels can be better protected and properly maintained. Additionally, should an accidental leak, spill or discharge occur, it can be contained more effectively in these specially prepared areas. Finally, should these materials need to be transported out of these designated zones to the job site, other special precautions can be taken to help prevent them from being discharged to the environment. Should a discharge occur under these conditions, absorbent materials or temporary barriers can be used by the Contractor to help minimise the potential environmental impact. If necessary, plans can then be developed for the clean up and removal of the materials.

Explosives used for blasting are considered Dangerous Goods and therefore the manner in which these materials are stored and handled at the airport site will be determined by the Mines Division of the Civil Engineering Services Department.

### 28.6.2 Recommendations

(a) The Contractor should not be permitted to burn waste such as cleared vegetation or timber within the site. Cleared vegetation should either be chopped or shredded and stockpiled on the site for later use (as a mulch on the upper layers of the reclamation in those areas adjacent to runways and taxiways which will later be grassed); removed off site to the Contractor's tip; or disposed of in some other manner acceptable to the Engineer.

(b) Any suitably inert building material should be utilised as fill. Remaining building wastes should be transferred to controlled tips for disposal.

(c) During the later stages of construction work, domestic waste should be removed together with any building waste. In the initial phase the relatively small quantities of domestic waste involved do not justify the use of containerised facilities. A refuse collection point similar to those used elsewhere in the

Territory would give sufficient provision for collection and short term storage of domestic wastes. For environmental hygiene reasons it is recommended that this waste is not stored for any period exceeding 48 hours and preferably only 24 hours.

(d) The Contractor should be required to coordinate any activities or operations that involve potentially hazardous materials or chemical wastes with the appropriate authorities including EPD, the Fire Services Department and the Marine Department.

(e) The Contractor should undertake at all times to prevent the uncontrolled disposal of hazardous materials and chemical wastes to the air, soil, surface waters, groundwaters and coastal waters.

(f) The Contractor should be responsible for collection and disposal of hazardous materials and chemical wastes and ensure that these tasks be carried out by competent and experienced personnel or subcontractors who are licensed to provide such services.

(g) The Contractor should monitor the safe progress of hazardous materials and chemical wastes from their point of arising to the final disposal point. This process is commonly referred to as "cradle-to-grave" control.

(h) The Contractor should be responsible for complying with the requirements of the Dangerous Goods Ordinance as they pertain to the use, storage and disposal of nonexempted quantities of these materials.

(i) The Contractor should be responsible for developing and, if necessary, implementing a plan for the containment and cleanup of hazardous materials, chemical wastes or oil. The plan should be developed in consultation with the Fire Services Department and the Marine Department and consistent with the Water Pollution Control and Oil Pollution Ordinances.

(j) The Contractor should insure that hazardous materials, chemical wastes and fuel are packed or stored in containers or vessels of suitable design and construction so as to prevent leakage, spillage or escape of the contents under normal conditions of handling, storage and transport.

### 28.6.3 Summary of Operational Impacts

Waste arisings from the new airport are predicted to be approximately 280 tonnes/day in 2010 and 500 tonnes/day in 2040. Of this, 63-76 percent will be generated from the airside areas, 18-31 percent from the landside areas and 6 percent from the airport related areas. Waste types will include domestic waste from the terminal and from aircraft, commercial waste from the administrative, catering and hotel facilities and from the airport related areas, industrial waste from the maintenance and cargo areas, putrescible waste from the catering operations and miscellaneous waste from customs and quarantine facilities.

The preferred disposal strategy is for wastes to be collected and compacted at a Refuse Transfer Station (RTS) on the airside/landside boundary. Containerised waste will then be transferred to the North Lantau Development RTS at Siu Ho Wan for disposal by barge to the Western New Territories (WENT) landfill. This will require a degree of compatibility between container types used at the two transfer stations.

Potential environmental impacts from solid waste handling and disposal include dust, odour, noise and leachate generation. Noise is not considered to be a major issue as current land use plans show no sensitive receptors in the vicinity. Enclosure of operations and restrictions on sound power levels of plant for health and safety reaons will result in acceptable noise levels outside the RTS.

Daily airport operations will involve a limited variety of hazardous materials, chemical wastes and Dangerous Goods. Without proper management, storage and treatment, these materials can pose both potential health and environmental risks. Based on the new airport Master Plan, existing conditions at Kai Tak, and what is known about hazardous materials at other major airports, the primary areas where these materials will occur are as follows:

- Aircraft Maintenance Facilities
- Fuel Storage and Transfer Facilities
- Ground Support Equipment Maintenance Facilities
- Air Cargo Storage Areas
- Fire Training Facility
- Airport Maintenance Facilities
- Isolation Pad
- Utilities
- Roadways and Aprons.

Routine maintenance of aircraft airframes, engines and components will give rise to waste fuel, used oil, and other petroleum-based solvents. Other services involving metal stripping, cleaning and plating generate waste materials containing acids, alkalis, cyanides, chromium, lead and other metals. Painting operations create paint waste and spent solvents. These materials will be collected and either reused on-site or transported off-site for recycling or disposal.

The on-site storage of hazardous materials and chemical wastes will only be permitted in specially designated areas. The design and use of these areas will incorporate secondary containment, air ventilation and a wide range of requirements for the labelling, construction and contents of storage vessels.

Fuel storage and transfer facilities will contain Jet A-1, avgas, petrol and diesel. Most of the fuel will be stored in two fuel farms located at the south side support area and will be distributed through underground pipelines and hydrant systems. Close supervision and record keeping; secondary containment of tanks, pipes and hydrants; and strict design and performance specifications will help prevent leaks and spills.

Similar to aircraft, the servicing and maintenance of aircraft ground support equipment will also involve used oil and other petroleum products which will be reused or transported off-site for disposal.

A very small portion of the air cargo that passes through the airport will be classifiable as hazardous or Dangerous Goods. The proper labelling, packaging, handling and storage of these materials will minimise their potential risk.

At the fire training facility, the fuel/water/firefighting foam mixture will be drained from the burn pit after each drill, treated in a fuel/water separator and stored on site for reuse.

### 28.8.2 Summary of Operational Phase Monitoring

Environmental monitoring programmes have been defined for noise, stormwater quality and marine ecology during the operational phase. Monitoring of commercial/industrial trade effluents generated by PAA and tenants will be a statutory license condition. Monitoring will be carried out by PAA or by tenants as appropriate, with confirmatory monitoring of licensed discharges carried out by the regulatory authority, EPD. PAA will audit the monitoring results on an ongoing basis as a self-check on compliance with statutory and guideline environmental quality limits. Operational phase monitoring and audit programmes are described in detail in the Environmental Monitoring and Audit Operations Manual.

Operational audits of the airport and associated facilities should be carried out on a five year basis, when the new airport Master Plan is recurrently reviewed. The audit should involve updating of NEF forecasts and air quality predictions, reviews of operational monitoring data and inspection of all facilities including those of chemical and hazardous material storage, solid waste handling, stormwater interception and drainage etc. PAA tenants should have the requirements for auditing included in lease conditions and should be subject to auditing by PAA or PAA's representative, in order that coordinated and consistent standards and mitigation measures can be applied for the entire airport facility.

### 28.8.3 Recommendations

In view of the magnitude of construction activities and potential environmental impacts, it is recommended that a full-time environmental scientist with supporting technical staff be a permanent part of the airport staff. The environmental staff should execute the environmental monitoring and audit programmes for which PAA is responsible; report on and interpret the monitoring results; and liaise with EPD and other relevant government departments. This type of arrangement would provide greater assurance that, during the construction phase, the monitoring will be conducted during periods when established criteria are most likely to be violated and that monitoring results will be promptly audited and acted upon. In the longer term, during the operational phase, the use of a permanent environmental staff will permit establishment of a coordinated approach to environmental management of the airport facility and will help to ensure that the [illegible] Hong Kong International Airport at Chek Lap Kok is an environmentally acceptable development.