Section 4

24 AIR QUALITY

4.1 INTRODUCTION

Air quality impacts at Sensitive Receivers (SRs) may be expected to occur during the construction and operational phases of the LAPH development. Emissions will occur from both stationary sources (construction sites and industrial processes) and transportation sources. Emissions of concern include sulphur dioxide (SO_2), nitrogen oxides (expressed as nitrogen dioxide, NO_2), carbon monoxide (CO), volatile organic compounds (expressed as ozone, O_3), lead, and particulates.

4.2 METHODOLOGY

4.2.1 General

The assessment has been undertaken considering the proposed phases of construction and subsequent operation. Five stages of development have been assessed:

- Phase I Construction;
- Phase I Operation and Phase II Construction;
- Phase II Operation and Phase III Construction;
- Phase III Operation and Phase IV Construction; and
- Phase IV Operation.

4.2.2 Air Quality Standards

Table 4.1 presents the Hong Kong Air Quality Objectives (AQOs) for SO_2, NO_2, particulates CO, O_3 and lead. The Hong Kong AQO does not include a short-term exposure standard for total suspended particulates (TSP), nor do the analogous USA or European Community air quality standards. The one-hour TSP impacts are therefore evaluated according to a guideline of $500\mu g/m^3$ which is in keeping with previous studies undertaken in Hong Kong (Highways Department, 1991, Territory Development Department, 1990). It is generally accepted that the hourly average TSP concentration of $500\mu g/m^3$ should not be exceeded and such a control limit has been imposed upon a number of recent construction projects in the Territory.

TABLE 4.1

HONG KONG AIR QUALITY OBJECTIVES

POLLUTANT	AVERAGING TIME				
	1 Hr	8 Hrs	24 Hrs	3 Mths	1 Yr
Sulphur Dioxide	800	–	350	–	80
Total Suspended Particulates	–	–	260	–	80
Respirable Suspended Particulates*	–	–	180	–	55
Nitrogen dioxide	300	–	150	–	80
Carbon monoxide	30,000	10,000	–	–	–
Photochemical Oxidants (as O_3)	240	–	–	–	–
Lead	–	–	–	1.5	–

Notes:
- All concentrations in micrograms per cubic metre measured at 298°K (25°C) and 101.325 kPa (one atmosphere).
- 1hr concentrations not to be exceeded more than three times per year.
- 8 and 24hr concentrations not to be exceeded more than once per year.
- 3Mth and 1Yr concentrations are arithmetic means.
- * Respirable suspended particulates (RSP) means suspended particles in air with a nominal aerodynamic diameter of 10 microns or less.

4.2.3 Impact Assessment

Impacts have been assessed using computer modelling techniques and assumptions approved by EPD and the United States Environmental Protection Agency (USEPA). Results are expressed either as estimated worst-case pollutant concentrations at SRs, or as setback distances required from emission sources in order to achieve concentrations within the AQO. The total concentration at the SRs is the sum of the impacts of the modelled emission sources plus a background concentration. The background concentration represents the effect of distant emission sources and any local emissions not explicitly modelled.

With regard to the calculation of setback distances, traffic data were not available for Phases II and III. Setbacks were therefore calculated for Phase I and IV, and comparison of trends in vehicle emission rates and traffic volumes was undertaken with respect to Phases II and III.

The Phase I road network is relatively simple with only two roads with significant traffic volumes. Accordingly setbacks were calculated at the two locations corresponding to the worst-case segments for each of the two major arteries, (north - south arterial connecting the NLE to the Port, and the east - west service road along the Phase I berths). On the minor roads, low traffic volumes indicate that the setbacks would be insignificant and certainly less than required by the Hong Kong Planning Standards and Guidelines.

In conjunction with the Phase IV assessment of the road network (which provides the worst-case situation), this evaluation is sufficient to identify landuse implications in terms of air quality.

4.2.4 Construction - Identification of Emission Sources and Sensitive Receivers

Construction activities for the LAPH development will be very similar in character to the construction activities for other container terminals in Hong Kong. An air quality assessment of impacts associated with container terminal construction, as well as quarrying at the Tsing Chau Tsai (TCT) Mega Borrow Area (a potential source of fill) has been carried out in a previous study, Highways Department, 1991. The assumptions, analysis methods, and findings of that study are also applicable to the LAPH construction and suggest that, where sensitive receivers exist within approximately 1km of construction, mitigation measures should be employed to reduce particulate impacts. The probability of particulate concentrations in excess of the AQO is greatest at distances of less than 500m.

Dredging, Excavation and Fill

Construction of the Container Port and Lamma Breakwater will involve dredging and the placement of rock and marine fill. A major source of fill material other than marine fill is likely to be the TCT Mega Borrow Area on Lantau. Once a phase of reclamation is completed, road construction and development will begin. Land based excavation and other construction activities will produce air pollutant emissions in varying degrees. The pollutants of most concern are TSP and RSP.

Emissions associated with placement of rock and marine fill consist of exhaust from diesel-powered barges and earthmoving equipment, and particulates generated by vehicle movement on unpaved sections of the reclamation. Impacts of quarrying at the TCT Mega Borrow Area will include diesel exhaust from vehicles and equipment as well as potentially significant amounts of particulates from the quarrying itself. The principal impact from road construction and development will be particulate emissions during the latter stages of activity when roads and structures are built. Particulates are generated by entrainment due to wind blowing over exposed earth surfaces, by vehicle movement on unpaved roads and during uncovered transfer of material. Stationary activities such as blasting, rock crushing, and concrete batching will also contribute to particulate emissions.

Road Construction

The Container Port transport system will entail significant amounts of road construction. Proposed roadways include the Container Port access and distributor roads, connections to Sham Tseng and Hong Kong Island and arteries serving the container berths, industrial development and the Marine Support Services Area (MSSA). An air quality assessment of impacts associated with major highway construction on Lantau has been carried out in a previous study, (Highways Department 1991). The study assessed TSP and RSP concentrations using the US, EPA Industrial Source Complex Short Term (ISCST) model, and emission rates derived by US, EPA (approved methods (AP-42)). The assumptions, analysis methods, and findings of this study are also applicable to the construction of roadways serving the Container Port development.

Drilling and Blasting

Where drilling and blasting are required, such as at the head of Penny's Bay, the previous study results (Highways Department, 1991), indicate that concentrations may exceed the 24-hour AQO for TSP and RSP, and the 1-hour guideline for TSP within 500m of the construction site. Where blasting is not involved, the major emitting activities are excavation, material transfer and traffic on unpaved roads. In these areas, concentrations above the AQO would only occur at distances considerably less than 500m from the construction site. Comparison of these distance criteria with the proposed locations of reclamation, quarrying, and roadway construction indicates the areas in which mitigation measures should be employed to reduce particulate impacts.

Sensitive Receivers

Few SRs exist within the primary Study Area at present. North of Penny's Bay, the residences at Ngong Shuen Au would be affected by construction of the Container Port Expressway, however these are expected to be relocated as part of the North Lantau Expressway/Port Expressway interchange project. Thus, no SRs will remain in the area north of Penny's Bay. The industrial development areas at Penny's Bay, including the existing power station and the developments at the northern edge of the Container Port reclamation are not as sensitive to air quality as residences, however they must be considered, since the AQO apply to all land uses. Impacts to SRs at Discovery Bay and Peng Chau are of less concern because of the greater distance to these locations. Current plans call for the expansion of Fa Peng into a Marine Support Services Area (MSSA). As a result, Fa Peng will remain as a small SR with respect to the TCT Mega Borrow Area, roadway construction for the link to Sham Tseng, and development of the MSSA. The area of active quarrying at the TCT Mega Borrow Area may vary over time, and could affect several aspects of the LAPH development. The location and magnitude of impacts will vary according to the phase of development.

Although Hei Ling Chau may be considered an SR due to its existing settlements, the island is located at considerable distance from the nearest significant emissions sources related to the LAPH development. The minimum distance from Hei Ling Chau to Phase IV berth areas and roadways exceeds 3.1km. At this distance, it is extremely unlikely that LAPH-related impacts could result in pollutant concentrations greater than the AQO. For comparison, note that Peng Chau, which is located much nearer to the port development, was included as an SR in the analysis. As indicated in Table 4.5, all estimated concentrations at Peng Chau were less than the AQOs.

Hei Ling Chau is included as an SR with respect to development at the Lamma Breakwater, as noted in Section 4.3.7. However, air quality impacts could not occur simultaneously at Hei Ling Chau from both the Lantau Port and the Breakwater, because the potential emission sources are not aligned with respect to wind direction.

4.2.5 Operation - Identification of Emission Sources and Sensitive Receivers

Potential operational air quality impacts may arise from numerous emission sources including:

- marine and harbour vessels;
- container port and associated activities;
- industrial land uses; and
- land transportation.

Marine and Harbour Vessels

Emission rates from vessels are not well documented and for the most part vessels are not subject to emission controls. This assessment anticipates that most vessels operating at the Lantau Port and the Lamma Breakwater reclamation would employ diesel engines of various sizes. These engines burn distillate or residual oil of varying sulphur and ash content. Emissions of SO_2, NO_2, and RSP could potentially be relatively high on a per-vessel basis. However, the large water areas encompassed by channels, anchorages and berths generally provides a considerable dispersion area for emissions before they reach SRs. At short vessel/receiver distances, odour impacts may be perceptible even if the AQO are not exceeded. The potential for odour impacts would be greatest where concentrations of small vessels exist, as in the proposed MSSA. The impacts of marine and harbour vessels are incorporated into the estimated background concentrations.

Container Port and Associated Facilities

These facilities involve container loading and stacking areas, with associated warehousing and offices. Large container cranes are electrically powered and do not contribute to local emissions. Transtainers and similar equipment are anticipated to be diesel powered, with emissions similar to heavy trucks. Motor vehicles also contribute to the emissions at the berth areas. Impacts due to port equipment and support services are anticipated to be of less concern than the emissions from other sources associated with the Lantau Port and are subsequently included in the estimated background concentrations.

Industrial Land Uses

Air quality impacts from industrial activities vary widely with respect to both the substances and rates of emission. As part of the LAPH development, industrial land will be created in Penny's Bay, at the foot of the TCT Mega Borrow Area (Figure 2.9) and behind the Lamma Breakwater. The precise character of the emissions from the industrial uses is not known at present. Previous studies (CLP, 1990) were reviewed and compared to the most recent plans to assess potential constraints on industrial development at Penny's Bay. Except as indicated below, anticipated industrial emissions are included in the background concentrations.

For the Lamma Breakwater the ISCST model was used to determine the maximum area wide emission rates that would still allow concentrations at the nearest SRs to remain within the AQO. Emissions for the Breakwater were modelled as area sources with a nominal release height of 15m, and a total area size of 400 Ha, corresponding to the extent of anticipated reclamation. Impacts were modelled for a range of meteorological conditions specified by the US, EPA, and the highest predicted concentrations were selected.

Land Transportation

Land transportation (cars, buses and goods vehicles) is of primary concern for the Lantau Port development. A large proportion of these vehicles are predicted to be diesel powered. The pollutants of greatest concern are NO_2, CO and RSP. With the implementation of the 1990 Air Pollution Control (Fuel Restriction) Regulations, SO_2 emissions have decreased considerably. As reliable SO_2 emissions data are not available for vehicles, these emissions have not been modelled, but are incorporated in the background concentrations. In general, the rates of emissions per vehicle are expected to decrease over time as new Hong Kong emission control regulations become effective. A decade or more will be required for complete effectiveness of the programme, as new vehicles with lower emissions are purchased and older, higher-emitting vehicles are phased out. At short roadway/receiver distances odour impacts may be perceptible even if the AQO are not exceeded.

The characteristics of the roadways and traffic expected with the Lantau Port are similar to the conditions anticipated for the North Lantau Expressway,(NLE). The air quality impacts of the NLE have previously been assessed in detail (Highways Department, 1991). Many of the assumptions, analysis methods, and findings of the NLE study are applicable to assessment of the Container Port-related roadway system, and have been adopted to maintain the consistency of the planning process. No cross-harbour roadways or rail links are planned for the Lamma Breakwater. Impacts of vehicles will be limited to the service road network that would be constructed to serve the industrial activities on the reclaimed land behind the Breakwater.

Background Concentrations

The NLE study estimated background concentrations where applicable to the Container Port area. Additional studies, including short term air quality monitoring at Discovery Bay and Cheung Chau, have been conducted more recently (Environmental Survey Data Report, October 1992). These and other studies (CLP 1990., HEC, 1990) have been reviewed and the background concentrations were updated to reflect the presence of the NLE, North Shore developments on Lantau, anticipated emission sources in the Container Port area and the Fuel Restriction Regulations. Table 4.2 provides the estimated background concentrations in the Study Area for the year 2011 corresponding to Phase IV. Background concentrations for the years 2000-2007, corresponding to earlier phases, would be slightly lower, reflecting the timing of implementation of the Container Port developments and other projects.

TABLE 4.2

ESTIMATED BACKGROUND AIR POLLUTANT CONCENTRATIONS (2011)

POLLUTANT	AVERAGING TIME			
	1hr	8hrs	24hrs	1yr
Sulphur Dioxide	100	--	30	10
Total Suspended Particulates	160	--	80	10
Respirable Suspended Particulates*	80	--	40	20
Nitrogen dioxide	150	--	90	20
Carbon monoxide	150	120	--	--

Note: All concentrations are in micrograms per cubic metre, measured at 298°K (25°C) and 101.325 kPa (1atm.).

Emission Rates

Emission rates from vehicles were estimated using emission factors provided by EPD. To account for variation in emissions with vehicle speed, the EPD factors were adjusted using the US, EPA MOBIL4.1 model. This model is the most recent version of the US EPA AP-42 document for mobile sources, and contains relationships between emission rates and speed. Table 4.3 provides the MOBILE4.1 vehicle emission rates used in the analysis for the year 2011. Estimated emission rates decrease by zero to 12% depending on vehicle type, (from 2000 to 2011), reflecting requirements for emission controls on new vehicles. Emission rates were adjusted accordingly for analysis of each phase of development. The rates vary with vehicle speed, and correspond to predicted speeds ranging from 14 to 65Kph.

TABLE 4.3

VEHICLE EMISSION RATES (2011)

VEHICLE TYPE	MOBILE 4.1 FACTORS (g/Veh-km)		
	NO_x	CO	RSP
Car (petrol)	0.62 → 1.13	3.77 → 23.8	0.032
Taxi and light-duty	0.77 → 1.20	0.75 → 3.95	0.261
Light Goods Vehicle and Light Bus	1.63 → 2.56	0.78 → 3.06	0.39
Medium Goods Vehicle	6.77 → 10.6	3.42 → 13.5	1.15
Heavy Goods Vehicle and bus (diesel)	8.80 → 13.8	3.42 → 13.5	1.16

Note: Ranges of values reflect dependence of emissions on speed, for predicted speed range of 14 - 65 Km/hr [speed data per MVA Asia 7/92].

It is desirable to produce emission rates for a more comprehensive breakdown of the traffic mix. However at the time of writing, information pertaining to the individual components of traffic was not available.

Meteorology and Dispersion

Concentrations at SRs due to vehicle emissions were estimated using the US, EPA approved CALINE3 model for a range of wind directions under meteorological conditions of limited dispersion. Table 4.4 provides the meteorological input values to CALINE3. At each SR, the condition resulting in the highest estimated concentration was selected. The one-hour modelled values calculated by CALINE3 were converted to 8-hour, 24-hour, and annual values using meteorological persistence factors recommended by USEPA, and traffic scaling factors based on predicted volumes.

TABLE 4.4

METEOROLOGICAL INPUTS FOR DISPERSION MODELLING OF ROADWAY TRAFFIC EMISSIONS

PARAMETER	VALUE
Wind speed	2.0m/sec
Wind directions	0° - 360° in 22.5° increments, corresponding to the 16 major compass directions
Pasquill-Gifford stability class	D
Ambient temperature	23°C
Mixing height	1000m
Aerodynamic surface roughness	108cm

Sensitive Receivers

As mentioned in section 4.2.4 few SRs currently exist in the Study Area. Peng Chau, southwest of the Container Port, has a significant population (approximately 4,500), small settlements are located at Ngong Shuen Au at the head of Penny's Bay, Fa Peng on north eastern Lantau, and Sz Pak at the entrance to Discovery Bay. Construction of the NLE and the Container Port Expressway will displace Ngong Shuen Au, leaving no existing SRs north of Penny's Bay. Fa Peng may remain as a small settlement associated with the planned Marine Support Services Area (MSSA), Sz Pak will remain, and it also represents the eastern extent of possible future residential development at Discovery Bay. Thus, the following locations were selected for modelling as the nearest existing SRs.

- Peng Chau;
- Fa Peng; and
- Sz Pak/future Discovery Bay related development.

Other potential SRs, such as Ma Wan, Hei Ling Chau, Discovery Bay, and Hong Kong Island are sufficiently distant such that impacts will be less than at the selected receivers, and no impacts are expected to exceed any AQO. Figure 4.1 indicates the locations of the existing SRs.

In addition to the existing receivers, the LAPH development will create numerous new, potential SRs. These locations include development at Penny's Bay, near the proposed MSSA, and on the Container Port reclamation. Precise receiver locations (e.g., structures) are not yet known, however, potential impacts can be expressed for planning purposes in terms of distances from roadways. Transects of receiver locations were included in the modelling of roadway impacts, and the setback distances required to maintain concentrations within the AQO were determined. A similar procedure was used in the NLE study to determine required setback distances for potential future receivers, such as the North Shore developments, from the NLE. The NLE was assumed to be already present in the modelling for the Container Port.

4.3 IDENTIFICATION AND ASSESSMENT OF IMPACTS

4.3.1 Phase I Construction

The northern section of the Container Port Expressway and service arteries extending across the reclaimed Penny's Bay (where industrial development will begin) to the first four container berths will be constructed and the first phase of the MSSA will be completed at Fa Peng. Since no SRs will remain at Penny's Bay, impacts and mitigation measures will be of concern mainly at Fa Peng, and to a lesser extent in the area of Penny's Bay Power Station. In order to avoid concentrations in excess of the AQO and the 1-hour TSP guideline, mitigation should be employed when blasting and major excavation occurs within 500m of these areas.

4.3.2 Phase I Operation, Phase II Construction

The major developments of Phase II will occur between the Phase I berths and Fa Peng and include expansion of the roadway network and the Container Port Expressway. The MSSA development will be extended northwards. The southwestern portion of Penny's Bay will be reclaimed and developed. Impact areas of concern will expand to include those Phase I developments adjacent to Phase II construction. The predominant construction activities will include reclamation and associated development, blasting and major excavation, therefore mitigation should be provided where sensitive locations are considerably less than 500m from work sites.

With Phase I in operation, roadway traffic emissions will occur from the northern section of the Container Port Expressway and from the service artery connecting the Container Port Expressway to the Phase I berths, the Penny's Bay Power Station and also developments in Penny's Bay. Because of the relatively low port traffic volumes and limited extent of the roadway system in Phase I, impacts at the existing SRs will be relatively small and within the AQO. However, larger impacts may occur near the roadways. Nitrogen oxides are of concern because of the high percentages of diesel trucks in the predicted traffic flow. Analysis of potential impacts of NO_2, CO and RSP from roadway traffic indicate that the critical impact is the 1-hour NO_2 concentration. The modelled concentrations indicate that 1-hour NO_2 concentrations could exceed the AQO before concentrations for other averaging periods would. One-hour NO_2 impacts were evaluated in terms of required setback distances from those roadways operating in Phase I. For the main Port Expressway/Port Service Artery the calculated setback of 0-10m from the inner roadside is sufficient to prevent concentrations above the AQO at SRs in Phase I. Along the service road for the Phase I berths, the lower traffic volumes also allow a setback distance of 0-10m in order to maintain the AQO.

4.3.3 Phase II Operation, Phase III Construction

Most Phase II construction will occur primarily in the harbour as reclamation proceeds for additional berths and the associated services and roadways. Mitigation of construction related air quality impacts will be of less concern during Phase III because the work areas are further remote from SRs. Mitigation of impacts should still be considered for adjacent areas with sensitive land uses developed during Phases I and II. The western edge of the Phase III reclamation will be located about 1km from the eastern shores of Peng Chau. This distance is at the upper limit of the radius within which concentrations may exceed the AQO, even for the highest-emitting activities. Accordingly, no need for mitigation during Phase

III construction is expected at Peng Chau with the proposed port layout.

For Phase II, the roadway system will have been expanded considerably to the east and southwest from the Phase I layout. Quantitative modelling was not performed for the Phase II roadway network because traffic data were not available. However, comparison of trends in vehicle emission rates and traffic volumes indicate that pollutant concentrations for Phase II operation would be less than the estimated concentrations for Phase IV, as discussed below.

4.3.4 Phase III Operation, Phase IV Construction

Phase IV construction expands the area reclaimed in Phase III, and includes the extension of the Container Port Expressway via the Green Island Link, using a tunnel, to Hong Kong Island. As with Phase III, mitigation measures should be employed to protect adjacent previously developed areas. Other SRs are sufficiently remote that no need for mitigation is required.

The primary addition to the roadway system for Phase III will be the extension of the service arteries to link the Phase III reclamation and berths with the existing roadways. Quantitative modelling could not be performed for the Phase III roadway network as traffic data were not available. However, comparison of trends in vehicle emission rates and traffic volumes indicates that pollutant concentrations with Phase III operation would be less than the estimated concentrations with Phase IV, as discussed below.

4.3.5 Phase IV Operation

Table 4.5 presents the estimated air quality impacts at the existing SRs for Phase IV. All concentrations are less than the corresponding AQO.

The sensitive receiver location modelled at Fa Peng represents an existing settlement. It is not immediately adjacent to the major roadway alignments, but will be surrounded by development that will include industry, port activities, roadways, and their associated emissions. As such, the Fa Peng receiver is anticipated to be representative of numerous locations within the Study Area where receivers may be created. Because of this anticipated similarity in conditions, the modelling results suggest approximate pollutant concentrations that might occur at new receivers, the locations of which are not yet known. These results provide an

TABLE 4.5

ESTIMATED MAXIMUM AIR POLLUTANT CONCENTRATIONS AT EXISTING SRs FOR PHASE IV

Pollutant	*Averaging Period*	*AQO*	*1 Peng Chau*	*2 Fa Peng*	*3 Sz Pak*
NO_2	*1hr*	*300*	*164*	*190*	*175*
	24hrs	*150*	*93*	*98*	*95*
	Annual	*80*	*21*	*22*	*21*
CO	*1hr*	*30,000*	*159*	*176*	*159*
	8hrs	*10,000*	*225*	*136*	*125*
RSP	*24hrs*	*180*	*40*	*42*	*41*
	Annual	*55*	*20*	*20*	*20*

Note: Concentration ($\mu g/m^3$) at Receiver

area wide perspective distinct from the planning concerns for a land use to be located immediately adjacent to a major roadway. In the latter case, which was modelled in terms of setback distances to attain the AQO, emissions from nearby traffic are known to be the predominant contributor to pollutant concentrations, and setbacks from a specific roadway alignment to a specific development site are determined.

Setback distances from roadways were also estimated in order to maintain concentrations less than the AQO at future SRs. As with Phase I, the critical impact is the 1-hour NO_2 concentration. Table 4.6 provides the required setback distances for major roadways in the Study Area and landuse implications in terms of setbacks required from the plot boundary.

The required distances result from the heavy traffic volumes and high proportion of goods vehicles, which have high NO_2 emission rates, as well as the impacts of non-traffic emission sources. Mitigation measures should be considered to reduce NO_2 concentrations where development is planned within these setback distances.

4.3.6 Impacts with Respect to Potential Development Restrictions at Penny's Bay

Concern has been expressed that air quality impacts of the Penny's Bay Power Station may require constraints to be imposed on nearby industrial development in Penny's Bay. Previous studies

TABLE 4.6

ROADWAY SETBACK DISTANCES REQUIRED IN PHASE IV TO MEET AQO AT FUTURE SRs

Roadway Section and Location	[1]Setback (metres)
Port Expressway (if area remote from Service Artery, section between NLE and Phase I berths.	30 (12) [2](14)
Service Artery (if area remote from Port Expressway), section between NLE and Phase I berths	10 (0)
Port Expressway plus Service Artery (if adjacent), section between NLE and Phase I berths	[3]40 (9)
Service Artery along Phase II berth area	45 (25)
Green Island Link plus Service Artery (if adjacent) reclamation area connecting Phase II and Phase III	25 (0)
Service Artery along Phase III-IV berth area	35 (15)
Expressway to Sham Tseng Link (remote from other service arteries)	35 (15)
MSSA Artery, Fa Peng area (remote from other major roadways)	10 (0)

Note: Setback is the distance from the centre line of the roadway, at which estimated maximum 1-hour NO_2 concentrations decrease below the AQO.

( ) denotes setback distance from road side at which estimated 1hr NO_2 decreases to below the AQO.
1 All setbacks have been calculated utilising EPD emission factors.
2 Concentrations are within the AQO without embankment.
3 setback calculated from inside road edge of each road (this is used when two roads are adjacent).

pertaining to the Power Station (CLP 1990) determined that, because of the elevated terrain in the Penny's Bay area, computer modelling techniques were inadequate to address potential impacts from the plant. As part of those studies, a physical modelling study was completed which concluded that impacts of the plant would be of concern only for unusually high wind speeds. Under these conditions, the power station's exhaust plume could fail to clear the ridges surrounding Penny's Bay and could produce impacts at high-rise structures in the Penny's Bay area. The study also took into account expected increases in concentrations due to nearby development. The study concluded that, unless the power station's stack heights were extended above 50m, building heights should be limited to 50m in an area in the southwestern part of the proposed Penny's Bay reclamation.

These studies were reviewed for the air quality analysis of the Container Port development. The estimated increases in concentrations due to non-power station sources in these studies are compatible with the assumptions used for air quality analysis of the Container Port development. In addition, the high wind conditions that lead to impacts from the power station plant would also tend to provide favourable dispersion of emissions generated by the Container Port development. While definitive assessment of terrain effects on air quality at Penny's Bay would require further physical modelling, the results of the analyses performed to date indicate that no additional constraints, beyond those recommended previously, need be placed on industrial development in the area due to the Container Port.

4.3.7 Impacts of Development at Lamma Breakwater

As discussed in Section 4.2.3, potential impacts were assessed using the ISCST model for a range of worst-case screening scenarios and wind directions recommended by US, EPA. Impacts were estimated at five receivers, corresponding to the nearest land locations in various directions. These receivers were located on Cheung Chau, Hei Ling Chau, northern Lamma (Po Lo Tsui), central Lamma (Lo So Shing), and southern Lamma (Ha Me Tsui). The scenarios and locations resulting in the highest modelled concentrations were selected.

Table 4.7 presents the results in terms of the maximum emission rates that would allow worst-case concentrations to remain below the AQO, and indicates that the allowable emission rates are usually lower for short-term impacts than long-term impacts. This suggests that, should mitigation be required for actual emissions in the future, the critical impacts to be addressed might be short-term rather than long-term conditions.

TABLE 4.7

MAXIMUM ALLOWABLE EMISSIONS AT LAMMA BREAKWATER RECLAMATION TO MAINTAIN AQO AT SRs

POLLUTANT	AVERAGING PERIOD	ALLOWABLE EMISSION RATE TO MAINTAIN AQO*	
		as g/(sec-m²)	as g/(hr-ha)
NO_2	1hr	2.4×10^{-6}	87
	24hrs	2.4×10^{-6}	87
	Annual	9.7×10^{-6}	350
CO	1hr	4.8×10^{-4}	17,000
	8hrs	2.3×10^{-4}	8,200
TSP	1hr**	5.5×10^{-6}	200
	24hrs	7.3×10^{-6}	260
	Annual	9.7×10^{-6}	350
RSP	24hrs	5.7×10^{-6}	200
	Annual	5.7×10^{-6}	200
SO_2	1hr	1.1×10^{-5}	410
	24hrs	1.3×10^{-5}	470
	Annual	1.1×10^{-5}	410
Pb	3mths	9.7×10^{-8}	3.5

Key: * Area-wide average emission rate for 400 Ha development tract, based on modelling of worst-case screening scenarios. All emission rates account for the contribution of background concentrations (see Table 4.2).

** Guideline value for construction only.

The maximum allowable emission rates are conservative (tending to overestimate potential impacts) for several reasons. First, most actual SRs are further from the breakwater than those modelled. Second, the meteorological conditions that resulted in the maximum modelled concentrations, and thus the minimum emission rates, includes Pasquill-Gifford Stability Class F and a wind speed of $1.0ms^{-1}$. This condition is relatively rare, especially for time periods exceeding a few hours. Third, the estimated background concentrations are based largely on data for more northerly locations and probably overestimate the actual background levels in the southern part of the Study Area. Finally, the modelled emission rates are assumed to occur from the entire 400Ha development area however a considerable proportion of the total land area is likely to be devoted to uses from which emission rates would be very low.

Although the details of any future development at the breakwater reclamation are not yet known, it is important to note that impacts of individual major emitters, such as a large plant with a tall stack, could be significantly different from the results of this analysis. Potential air quality impacts of such major emission sources must be addressed in specific studies when sufficient information becomes available.

4.4 MITIGATION MEASURES

4.4.1 Construction

Existing SRs are sufficiently remote from much of the construction and quarrying activity that only standard dust control measures will be required for emission sources in many locations. However, mitigation measures are recommended for construction and quarrying activities within approximately 500m of Fa Peng, Penny's Bay Power Station and any receivers constructed as part of a previous phase.

The following measures to reduce particulate and other air quality parameters should be considered, as applicable:

- where feasible, transport materials by barge rather than by road;
- require proper maintenance of engine-powered equipment;
- prohibit excessive idling of vehicles and equipment;
- minimise exposed areas of disturbed soil;
- minimise entrainment of dust from exposed soil by covering, wetting, or landscaping;
- provide water sprays to minimise dust during material delivery and transfer operations;
- cover all loads of earth or rubble on trucks and barges;
- minimise use of dirt roads, pave or stabilise temporary access roads and parking areas;

- wash vehicles and wheels when leaving the site;
- establish speed limits for construction vehicles;
- where vehicles traverse populated areas, provide street sweeping;
- establish and enforce access routes and staging areas for construction equipment that minimise impacts on SRs;
- use the minimum practical charge during blasting;
- minimise free-fall distances of materials dropped through chutes, from conveyor ends, or by bucket loaders and similar equipment;
- enclose all conveyors and discharge points from process sources. Provide belt cleaners, water sprays, or fabric filters as necessary;
- control dust emissions from drilling by the use of fabric filters;
- for concrete batching, store cement in closed silos with fabric filters, and store sand and aggregate in bunkers, rather than in open piles;
- consideration of 'glory hole' method of excavation at Tsing Chau Tsai Mega Borrow area;
- for rock crushing and screening, provide enclosures, windscreens, and water sprays as necessary at the loading point, and enclose the crushing and screening operations;
- curtail dust-producing activity during periods of dry weather with high winds;
- incorporate mitigation requirements, possibly with incentives for compliance, into construction contracts; and
- monitor actual construction practices and pollutant concentrations, See Section 4.5, to ensure compliance with mitigation requirements.

4.4.2 Operation

Although all estimated pollutant concentrations are within the AQO at existing sensitive receivers, relatively high NO_2 concentrations are also predicted for areas in close proximity to major roadways. Setback distances can be used to protect land uses along adjacent roadways, however, many of the estimated setbacks required to meet the AQO in the Study Area are in the range 0-25m from the plot boundary. Without mitigating measures, the need to reserve this quantity of land will constrain development in the Study Area. Such mitigation includes provision of centralised air conditioning and fixed windows in buildings which straddle the setback distance. This is acceptable providing that air conditioning intakes are located beyond the setback distance.

The following operational measures to reduce air quality impacts should be considered, as applicable:

General

- observe provisions of Environmental Guidelines in HKPSG;
- mandate compliance with all applicable EPD requirements; and
- include the above requirements in contract specifications where applicable.

Road Traffic

- provide maximum setbacks from roadways to areas of human activity;
- encourage maximum development of the MTR to minimise road traffic;
- encourage maximum development of the bus system and connections to the MTR;
- make public transportation as attractive as possible through service quality, intermodal connections, convenience, access, fare structure, and amenities;
- lay out the road system to minimise travel distances;
- minimise vehicle queuing through provision of adequate road capacity demand-responsive signal systems, and traffic management techniques;

- implement incident management procedures to reduce traffic congestion caused by construction activities and accidents; and

- develop a programme to coordinate movement of empty containers to reduce unnecessary truck trips.

Vessel Traffic

- require cleaner diesel fuels and apply requirements to marine fuels; and

- plan anchorages to avoid excessive concentrations of vessels near SRs.

Container/Bulk Loading

- see truck trip coordination program above; and

- power cranes, loaders, and similar equipment by electricity rather than diesel where feasible.

Vessel Repair/Refitting

- encourage use of low-emission paints;

- minimize volatile solvent usage; and

- require environmental audits and pollutant prevention programs.

Industrial Land Uses

- encourage use of natural gas and electricity, if feasible, rather than diesel or coal;

- establish covenants, special districts, and similar arrangements that would improve implementation of incentives for low-emission processes, advanced control technologies, energy efficient equipment etc.;

- require environmental audits and pollution prevention programs; and

- locate major emission sources and Specified Processes at maximum distances from SRs, accounting for terrain and meteorological conditions (as determined by research, e.g. CLP studies).

4.5 MONITORING AND AUDIT REQUIREMENTS

4.5.1 Construction

Enforcement of dust control measures, through proper supervision of work practices and equipment maintenance, is likely to result in the most effective mitigation of particulate impacts. A clear management and reporting system should be implemented before the start of construction. Construction contracts should include requirements for compliance with mitigation plans, and remedial action if necessary. Contracts should include incentives for compliance and penalties for non-compliance.

The effectiveness of mitigation should be evaluated through air quality monitoring, (outline monitoring schedules are presented in Section 14). Particulate concentrations, wind speed and wind direction should be monitored at locations likely to receive the greatest impacts. Background monitoring should be conducted prior to construction to supplement baseline data measurements performed at Discovery Bay and Cheung Chau. The frequency and location of monitoring should be adjusted depending on the specific construction activities in progress. US, EPA-reference samplers should be used at stationary sites. Since these require gravimetric analysis of the sample to obtain results, portable dust meters (photometers) should be employed by mobile inspectors to monitor dust levels concurrent with activities that have potential to cause impacts. This method allows rapid identification and correction of excessively dusty activities.

EPD should be consulted for approval of specific plans and protocols for particulate sampling and mobile dust monitoring. The developer should provide the monitoring personnel with a plan specifying the actions to be taken in the event that excessive particulate impacts are identified.

4.5.2 Operation and Long Term Trends

Long term operational impacts of the LAPH development on air quality, and the associated audit and mitigation requirements, should be addressed as necessary on a regional basis through legislation, EPD regulation, and voluntary programmes by industrial and trade associations.

Existing air quality data for the Study Area is relatively scarce. The baseline air quality measurements conducted for the LAPH development were limited to a total of four weeks at each of two sites. The lack of comprehensive data and the significant impacts of the LAPH development suggest that one or more permanent air quality monitoring stations should be established in the Study Area. The purpose of monitoring would be to establish current baseline data and trends due to the combined impact of the new airport, the new regional transportation system, development on North Lantau, the LAPH development and new industry. To provide true baseline data, the station should be established well before the opening of the new airport. Suggested locations have included North Lantau and Penny's Bay Power station. Other possible locations might include the previous sites of limited monitoring at Discovery Bay and Cheung Chau. Parameters to be monitored should include meteorology, NO_2, SO_2, TSP and RSP as a minimum.

4.6 CONCLUSIONS

4.6.1 General

Air quality impacts at SRs may be expected to occur during the construction and operational phases of the project. Emissions will occur from both stationary sources (construction sites and industrial processes) and transportation sources. Impacts have been assessed using computer modelling techniques and assumptions approved by EPD and US, EPA.

The pollutant of greatest concern during construction activities is particulates. Anticipated construction activities were evaluated in terms of the distance within which air quality impacts could occur in excess of the AQO or the 1-hour TSP guideline. Where SRs exist within 500m of construction activities, mitigation measures should be employed to reduce particulate impacts.

Potential operational air quality impacts may arise from numerous emission sources, including vessels, container port and support activities, industrial land uses, and land transportation. Road transportation is of primary concern for the Lantau Port. The pollutant of greatest concern is NO_2. Emission rates from vehicles were estimated using EPD emission factors and the MOBILE4.1 computer model, with adjustments for Hong Kong vehicle characteristics. Concentrations at SRs due to vehicle emissions were estimated using the CALINE3 model for conditions of limited dispersion, and compared to the AQO. Few SRs currently exist in the Study Area but the Container Port-related development will create numerous new, potentially SRs. Where receivers do not yet exist, potential impacts were expressed for planning purposes in terms of setback distances required to meet the AQO.

For the Lamma Breakwater, the ISCST model was used to determine the maximum area wide emission rates that would still allow concentrations at the nearest SRs to remain within the AQO. Impacts were modelled for a range of meteorological conditions specified by US, EPA, and the highest predicted concentrations were selected.

Impacts during construction of Phase I would be of concern mainly at Fa Peng (however there are few, if any residents), and to a lesser extent in the area of Penny's Bay Power Station. Mitigation measures should focus on these areas. Major development in Phase II will occur from the Phase I berths northward. The southwestern portion of Penny's Bay will be reclaimed and developed. Impact areas of concern will expand to include those Phase I developments adjacent to Phase II construction. Most Phase III construction will occur in the harbour as reclamation proceeds. Mitigation of construction-related air quality impacts will be of lesser concern during Phase III because the work areas are further remote from SRs. Mitigation of impacts should still be considered for adjacent areas developed with sensitive land uses during Phases I and II. Phase IV construction expands the area reclaimed in Phase III. As with Phase III, mitigation measures should be employed to protect adjacent previously developed areas. Other SRs are sufficiently remote that no need for mitigation is required.

During operation, estimated impacts at the existing SRs are within the AQO. Phase IV 1-hour NO_2 levels in the Fa Peng area become fairly high, though less than the AQO, due to the intensity of development as well as proximity to major roadways. These results suggest the conditions that may occur at receivers similarly situated in proximity to emission sources. Analysis of potential impacts from roadway traffic indicated that the critical impact is 1-hour NO_2 concentration. One-hour NO_2 impacts were evaluated in terms of required setback distances from roadways, in order to maintain concentrations less than the AQO at future SRs.

Potential constraints on other developments due to an increase in emissions were assessed. The results suggest that no additional constraints, beyond those recommended in previous studies, need be placed on industrial development in the area due to the LAPH development.

It should be noted here that unless the CLP power station's stack height is increased, building heights should be limited to 50m in an area in the south western part of the proposed Penny's Bay reclamation. Mitigation measures for both construction and operational impacts were recommended. During construction, enforcement of dust control measures through proper site supervision and reporting, is likely to result in the most effective mitigation of particulate impacts. Construction contracts should include requirements for compliance with mitigation plans, and remedial action if necessary. The effectiveness of mitigation should be evaluated through air quality monitoring, using both stationary samplers and portable meters for rapid response to problems.

4.6.2 Recommendation

In order to provide important data on baseline air quality and trends, a permanent air quality monitoring station(s) should be established in the Study Area.

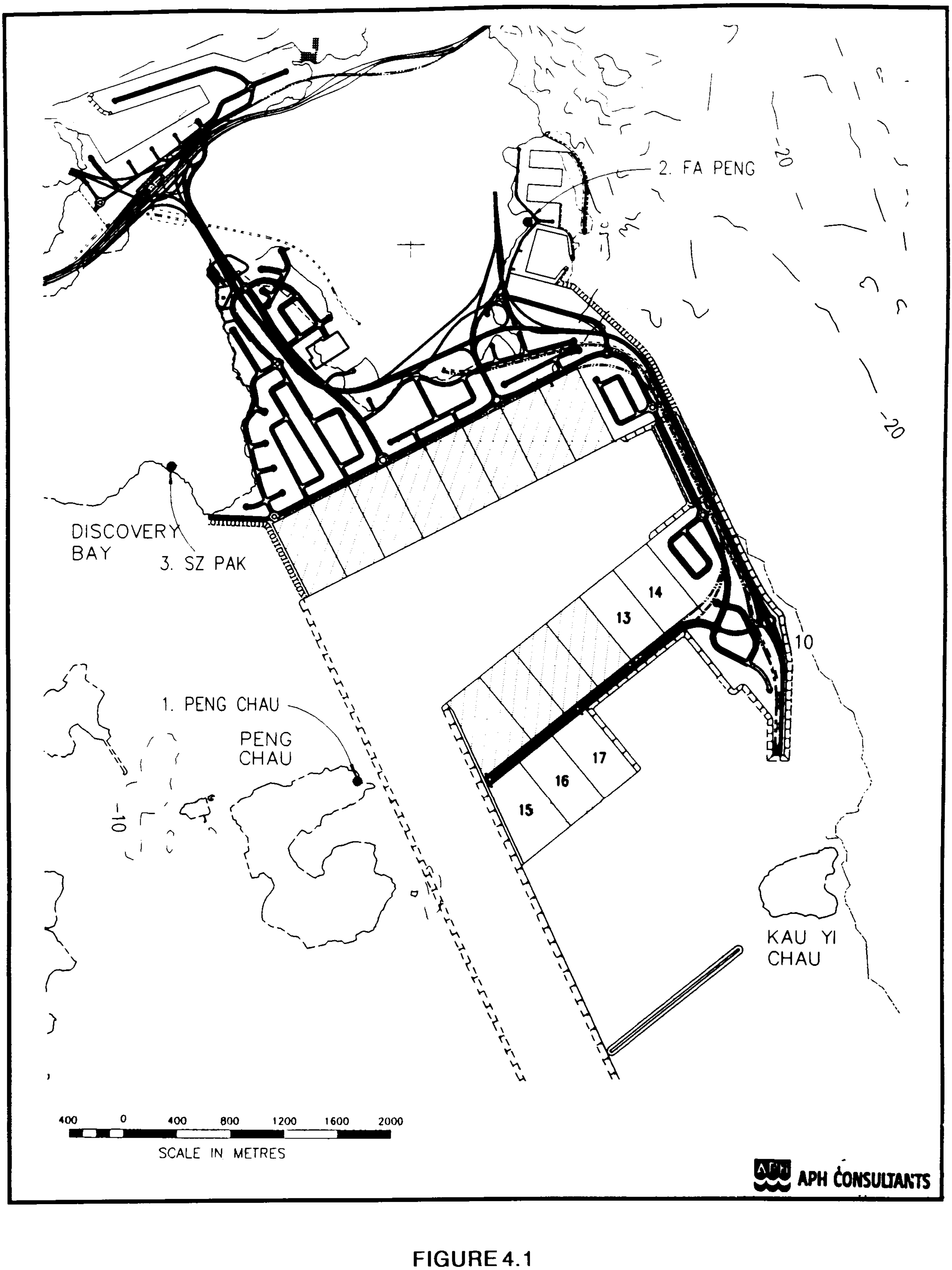

FIGURE 4.1

EXISTING SENSITIVE RECEIVERS FOR AIR QUALITY MODELLING ANALYSIS