3. Air Quality and Health Impact Assessment

3.1 Introduction

This section presents an assessment of the potential air quality and health impacts associated with the carrying out of the Project. The Project consists mainly of ground decontamination works prior to redevelopment, and therefore does not include an operation phase.

Potential air quality and health impacts associated with the Alternative Ground Decontamination Works at the proposed Kennedy Town Comprehensive Development Area (CDA) site were assessed. Dust generated from excavation and the associated decontamination processes are the primary concern during the carrying out of the Project. Other than construction dust, any resultant or related odour, gaseous emissions as well as released contaminated vapour and particles were assessed.

Representative Air and Health Sensitive Receivers (ASRs) within 500 m from the Project site boundary as well as areas where the air quality may be affected by the Project have been identified and the worst case impacts on these receivers were assessed. Suitable mitigation measures, where necessary, are recommended to protect the ASRs and to achieve the legislative criteria and guidelines.

The Air Quality and Health Risk Assessment is prepared in accordance with the Environmental Impact Assessment (EIA) Study Brief Clause 3.2.1 (i) – “potential air quality impact and the associated health risks on sensitive receivers due to the Project and associated works, including construction dust emissions, odour, gaseous emissions as well as released contaminated vapour and particulates etc.”.

3.2 Legislation and Standards

3.2.1 General

Representative ASRs within 500 m from the Project site boundary as well as areas where the air quality may be affected by the Project were identified and the worst case impacts on these receivers was assessed. Health impacts for emissions from Toxic Air Pollutants (TAPs) were conducted. TAPs refer to those air pollutants that would cause serious health effects, including cancer, or adversely affect the environment. Health impacts were also assessed for criteria pollutants. Suitable mitigation measures, where necessary, were recommended to protect the ASRs and achieve the legislative criteria and guidelines.

The following legislation and regulations provide the standards and guidelines for evaluation of air quality impacts and the type of works that are subject to air pollution control:

- Technical Memorandum on Environmental Impact Assessment Process (EIAO-TM) (Environmental Impact Assessment Ordinance (EIAO), Cap. 499.S16), Annexes 4 and 12;
- Air Pollution Control Ordinance (APCO) (Cap. 311) and the Air Quality Objectives (AQO);
- Air Pollution Control (Construction Dust) Regulation, and;
- Guidance Manual for Use of Risk-based Remediation Goals for Contaminated Land Management.

3.2.2 Technical Memorandum on Environmental Impact Assessment Process

The criteria and guidelines of evaluation for air quality impacts are laid out in Annex 4 and Annex 12 of the *Technical Memorandum on Environmental Impact Assessment Process (EIAO-TM)*. Annex 4 stipulates the criteria for evaluating air quality impacts. This includes meeting the *Air Quality Objectives (AQO)* and other standards established under the *Air Pollution Control Ordinance (APCO)*, as well as meeting the hourly Total Suspended Particulate (TSP) concentration of 500 µg/m^3 and the 5-second average odour concentration of 5 Odour Units (ou/m^3). Annex 12 provides the guidelines for conducting air quality assessments under the EIA process, including determination of ASRs, assessment methodology and impact prediction and assessment.

3.2.3 Air Pollution Control Ordinance

The principal legislation for the management of air quality is the *APCO (Cap 311).* The APCO specific AQOs stipulate the statutory limits of air pollutants and the maximum allowable numbers of exceedances over specific periods. The prevailing AQOs are as listed in **Table 3.1**. Criteria pollutants are not normally considered as TAPs; however the health impacts were assessed for these pollutants, as required in the Study Brief.

Table 3.1: Hong Kong Air Quality Objectives

Pollutant	Averaging Time	AQO concentration (µg/m³)	Allowable exceedances
Sulfur Dioxide (SO_2)	10 minute	500	3
	24 hour	125	3
Respirable Suspended Particulates (RSP)	24 hour	100	9
	Annual	50	0
Fine Suspended Particles (FSP)	24 hour	75	9
	Annual	35	0
Nitrogen Dioxide (NO_2)	1 hour	200	18
	Annual	40	0
Carbon Monoxide (CO)	1 hour	30,000	0
	8 hour	10,000	0
Ozone (O_3)	8 hour	160	9
Lead (Pb)	Annual	0.5	0
Total Suspended Particulates (TSP)[(1)]	1 hour	500	-

Note (1) EIAO-TM criterion, not an AQO

3.2.4 Air Pollution Control (Construction Dust) Regulation

The *Air Pollution Control (Construction Dust) Regulation* enacted under the APCO defines notifiable and regulatory works activities that are subject to construction dust control, as listed below:

Notifiable Works:

1. Site formation

2. Reclamation
3. Demolition of a building
4. Work carried out in any part of a tunnel that is within 100 m of any exit to the open air
5. Construction of the foundation of a building
6. Construction of the superstructure of a building
7. Road construction work

Regulatory Works:

1. Renovation carried out on the outer surface of the external wall or the upper surface of the roof of a building
2. Road opening or resurfacing work
3. Slope stabilisation work
4. Any work involving any of the following activities:
    a. Stockpiling of dusty materials
    b. Loading, unloading or transfer of dusty materials
    c. Transfer of dusty materials using a belt conveyor system
    d. Use of vehicles
    e. Pneumatic or power-driven drilling, cutting and polishing
    f. Debris handling
    g. Excavation or earth moving
    h. Concrete production
    i. Site clearance
    j. Blasting

Notifiable works require that advance notice of activities shall be given to the Environmental Protection Department (EPD). *The Air Pollution Control (Construction Dust) Regulation* also requires the works contractor to ensure that both notifiable works and regulatory works are conducted in accordance with the Schedule of the Regulation, which provides dust control and suppression measures. The Project includes site formation, stockpiling of dusty materials; loading, unloading or transfer of dusty materials; use of vehicles; excavation or earth moving, and; site clearance.

3.2.5 Guidance Manual for Use of Risk-based Remediation Goals for Contaminated Land Management

The *Guidance Manual for Use of Risk-based Remediation Goals for Contaminated Land Management* introduces the risk based approach in land contamination assessment and present instructions for comparison of soil and groundwater data to the Risk-based Remediation Goals (RBRGs) for 54 chemicals of concern, based on the best of EPD's knowledge on what may reasonably be found in contaminated sites in Hong Kong. The RBRGs were derived to suit Hong Kong conditions by following the international practice of adopting a risk-based methodology for contaminated land assessment and decontamination. They were also designed to protect the health of people who could potentially be exposed to land impacted by any of the abovementioned chemicals of concern under four broad post restoration land use categories. Furthermore, the RBRGs serve as the remediation targets if decontamination is necessary.

3.2.6 Site Investigation and Relevant Standards

A detail of the Project background is discussed in **Section 1.1**. As referenced from Chapter 7, a land contamination assessment was previously conducted in 2000 for the Project site under the Approved EIA Report. A preliminary site investigation (SI) was carried out in May 2000, when a total of 31 boreholes (TB1 to TB30 and TB10A) were drilled and soil samples were extracted from various depths. Soil samples were collected and analysed for heavy metals, petroleum carbon ranges, BTEX and PAH.

Under a specific EP condition, a Contamination Confirmatory Investigation (CCI) Proposal was submitted and approved by DEP on January 2003 after the EIA stage to confirm the extent of contamination at a certain area of the proposed CDA site in addition to that identified in the Approved EIA Report. Soil samples were collected and analysed for a total of 119 boreholes in this further SI. For those areas that had not been investigated at the EIA stage, a "grid" approach was proposed in the CCI Proposal. Soil samples from the grid boreholes were collected and analysed for heavy metals, petroleum carbon ranges, BTEX and PAH. In order to provide a more comprehensive picture on the extent of contamination, additional boreholes were also undertaken for comprehensive testing. Soil samples collected from such boreholes were also analysed for heavy metals, petroleum carbon ranges, BTEX and PAH. A total number of 33 TAPs were identified from the SI works.

Finally in 2013, additional SI works were carried out for land contamination assessment purpose under this EIA study. Soil samples were collected from 4 boreholes, where heavy metals, petroleum carbon ranges, PAH and BTEX were analysed.

From an Air Quality perspective, emissions may arise from the soil contaminants adhering to the soil particles and dispersing or through volatilisation from the exposed soil surface. The Air Quality Assessment has taken into account all the pollutants identified in the SI described above and based on the list of TAPs in the RBRGs a subset of TAPs was identified as being present at the Kennedy Town CDA. The air quality and health impact for acute and chronic non-carcinogenic risks were assessed against relevant reference values for the identified TAPs. The carcinogenic risk of the TAPs were assessed by calculation of incremental lifetime cancer risk estimated based on the relevant inhalation unit risk values. For those TAPs for which reference/risk values have been identified in the approved EIA for the Expansion of Hong Kong International Airport into a Three-Runway System (Register No.: AEIAR-185/2014) (hereafter known as "Third Runway EIA"), the same reference/risk values were adopted in this assessment. For those TAPs for

which no reference values have been identified in the approved Third Runway EIA, the following hierarchy was adopted for the selection of reference values:

1. Worldwide level
    - WHO, Air Quality Guidelines for Europe (2000).
2. Country level
    - Integrated Risk Information System (IRIS), USEPA;
    - Agency for Toxic Substances and Disease Registry (ATSDR), USEPA;
    - Australia, National Ambient Air Quality Standards (1998); and
    - New Zealand, health-based guideline values (2002).
3. Local Level (i.e. states, provinces or cities)
    - Cal/EPA Acute reference level from Office of Environmental Health Hazards Assessment, California;
    - Hong Kong, Technical Memorandum for Issuing Air Pollution Abatement Notices to Control Air Pollution from Stationary Polluting Processes;
    - New Hampshire Code of Administrative Rules, Table of All Regulated Toxic air Pollutants;
    - Ontario's Ambient Air Quality Criteria, Standards Development Branch, Ontario Ministry of the Environment; and
    - Texas Commission on Environmental Quality.

When two or more reference values are identified within the same level mentioned above, the more stringent values are adopted in this assessment.

The inhalation unit risk values for carcinogenic risks as well as the reference values for acute and chronic non-carcinogenic risks for all the identified TAPs, including heavy metals (HM) and hydrocarbons (HC), are detailed in **Table 3.2**.

Table 3.2: Carcinogenic risks, acute and chronic non-carcinogenic risks for identified TAPs

Pollutants	Carcinogenic risk		Non-carcinogenic risk - reference values					
	Inhalation Unit Risk		Chronic (annual)		Acute (daily)		Acute (hourly)	
	$(\mu g/m^3)^{-1}$	Source (2)	$\mu g/m^3$	Source (2)	$\mu g/m^3$	Source (2)	$\mu g/m^3$	Source (2)
Arsenic	1.50E-03	WHO	1.50E-02	Cal/EPA	3.60E-02	New Hampshire	2.00E-01	Cal/EPA
Barium	-	-	5.00E-01	Texas	2.50E+00	New Hampshire	5.00E+00	Texas

Pollutants	Carcinogenic risk		Non-carcinogenic risk - reference values					
	Inhalation Unit Risk		Chronic (annual)		Acute (daily)		Acute (hourly)	
	$(\mu g/m^3)^{-1}$	Source (2)	$\mu g/m^3$	Source (2)	$\mu g/m^3$	Source (2)	$\mu g/m^3$	Source (2)
Cadmium	1.80E-03	IRIS	1.00E-02	ATSDR	3.00E-02	ATSDR	1.00E-01	Texas
Cobalt	-	-	1.00E-01	ATSDR	7.10E-02	New Hampshire	2.00E-01	Texas
Chromium (III)	-	-	1.10E-01	New Zealand	5.00E-01	Ontario	-	-
Chromium (VI)	4.00E-02	WHO	1.00E-01	IRIS	3.00E-01	ATSDR	8.50E-03	HKEPD
Copper	-	-	2.40E+00	Cal/EPA	3.60E+00	New Hampshire	1.00E+02	Cal/EPA
Molybdenum	-	-	3.00E+00	Texas	1.10E+01	New Hampshire	3.00E+01	Texas
Nickel	3.80E-04	WHO	9.00E-02	ATSDR	2.00E-01	ATSDR	2.00E-01	Cal/EPA
Lead	1.20E-05	Cal/EPA	5.00E-01	WHO	1.50E-01	New Hampshire	-	-
Tin	-	-	2.00E+00	Texas	1.00E+01	Ontario	2.00E+01	Texas
Zinc	-	-	2.00E+00	Texas	-	-	2.00E+01	Texas
Mercury	-	-	1.00E+00	WHO	3.00E-01	New Hampshire	6.00E-01	Cal/EPA
Naphthalene	3.40E-05	Cal/EPA	1.00E+01	WHO	2.25E+01	Ontario	5.00E+02	Texas
Acenaphthylene	-	-	1.00E-01	Texas	-	-	1.00E+00	Texas
Acenaphthene	-	-	1.00E-01	Texas	-	-	1.00E+00	Texas
Fluorene	-	-	1.00E+00	Texas	-	-	1.00E+01	Texas
Phenanthrene	-	-	5.00E-02	Texas	7.10E-01	New Hampshire	5.00E-01	Texas
Anthracene	-	-	5.00E-02	Texas	-	-	5.00E-01	Texas
Fluoranthene	-	-	5.00E-02	Texas	-	-	5.00E-01	Texas
Pyrene	-	-	5.00E-02	Texas	7.10E-01	New Hampshire	5.00E-01	Texas
Chrysene	1.10E-05	Cal/EPA	5.00E-02	Texas	2.40E-01	New Hampshire	3.60E-01	New Hampshire
Benzo(a) anthracene	1.10E-04	Cal/EPA	5.00E-02	Texas	3.60E-01	New Hampshire	5.00E-01	Texas
Benzo(b) fluoranthene	1.10E-04	Cal/EPA	5.00E-02	Texas	-	-	3.60E-01	New Hampshire
Benzo(k) fluoranthene	1.10E-04	Cal/EPA	5.00E-02	Texas	-	-	5.00E-01	Texas
Dibenzo (a,h) anthracene	1.20E-03	Cal/EPA	5.00E-02	Texas	-	-	5.00E-01	Texas
Indeno(1,2,3-cd) pyrene	1.10E-04	Cal/EPA	5.00E-02	Texas	-	-	5.00E-01	Texas
Benzo(g,h,i) perylene	-	-	5.00E-02	Texas	-	-	5.00E-01	Texas
Benzo(a)pyrene	8.70E-02	WHO	3.00E-04	New Zealand	-	-	3.00E-02	Texas
Benzene	6.00E-06	WHO	3.00E+01	IRIS	2.90E+01	ATSDR	2.70E+01	Cal/EPA
Toluene	-	-	5.00E+03	IRIS	3.75E+03	ATSDR	1.50E+04	Texas
Ethylbenzene	2.50E-06	Cal/EPA	1.00E+03	IRIS	2.17E+04	ATSDR	8.67E+04	Texas
Xylenes (Total)	-	-	1.00E+02	IRIS	8.82E+03	ATSDR	7.37E+03	Texas

Note (1) Dash (-) means no relevant reference values were found

(2) Reference sources:

WHO - WHO, Air Quality Guidelines for Europe (2000)

IRIS - Integrated Risk Information System (IRIS), USEPA

Cal/EPA - Cal/EPA Acute reference level from Office of Environmental Health Hazards Assessment, California
New Hampshire - New Hampshire Code of Administrative Rules, Table of All Regulated Toxic air Pollutants
ATSDR - Agency for Toxic Substances and Disease Registry (ATSDR), USEPA
New Zealand - New Zealand, health-based guideline values (2002)
Texas - Texas Commission on Environmental Quality
HKEPD - Technical Memorandum for Issuing Air Pollution Abatement Notices to Control Air Pollution from Stationary Polluting Processes, EPD, Hong Kong
Ontario - Ontario Ambient Air Quality Criteria, Standards Development Branch, Ontario Ministry of the Environment

Total Petroleum Hydrocarbons (TPH)

TPH consists of a complex mixture of hydrocarbons that are found in crude oil, ranging from light, volatile and short-chained organic compounds to heavy, long-chained and branched compounds (Agency for Toxic Substances and Disease Registry, 1999). Due to its composite nature, there are no reference values available for the assessment of TPH as a whole. The American Society for Testing and Materials (ASTM) Approach, as described in *"Provisional Peer-Reviewed Toxicity Values for Complex Mixtures of Aliphatic and Aromatic Hydrocarbons (CASRN Various)"*, USEPA, 2009, is adopted to evaluate the health impacts caused by TPH. Based on the ASTM Approach, a significant portion of the total potential impact on human health from TPH is assumed to be due to its indicator compounds. The impact on health of TPH is thus assessed through that of the indicator pollutants. If the indicator pollutants are within acceptable ranges, it is reasonable to argue that the potential health impacts due to TPH would not be significant.

Since the TPH of C6-C8 carbon range are light and short-chained compounds, they are much more volatile than the TPH of higher carbon-ranges (TPHCWG, 1999), hence having significantly higher potential impact on air quality. Based on the SI for which TPH concentrations of different carbon ranges are available, it can be estimated that the total concentrations of four pollutants within the C6-C8 carbon range, i.e., benzene, toluene, ethylbenzene and total xylenes, contribute to a significant portion (about 59%) of the TPH within the C6-C8 carbon range (**Appendix 3.4b**). As a result, these four pollutants are adopted as the indicator pollutants for the purpose of assessment of health impacts due to TPH.

Due to the volatilisation of hydrocarbons (HC), some odour may be present during the excavation and decontamination stages of the Project. According to approved EIA, *Demolition of Buildings and Structures in the Proposed Kennedy Town Comprehensive Development Area Site (EIA-064/2001)*, during the intrusive site investigations there were no strong odours associated with any of the borehole samples.

3.3 Project Site

3.3.1 Local Environment and Site Description

The Project is a 32,000 m^2 site located in Kennedy Town on the coast of Hong Kong Island. The Kennedy Town CDA site is located on the on the coast and is bordered by the sea on the northern boundary. General land-uses immediately surrounding the site are:

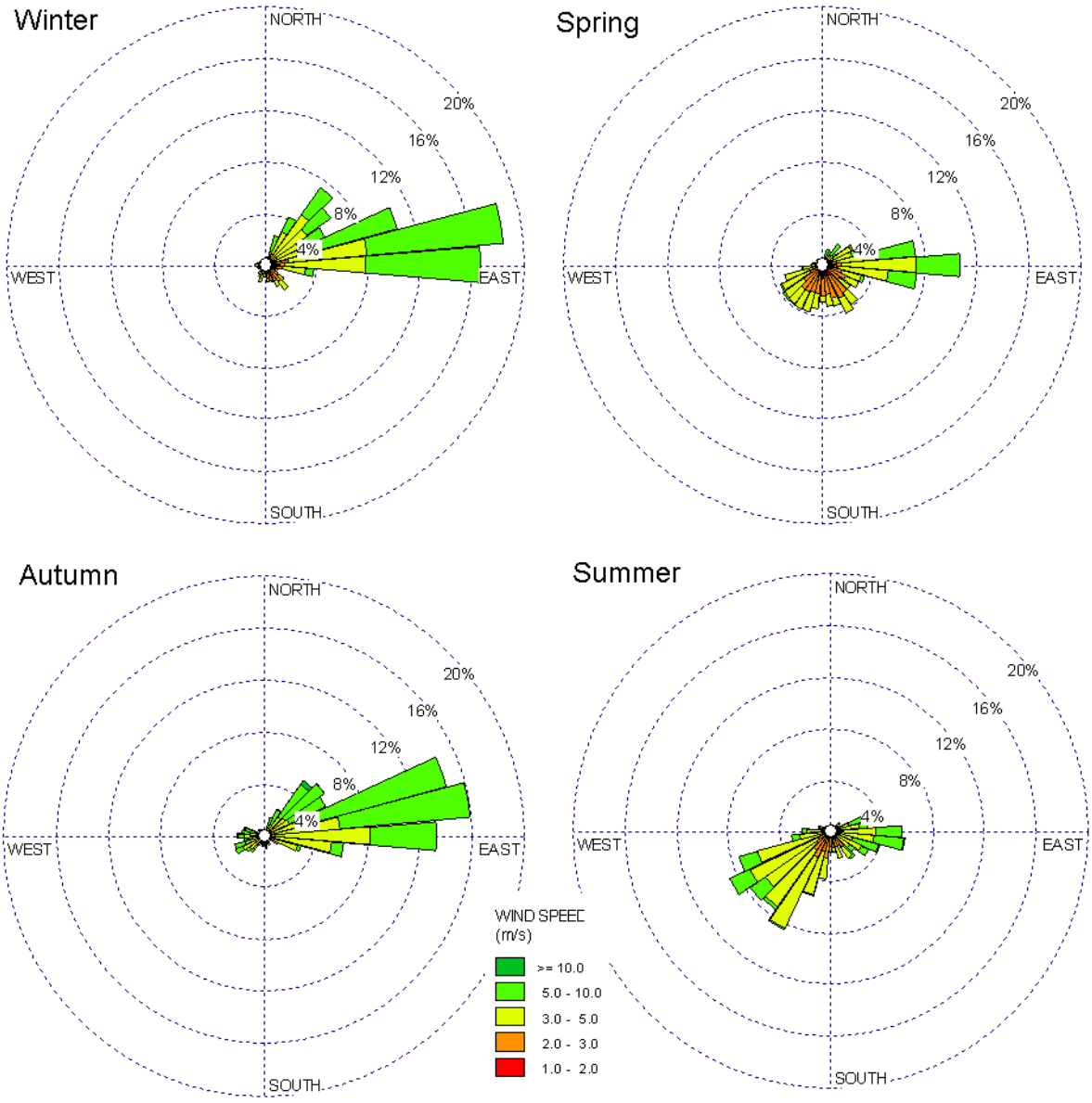
- residential and educational to the east and south;
- commercial to the west, and;
- Victoria Harbour bordering the site to the north.

The Study Area was largely formed by reclamation and has been used for various land uses (including those listed in **Table 8.1**). Based on the desktop review and site inspections and surveys, land contamination was detected or may have occurred due to the previous/current land uses concerned. The presence of contaminated materials was identified at almost every grid in the Kennedy Town CDA site and the extent was still considered widespread both horizontally and vertically.

3.3.2 Meteorology

The Pollutants in the Atmosphere and their Transport over Hong Kong (PATH) model, a regional air quality model prediction developed by EPD, was used to predict the meteorology at the Kennedy Town site. The PATH model can also be used to predict background air quality as a result of various sources in Hong Kong and the surrounding regions, including the Pearl River Delta Economic Zone (PRDEZ). **Graph 3.1** shows seasonal windroses for Kennedy Town CDA site from 2010 PATH data at grid (25, 25). Features of the wind profile that are significant for Kennedy Town CDA site are both wind speed and direction. At high wind speed, wind-blown dust emissions can become significant. At the Kennedy Town CDA site, winds from the east are dominant for most of the year, particularly so for autumn, winter and spring. In the summer winds from the south west dominate. This means that the winds are predominantly blowing off shore from the Project site.

Graph 3.1: Seasonal Windroses for Kennedy Town CDA Site from PATH Data at Grid (25, 25) (Wind Blowing From)



3.3.3 Background Air Quality

Dust

In accordance with the *Guidelines in Assessing the 'TOTAL' Air Quality Impacts*, Kennedy Town CDA site is categorised as an urban area. Since there is no EPD general air quality monitoring station located in this area, the recent five years (2008 –2012) annual average monitoring data recorded at EPD's general air quality monitoring stations at the Central/Western station is shown as a reference concentration for the current background concentrations, as this station is located closest to the Kennedy Town CDA site.

Since the Project consists mainly of ground decontamination works prior to redevelopment, dust generated from excavation and the associated decontamination processes are the primary concern during the carrying out of the Project. The machinery (i.e. combustion sources) used on site is not expected to generate significant amount of NOx, SO_2 and CO. Therefore only TSP, RSP, FSP and relevant TAPs data obtained at a nearby monitoring station (i.e. Central/Western) is used for describing the existing air quality.

With reference to EPD's *Air Quality Annual Report*, the 5-year annual average concentrations for TSP and RSP (2008-2012) and the 2012 annual concentrations for FSP at EPD's general air quality monitoring station in Central/Western are shown in **Table 3.3**.

Table 3.3: Annual average background for particulate matter air pollutant concentrations (Year 2008-2012)

Pollutant	Annual Average Concentration (µg/m^3)					5-year annual average background concentration (µg/m^3)
	2008	2009	2010	2011	2012	
Total Suspended Particulates (TSP)	78	73	76	78	62	73
Respirable Suspended Particulate (RSP)	**51**	47	47	50	46	48
Fine Suspended Particulate (FSP)(1)	-	-	-	-	29	29

Note: Monitoring results that exceeded current criteria are shown in bold characters.

1) Annual average concentration (2012)

2) Annual average concentrations from 2008 to 2012 are used in order to be consistent with the latest available heavy metal and hydrocarbon background data from EPD

As shown in **Table 3.1**, RSP and FSP also are required to be assessed on a 24-hour average basis. With reference to EPD's *Air Quality Annual Report*, the 24-hour average concentrations and exceedances at EPD's general air quality monitoring station in Central/Western are shown in **Table** 3.4.

Table 3.4: 24-hour average background and exceedances for particulate matter air pollutant concentrations (Year 2008-2012)

Pollutant	10th highest 24-hour Average Concentration (µg/m^3) [number of exceedances per year]				
	2008	2009	2010	2011	2012
Respirable Suspended Particulate (RSP)	**115 [22]**	99 [9]	**101 [22]**	**103 [15]**	95 [6]
Fine Suspended Particulate (FSP)	-	-	-	-	68 [4]

Note: Monitoring results that exceeded current criteria are shown in bold characters.

1) Annual average concentrations from 2008 to 2012 are used in order to be consistent with the latest available heavy metal and hydrocarbon background data from EPD

The closest EPD air quality monitoring station to the Project is located at Central/Western at 2 High Street, Sai Ying Pun. Considering the differences of the Central/Western EPD air quality monitoring station and the Project site in terms of geographic location, local sources (including vehicular and marine traffic) and the associated differences in meteorological data and emissions, the future background air pollutant concentrations used for predicting the total air quality impact due to Project emissions were extracted from the PATH model 2015 (released by EPD in June 2012), as it was considered to be more representative for the assessment in the vicinity of the Project site.

As the PATH model does not generate TSP results, the PATH RSP results were taken to represent the background contributions for TSP at the ASRs. This is considered to be a reasonable assumption as particulate matter of sizes larger than RSP from far-field sources would have been largely settled before reaching the ASRs. Therefore, the background hourly TSP levels was reasonably estimated as the same as RSP concentrations for the purpose of estimating the cumulative 1-hour TSP levels due to the activities of the Project.

PATH model was used to predict far-field contributions to the background RSP levels on an hour-by-hour basis within the 500 m assessment area during the Project. The hourly RSP levels as predicted by PATH were then multiplied by a factor of 0.75 to conservatively estimate the corresponding FSP levels according to EPD's *Guidelines on the Estimation of $PM_{2.5}$ for Air Quality Assessment in Hong Kong*. The 2010 meteorological data as extracted from the relevant grids of PATH was used for running models.

Heavy Metals and Hydrocarbons

Ambient background information has been collected for a variety of heavy metals and hydrocarbons, and the best available information used. Where data was available the background concentrations were included to determine cumulative effects of the Project on the surrounding ASRs.

Comprehensive Toxic Air Pollutant (TAP) stations are operated by EPD and are located in Tsuen Wan and Central / Western. As with dust emissions, the recent five years (2008 – 2012) monitoring data recorded at the TAP monitoring stations were shown as a reference concentration for the current background concentrations. The stations measure a variety of air pollutants including Chromium VI, Polychlorinated Biphenyls (PCB), Polycyclic Aromatic Hydrocarbons (PAH) and Volatile Organic Compounds (VOC). As the Central / Western station is located the closest to the Project site, this information was used for the background concentrations. Measurements of the pollutants were taken for a period of 24 hours, between once and twice per month.

As only 24-hour measurements are available, the maximum 24-hour concentration was used to represent the hourly background concentration, the average of all the maximum 24-hour concentrations obtained over the 5-year period was used to represent the daily background and annual average background was calculated as the average of all measurements over the 5-year period.

Ambient background concentrations for lead have been measured historically in Hong Kong. Since leaded petrol was banned on 1 April 1999, it is no longer considered as a primary source in Hong Kong. According to the "*Air Quality in Hong Kong 2012*" published by EPD, the ambient lead concentrations continued to remain at very low levels during 2012 as in previous years, and the overall 3-month averages, ranging from 0.011 $\mu g/m^3$ (in Tung Chung) to 0.057 $\mu g/m^3$ (in Yuen Long), were well below the annual AQO limit of 0.5 $\mu g/m^3$. As lead is one of the identified heavy metal pollutants for the Project, the background data was used to determine cumulative effects.

Ambient background concentrations for Chromium VI were taken from the TAP monitoring station at Central /Western as no data was available in Air Quality Health Index (AQHI) website for this pollutant. Therefore, with the exception of Chromium VI and Lead, ambient background concentrations for all Heavy Metals were calculated from the average of the recent five years (2008 – 2012) Air Quality Reports for Airborne Species Concentration, taken from the AQHI website. The data recorded at Central / Western station was used for the background concentrations.

The assumed background data for available Heavy Metal and Hydrocarbon concentrations are shown in **Table 3.5**.

Table 3.5: Average Background Air Pollutant Concentrations for Heavy Metals and Hydrocarbons

Pollutant	Hourly Concentration ($\mu g/m^3$) [Reference value]	Daily Concentration ($\mu g/m^3$) [Reference value]	Annual average Concentration ($\mu g/m^3$) [Reference value]
Arsenic	No data [2.00E-01]	No data [3.60E-02]	4.28E-03 [1.50E-02]
Barium	No data [5.00E+00]	No data [2.50E+00]	1.42E-02 [5.00E-01]
Cadmium	No data [1.00E-01]	No data [3.00E-02]	1.01E-03 [1.00E-02]
Cobalt	No data [2.00E-01]	No data [7.10E-02]	No data [1.00E-01]
Chromium metal and chromium III	N/A	No data [5.00E-01]	2.28E-03 [1.10E-01]
Chromium VI	2.20E-04 [8.50E-03]	1.26E-04 [3.00E-01]	1.02E-04 [1.00E-01]
Copper	No data [1.00E+02]	No data [3.60E+00]	4.50E-02 [2.40E+00]
Molybdenum	No data [3.00E+01]	No data [1.10E+01]	No data [3.00E+00]
Nickel	No data [2.00E-01]	No data [2.00E-01]	6.18E-03 [9.00E-02]
Lead	N/A	No data [1.50E-01]	5.70E-02 [5.00E-01]
Tin	No data [2.00E+01]	No data [1.00E+01]	No data [2.00E+00]
Zinc	No data [2.00E+01]	N/A	1.89E-01 [2.00E+00]
Mercury	No data [6.00E-01]	No data [3.00E-01]	2.16E-04 [1.00E+00]
Naphthalene	7.21E-01 [5.00E+02]	5.33E-01 [2.25E+01]	3.37E-01 [1.00E+01]
Acenaphthylene	1.85E-02 [1.00E+00]	N/A	6.85E-03 [1.00E-01]
Acenaphthene	6.98E-02 [1.00E+00]	N/A	2.41E-02 [1.00E-01]
Fluorene	1.78E-02 [1.00E+01]	N/A	6.19E-03 [1.00E+00]
Phenanthrene	3.56E-02 [5.00E-01]	2.94E-02 [7.10E-01]	1.78E-02 [5.00E-02]
Anthracene	2.56E-03 [5.00E-01]	N/A	1.17E-03 [5.00E-02]
Fluoranthene	7.54E-03 [5.00E-01]	N/A	3.03E-03 [5.00E-02]
Pyrene	5.17E-03 [5.00E-01]	4.22E-03 [7.10E-01]	2.41E-03 [5.00E-02]
Chrysene	2.05E-03 [3.60E-01]	1.34E-03 [2.40E-01]	3.79E-04 [5.00E-02]
Benzo(a)anthracene	2.72E-03 [5.00E-01]	8.54E-04 [3.60E-01]	2.18E-04 [5.00E-02]
Benzo(b)fluoranthene	1.60E-03 [3.60E-01]	N/A	3.08E-04 [5.00E-02]
Benzo(k)fluoranthene	7.60E-04 [5.00E-01]	N/A	1.27E-04 [5.00E-02]
Dibenzo(a,h)anthracene	9.00E-05 [5.00E-01]	N/A	2.33E-05 [5.00E-02]
Indeno(1,2,3-cd)pyrene	1.38E-03 [5.00E-01]	N/A	2.56E-04 [5.00E-02]
Benzo(g,h,i)perylene	1.80E-03 [5.00E-01]	N/A	3.25E-04 [5.00E-02]
Benzo(a)pyrene (BaP)	1.09E-03 [3.00E-02]	N/A	1.75E-04 [3.00E-04]
Benzene	6.60E+00 [2.70E+01]	4.94E+00 [2.90E+01]	1.61E+00 [3.00E+01]
Toluene	2.70E+01 [1.50E+04]	1.64E+01 [3.75E+03]	5.42E+00 [5.00E+03]
Ethylbenzene	6.50E+00 [8.67E+04]	5.06E+00 [2.17E+04]	1.34E+00 [1.00E+03]
Xylene	2.36E+01 [7.37E+03]	1.15E+01 [8.82E+03]	2.64E+00 [1.00E+02]

Notes (1) N/A means Not Assessed

(2) For those pollutants where no data is available for their background levels, the pollutant concentrations due to the Project are estimated for assessment purposes.

As shown in **Table 3.5** the 5-year average background concentrations for all pollutants meet their respective reference values.

3.3.4 Air and Health Sensitive Receivers

In accordance with the Study Brief, this EIA assessed the potential air quality impacts and the associated human health risks due to the Project at identified 'receptors'.

The existing and planned representative ASRs that may be affected by the Project within 500 m from the Project site boundary were identified and are summarised in **Table 3.6**. The locations of ASRs and the boundary of 500 m assessment area are shown in **Figure 3.1**. In addition to the identified ASRs, there may be some staff on shift duty located on the reprovisioned parts of the site during part of the Project duration. As the locations of these users are not known, these ASRs were assessed through review of the contour plots (refer to **Figures 3.8 to 3.17**).

Table 3.6: Representative ASRs Identified for the Assessment

No.	ASR	Description	Use	Horizontal distance from Kennedy Town CDA Boundary (m)	Existing/ Planned	Height above Ground (m)	No. of Storeys
1	KT-A1a	Cheong Kat Mansion	Residential	25	Existing	4	25
2	KT-A1b					8	
3	KT-A1c					12	
4	KT-A1d					16	
5	KT-A1e					20	
6	KT-A1f					30	
7	KT-A1g					40	
8	KT-A1h					50	
9	KT-A1i					60	
10	KT-A1j					70	
11	KT-A1k					80	
12	KT-A1l					90	
13	KT-A1m					100	
14	KT-A2a	The Merton (Block 2)	Residential	32	Existing	4	45
15	KT-A2b					8	
16	KT-A2c					12	
17	KT-A2d					16	
18	KT-A2e					20	
19	KT-A2f					30	
20	KT-A2g					40	
21	KT-A2h					50	
22	KT-A2i					60	
23	KT-A2j					70	

No.	ASR	Description	Use	Horizontal distance from Kennedy Town CDA Boundary (m)	Existing/ Planned	Height above Ground (m)	No. of Storeys
24	KT-A2k					80	
25	KT-A2l					90	
26	KT-A2m					100	
27	KT-A2n					110	
28	KT-A2o					120	
29	KT-A2p					130	
30	KT-A2q					140	
31	KT-A2r					150	
32	KT-A2s					160	
33	KT-A2t					170	
34	KT-A2u					180	
35	KT-A3a	Centenary Mansion (Block 1)	Residential	35	Existing	4	27
36	KT-A3b					8	
37	KT-A3c					12	
38	KT-A3d					16	
39	KT-A3e					20	
40	KT-A3f					30	
41	KT-A3g					40	
42	KT-A3h					50	
43	KT-A3i					60	
44	KT-A3j					70	
45	KT-A3k					80	
46	KT-A3l					90	
47	KT-A3m					100	
48	KT-A4a	Cayman Rise (Block 1)	Residential	35	Existing	4	31
49	KT-A4b					8	
50	KT-A4c					12	
51	KT-A4d					16	
52	KT-A4e					20	
53	KT-A4f					30	
54	KT-A4g					40	
55	KT-A4h					50	
56	KT-A4i					60	
57	KT-A4j					70	
58	KT-A4k					80	
59	KT-A4l					90	
60	KT-A4m					100	
61	KT-A4n					110	
62	KT-A4o					120	

No.	ASR	Description	Use	Horizontal distance from Kennedy Town CDA Boundary (m)	Existing/ Planned	Height above Ground (m)	No. of Storeys
63	KT-A5a	Bayanihan Kennedy Town Centre	Educational	35	Existing	4	6
64	KT-A5b					8	
65	KT-A5c					12	
66	KT-A5d					16	
67	KT-A5e					20	
68	KT-A6a	Kennedy Town Jockey Club Clinic	Medical Clinics	20	Existing	4	3
69	KT-A6b					8	
70	KT-A6c					12	
71	KT-A7a	SKH Lui Ming Choi Memorial Primary School	Educational	52	Existing	4	6
72	KT-A7b					8	
73	KT-A7c					12	
74	KT-A7d					16	
75	KT-A7e					20	
76	KT-A8a	No. 60 Victoria Road	Residential	107	Existing	4	25
77	KT-A8b					8	
78	KT-A8c					12	
79	KT-A8d					16	
80	KT-A8e					20	
81	KT-A8f					30	
82	KT-A8g					40	
83	KT-A8h					50	
84	KT-A8i					60	
85	KT-A8j					70	
86	KT-A8k					80	
87	KT-A8l					90	
88	KT-A8m					100	
89	KT-A9a	St Luke's Settlement Neighbourhood Elderly Centre	Elderly Home	15	Existing	4	2
90	KT-A9b					8	
91	KT-P1a	No.37A Cadogan Street	Residential	40	Planned	4	44
92	KT-P1b					8	
93	KT-P1c					12	
94	KT-P1d					16	
95	KT-P1e					20	
96	KT-P1f					30	
97	KT-P1g					40	
98	KT-P1h					50	
99	KT-P1i					60	
100	KT-P1j					70	

No.	ASR	Description	Use	Horizontal distance from Kennedy Town CDA Boundary (m)	Existing/ Planned	Height above Ground (m)	No. of Storeys
101	KT-P1k					80	
102	KT-P1l					90	
103	KT-P1m					100	
104	KT-P1n					110	
105	KT-P1o					120	
106	KT-P2a	Development within Kennedy Town CDA Site	Residential (under planning, assumed use subject to review)	-	Planned	4	-
107	KT-P2b					8	
108	KT-P2c					12	
109	KT-P2d					16	
110	KT-P2e					20	
111	KT-P2f					30	
112	KT-P2g					40	
113	KT-P2h					50	
114	KT-P2i					60	
115	KT-P2j					70	
116	KT-P2k					80	
117	KT-P2l					90	
118	KT-P2m					100	
119	KT-P2n					110	
120	KT-P2o					120	
121	KT-P2p					130	
122	KT-P2q					140	
123	KT-P2r					150	
124	KT-P2s					160	
125	KT-P2t					170	
126	KT-P2u					180	
127	KT-P3a	Development within Kennedy Town CDA Site	Residential (under planning, assumed use subject to review)	-	Planned	4	-
128	KT-P3b					8	
129	KT-P3c					12	
130	KT-P3d					16	
131	KT-P3e					20	
132	KT-P3f					30	
133	KT-P3g					40	
134	KT-P3h					50	
135	KT-P3i					60	
136	KT-P3j					70	
137	KT-P3k					80	
138	KT-P3l					90	
139	KT-P3m					100	

No.	ASR	Description	Use	Horizontal distance from Kennedy Town CDA Boundary (m)	Existing/ Planned	Height above Ground (m)	No. of Storeys
140	KT-P3n					110	
141	KT-P3o					120	
142	KT-P3p					130	
143	KT-P3q					140	
144	KT-P3r					150	
145	KT-P3s					160	
146	KT-P3t					170	
147	KT-P3u					180	

3.3.5 Pollution Sources and Process Description

Mott Connell Limited conducted the study *Agreement No. CE85/2001 (CE) Demolition and Decontamination Works at the Kwai Chung Incineration Plant and at the proposed Kennedy Town Comprehensive Development Area Site – Design and Construction Design of Advance Works and Application for Further Environmental Permit – KTCDA Site, Final Environmental Report for FEP application*in November 2005.

The risk assessment calculated the migration of contaminants from different zones at and below ground and was based on the concentration levels of the contaminants in the soil and groundwater. Soil contaminant data for 870 samples from 187 boreholes, and 23 groundwater samples collected during the Contamination Confirmatory Investigation (CCI) in 2003 were used in the assessment, and the 95th percentile of the contaminant loadings from the soil samples and maximum contaminant loadings for the groundwater samples were calculated for use.

Additional Site Investigation (SI) works, consisting of soil and groundwater sampling, was carried out in the bus depot area (at BD1 to BD4) from 19 July 2013 to 7 August 2013. Samples were obtained at the proposed borehole locations, as indicated in *Figure 2.3* of **Appendix 7.2**. A total of four boreholes and four groundwater wells were established. A total of 27 soil samples and four groundwater samples (excluding samples collected for Quality Assurance (QA)/Quality Control (QC) purposes) were collected for laboratory analysis. Based on the analytical results, the classification of soil type within this area is unlikely to be affected given that exceedances of other heavy metals (such as lead, copper and zinc) were already found in the same area and at similar depths during the SI carried out in the original EIA under Agreement no. CE15/99 and CCI in 2003. Details of the additional SI are provided in the Section 3.4 of the Contamination Assessment Report (CAR) (**Appendix 7.2**).

No major site activities took place between the conclusion of the SI in 2003 and mid-2007. Phase 1 Part 1 works commenced in September 2007 and were completed in July 2009. For Phase 1 Part 2, the site has been handed over to MTR Corporation Limited (MTRCL) for West Island Line (WIL) project and the Highways Department (HyD) for maintenance depot since July 2009. Additional concrete paving and a layer of general fill material was provided by MTRCL for site areas where temporary site office and storage of construction materials were to be located prior to their use. Regular visual inspections to ensure the structural integrity of the concrete paving are ongoing. Under the requirements of the EP of the WIL project

(Permit No. EP-313/2008/F), a Removal Plan with proposed sampling points will be submitted to EPD before commencement of removal of the additional concrete paving and the layer of general fill material. In case any land contamination occurs, the removal and treatment will be undertaken by the MTRCL before handing over the site.

The Highways Department maintenance depot is only used as a temporary site office. Site inspection was performed in May 2012; none of the contaminated land use types were identified as listed in Table 2.3 of the Practice Guide for Investigation and Remediation of Contaminated Land (EPD, 2011).

In addition, there has also been no change in land use at the Cadogan Street Temporary Garden, public car park, Refuse Collection Point (RCP) and existing roads since 2000. These areas are not regarded as potential sources of further contamination.

Currently, the areas mentioned above are covered with concrete layers with the minimum thickness stipulated by the EP. Therefore, no further contamination of the underground soil is found to have occurred.

In accordance with the EIA Study Brief, Appendix A, Clause 3 (ii), a quantitative assessment was carried out to evaluate the construction dust impact. Due to the extensive excavation at the site and the close proximity of the ASRs to the Project, it is considered appropriate to carry out a quantitative construction dust assessment. The major activities that may generate construction dust and the associated emissions include the following:

- Excavation and backfilling activities;
- Movement of mobile plant and vehicles on site;
- Stockpiling of contaminated soils for decontamination, and stockpiling of clean fill, and;

Other emissions that are to be considered are the outlet emissions from the bioremediation piles.

Excavation

As detailed in **Section 2.5** and illustrated in **Graphic 7.1** and **7.2**, the excavated soil will be sorted on-site into different types and handled in the following ways:

- Cleanfill, which will not require decontamination;
- HM contaminated soil to be decontaminated in-situ via cement solidification,
- HC contaminated soils to be decontaminated in biopiles, and;
- Soils contaminated with both HM and HC will be treated in biopiles followed by in-situ cement solidification

During the works period each working area is excavated at different times. Contaminated areas which are not being excavated will remain paved until it is necessary to remove the paving to carry out the excavation and backfilling works. The surfaces of inactive contaminated areas with removed paved layer will be covered with impermeable sheeting, or otherwise covered to prevent mobilisation of dust.

Three different Reprovisioning Options, namely OptionA, OptionB, and OptionC, were identified for implementation of the Project, each of which was assessed under this EIA. Detailed information of the

three Reprovisioning Options can be found in **Section 2.5**. The site is broken into a number of working areas which are shown in **Figure 3.2**. During the works period each working area will be excavated at different times. The excavated soil will be sorted into piles which are to be handled as follows: cleanfill, which does not require decontamination; cement solidification, for decontamination of HM, and; biopiling for decontamination of HC.

During the excavation stage the entire site is divided into a number of small grids, with a typical size of 961 m^2. It was assumed that no more than three individual works areas of 20 m by 20 m will be in operation at once in each zone group (i.e. 1200 m^2). A maximum of 3200 m^2 was assumed to be active at any one time over the entire Project site. Zones are grouped based on the excavation areas, which include Zone 1A and Zone 3; Zone 2; Zone 4, 5A and 5B, and; Zone 1B and Zone 1C (refer to **Figure 3.2**).

After decontamination works, all soil is to be backfilled on-site. The excavated soil not requiring decontamination shall be backfilled first and the remaining contaminated soil shall be treated by biopile and/or cement solidification before being backfilled on site.

The next grid shall be handled with the same process repeated. This process will be repeated until all grids are covered, hence the whole site decontaminated.

Throughout the duration of the Project there will be stockpiles on site for storage of cleanfill and soils awaiting decontamination. However, these stockpiles are to be covered to prevent additional dust emissions.

Biopiling

Biopiling is proposed to treat the soil that is contaminated with HC (see **Graphic 3.1**). Biopiling uses microorganisms to degrade contaminants in soil to harmless compounds such as water, carbon dioxide and other innocuous products.

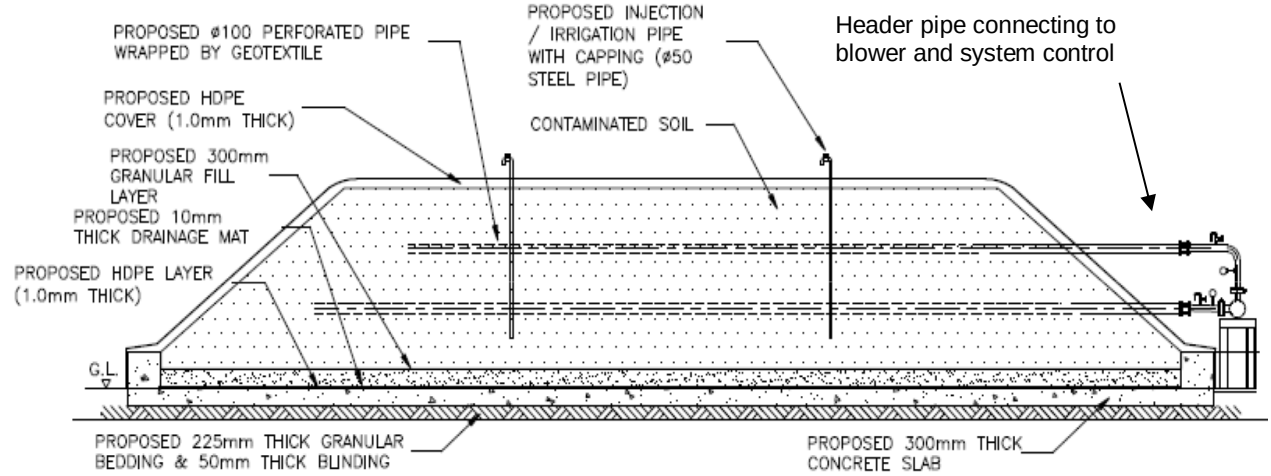
Biopiling involves drawing air into each biopile, creating a negative pressure within the pile. Negative pressure prevents fugitive emissions from the biopile. The biopiles are to be covered with impermeable sheeting to prevent fugitive dust and gaseous emissions. Introduced air encourages volatilisation of the HC and maintains an aerobic condition for the biological breakdown of HCs.

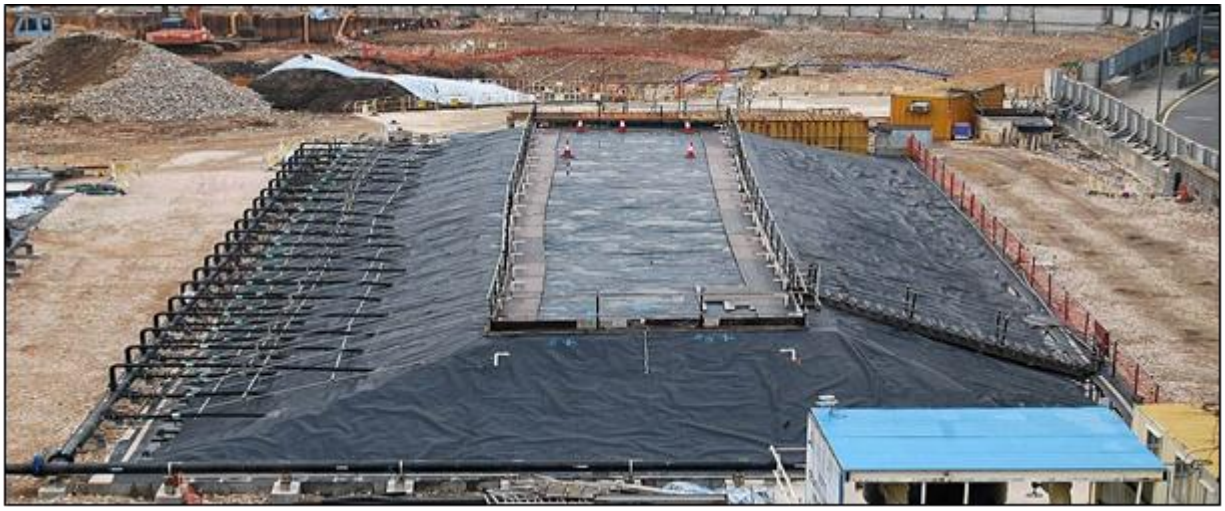
The air extracted from the biopile is expected to contain a combination of volatilised HCs and biological degradation products, that is, carbon dioxide and water vapour, as well as excess air from the process. The exhaust gases are to be passed through an activated carbon filter to remove residual contaminants. It is expected that the activated carbon filter should have a removal efficiency of 99%[1] as is commonly specified

[1] Data from USEPA's Office of Research and Development (ORD) and Emissions Standards Division's performance testing of various carbon adsorption beds for various industries is presented in the USEPA (1988) *Report on Carbon Adsorption for Control of VOC Emissions: Theory and Full Scale System Performance*. The results of the analysis demonstrate that properly designed and operated carbon adsorption systems are able to achieve well above 95% removal of VOCs on a continuous basis, for a wide variety of contaminant blends and ages. Removal efficiencies of greater than 99% were demonstrated several test beds (up to 99.8% removal). Efficiency is dependent on a number of factors, including inlet composition and concentration, temperature, humidity, duration and flowrate; bed size (surface area), number of beds, bed age, adsorbate and presence of fouling. Apart from the inlet parameters, most of these efficiency factors can be effectively controlled through the design specifications and appropriate operation and maintenance.

(Maunsell, Oct 2007; and Maunsell, Feb 2002).Soil gas monitoring for biopiles were shown to have 0 ppm Volatile Organic Compounds (VOCs) for eight monitoring events at 42 monitoring locations as recorded in the *Biopile Operation Monitoring and Cleanup Report (8 December 2010 to 7 January 2011)* (**Appendix 3.1**). Therefore HC emissions from the air extracted from the biopile are expected to be negligible. However, the formation of the biopiles may cause some dust emissions, and were considered in the modelling of dust emissions.

Graphic 3.1: General Cross-Section and Oblique View of a Biopile





Source: Kwai Chung Incineration Plant Demolition and Decontamination Works Technical Paper

Cement Solidification

Cement solidification is proposed to immobilise heavy metals in the soil. Soils contaminated with HMs are mixed with cement or other binding material and water. After sufficient residence time, the solidified product will be removed from the processing equipment and is ready for use as backfill within the site. Cement solidification is a wet process and the equipment is fully enclosed during mixing. Negligible dust emissions

are expected from this process. Soils that require both HC and HM decontamination will first go through HC decontamination by biopiling and then through HM decontamination by cement solidification.

Backfilling

Backfilling of the site will use the treated soils and clean fill. The emissions from backfilling were therefore not considered to pose a health hazard as the soils are treated to the Risk-Based Remediation Goals (RBRGs). Dust emissions from backfilling were modelled in a similar nature to those of excavation.

Prediction of dust emissions is based on emissions factors from the *Compilation of Air Pollution Emission Factors (AP-42), 5th Edition* published by United States Environmental Protection Agency (USEPA). The emission factor for a typical heavy construction activity is 2.69 megagrams (Mg)/hectare/month according to *Section 13.2.3.3 of AP-42*. Based on *Table 11.9-4 of AP-42*, the emission factor for wind erosion of 0.85 megagrams (Mg)/hectare/year is adopted. Although stockpiles are generally to be covered, during loading or unloading, the stockpiles will have some of the covers removed.

Concurrent Projects

The Project is scheduled to begin at the earliest in 2015. Due to construction of concurrent projects within the 500 m assessment area cumulative impacts are expected. Concurrent projects are shown in **Figure 3.3**. The concurrent projects that may contribute to cumulative construction dust include:

- Residential Development at the Ka Wai Man Road and Ex-Mount Davis Cottage Area (Assumed construction period: 2013 – 2021)
- Reprovisioning of Kennedy Town Saltwater Pumping Station (Construction period: Not available)
- Development within the Kennedy Town CDA site (Construction period: Not available)

The major processes onsite are related to excavation and decontamination. As the Project is based around excavation and soil decontamination activities and the associated emissions, the Project is not expected to generate significant NO_2, SO_2, CO, O_3 from dust emissions, cement solidification or biopiling processes. Therefore only TSP, RSP, FSP, lead and other heavy metals from dust dispersion, and emissions and odour from HC dispersion were considered in this assessment.

3.4 Assessment Methodology

3.4.1 Previous Studies

With reference to the Third Runway EIA, health impact assessment requires the following steps to be followed:

1. Identification of key pollutants (refer to **Section 3.2**)
2. Determination of modelling scenarios (refer to **Section 3.4.3** and **3.4.4**)
3. Identification of exposure pathways (refer to **Section 3.4.6**)

4. Determination of concentrations at the ASRs (refer to **Section 3.5**)

5. Assessment of risk level based on pollutant concentrations at ASR (refer to **Section 3.4.6**)

6. Mitigation (refer to **Section 3.6**)

Details of the above steps are described in the various above-mentioned sub-sections.

3.4.2 Model Description

The Project was assessed through air quality modelling in accordance with the *EPD's Guidelines on Choice of Models and Model Parameters*. The following air dispersion models were employed:

- Fugitive Dust Model (FDM) is a Gaussian air quality model and was used to predict the air pollutant concentrations due to open dust source impacts for both dust and contaminated soil effects.
- Industrial Source Complex – Short Term version 3 (ISCST3) is a Gaussian air quality model and was used to predict HC concentration due to decontamination of contaminated soils.

Model Limitations

It should be noted that FDM and all Gaussian based dispersion models have limited ability to predict dispersion in the following situations.[2]

Causality Effects

Gaussian plume models assume pollutant material is transported in a straight line instantly (like a beam of light) to receptors that may be several hours or more in transport time away from the source. The model takes no account for the fact that the wind may only be blowing at 1 m/s and will have only travelled 3.6 km in the first hour. This means that Gaussian models cannot account for causality effects, where the plume may meander across the terrain as the wind speed or direction changes. This effect was not considered to be significant for the Kennedy Town CDA site as the site is small.

Low wind Speeds

Gaussian plume models 'break down' during low wind speed or calm conditions due to the inverse speed dependence of the steady state plume equation. These models usually set a minimum wind speed of 0.5 m/s or 1.0 m/s and ignore or overwrite data below this limit. This may cause some over-estimation as calm hours are not accounted for. During calm hours, dust emissions that would otherwise remain static, are transported off-site. This may have resulted in an over-estimation at nearby offsite ASRs.

Straight-line Trajectories

Gaussian models will typically overestimate terrain impingement effects during stable conditions because they do not account for turning or rising wind caused by the terrain itself. For the Kennedy Town CDA site

[2] *Good Practice Guide for Atmospheric Dispersion Modelling.* Ministry for the Environment, New Zealand (June 2004)

assessment this effect may cause an over-estimation at lower terrain levels where impingement occurs. However as dust emissions are a non-buoyant, ground level source, this effect was expected to be minor and any overestimation conservative.

Spatially Uniform Meteorological Conditions

Gaussian models assume that the atmosphere is uniform across the entire modelling domain, and that transport and dispersion conditions exist unchanged long enough for the material to reach the receptor even if this is several kilometres away. In the atmosphere, truly uniform conditions rarely occur. As the Kennedy Town CDA site and surrounding assessment area is sufficiently small, uniform meteorological conditions were considered appropriate.

No Memory of Previous Hour's Emissions

In calculating each hour's ground-level concentrations, Gaussian models have no memory of the contaminants released during the previous hours. This limitation is especially important for the proper simulation of morning inversion break-up, fumigation and diurnal recycling of pollutants.

Mixing Height

Hourly meteorological data for a full year as extracted from the PATH model released by EPD in December 2012 (meteorological data year 2010, grid 25, 25) was used in FDM and ISCST3. The data was considered to be the most up to date data available. PATH data has been observed to have a lower mixing height for some hours, when compared to the measured mixing height. The minimum mixing height recorded by Hong Kong Observatory (HKO) in 2010 is 121.3 m, whereas the PATH minimum mixing height is 40 m. The HKO minimum mixing height of 121.3 m was used to replace any MM5 mixing height below this value. This approach was considered appropriate as it minimised over-estimation due to lower mixing heights. The PATH data with the above modification was considered to be representative of the site wind data at Kennedy Town CDA site.

3.4.3 Dust and Heavy Metal Assessment

Model Description - FDM

To assess the air quality through air quality modelling, use of the model FDM was required. In accordance with the *EPD's Guidelines on Choice of Models and Model Parameters*, FDM was used to predict the air pollutant concentrations due to open dust source impacts for both dust and heavy metal contaminated soil effects. FDM is a computerised air quality model specifically designed for computing the concentration and deposition impacts from fugitive dust sources. The model is generally based on the Gaussian Plume formulation for computing concentrations, but the model has been specifically adapted to incorporate an improved gradient transfer deposition algorithm. FDM is one of the air quality models listed as commonly used for EIA studies by EPD in *Guidelines on Choice of Models and Model Parameters*.

Methodology - FDM

The excavation and reinstatement of the ground, formation and decommissioning of biopiles and wind erosion at the Kennedy Town CDA site are the main sources of dust emissions during the Project. The Project was modelled for Reprovisioning Options A, B and C.

FDM has the ability to model various particle sizes. To take account of the different emissions for TSP, RSP and FSP, FDM modelled a "split" particle size. That is the emissions were split into particles sizes of less than or equal to 2.5 µm (FSP), less than or equal to 10 µm (RSP) and greater than 10 µm (TSP). It was assumed that only the RSP portion contributed to the HM emissions and all of the emissions (TSP, RSP and FSP) contributed to the dust emissions.

Modelling Scenarios

A tiered approach was used to estimate the project emissions throughout the carrying out of the Project. Pollutants assessed were TSP, RSP, FSP and various HM. A hypothetical Tier 1 screening assumed 100% of the total site area was emitting dust. This Tier 1 scenario (i.e. assuming 100% active area for the Kennedy Town CDA Project and the concurrent project) is hypothetical and used for screening purposes to identify which ASRs may be subject to dust concentrations above the relevant standards. The Tier 1 hourly TSP, daily and annual RSP and daily and annual FSP levels at all the ASRs were predicted for scenarios with and without dust mitigation measures in place. The Tier 1 scenario is therefore a hypothetical scenario that is very conservative and can represent any of the three Reprovisioning Options for different sequencing and phasing of the works as described in **Section 2.5**.

For the purpose of the Tier 1 screening, the dust mitigation measures, including frequent water spraying, were taken into account when estimating the dust emission rates from the decontamination activities. Details of the Tier 1 dust sources including their estimated emission rates are detailed in **Appendix 3.7** and coordinates and dimensions are found in **Appendix 3.8**. Locations of the assumed dust sources for Tier 1 assessment are shown in **Figure 3.4**. The Tier 1 hourly TSP, daily and annual RSP and daily and annual FSP levels at all the ASRs were predicted for both scenarios of with and without the dust mitigation measures in place. All active areas were assumed to have wind erosion. Heavy construction and wind erosion at the concurrent projects 'Residential Development at the Ka Wai Man Road and Ex-Mount Davis Cottage Area' and 'Reprovisioning of Kennedy Town Saltwater Pumping Station' were assumed to occur concurrently.

Where necessary, any ASRs identified with any non-compliance with the TSP, RSP and/or FSP criteria under Tier 1 screening, with mitigation measures in place, were selected for subsequent Tier 2 assessment. It was assumed in the Tier 2 assessment that the percentage active area of the Kennedy Town CDA site for each stage and the corresponding active areas of the relevant concurrent project would be located closest to the ASR being assessed for Tier 2 assessment and the maximum predicted annual average percentage for all zone was calculated and applied to the entire area as a conservative assumption. Details of the Tier 2 dust sources including their estimated emission rates are detailed in **Appendix 3.9**. The Tier 2 TSP, RSP and/or FSP concentrations at each of the ASRs were predicted with the dust mitigation measures in place.

Roughness Factor

The *Guideline on Air Quality model (revised),USEPA - 450/2-78-027R, July 1986* was used to calculate the roughness length for use in FDM.

The EPD guideline *Choice of Models and Model Parameters* recommends that the selection of rural or urban dispersion coefficients in a specific application should follow a land use classification procedure. If the land use types including industrial, commercial and residential uses account for 50% or more of an area

within a 3 km radius from the source, the site is classified as urban; otherwise it is classified as rural. The surface roughness height is closely related to the land use characteristics of a study area and associated with the roughness element height. As a first approximation, the surface roughness can be estimated as 3% to 10% of the average height of physical structures. Typical values used for urban and new development areas are 370 cm and 100 cm, respectively.

Within a 3 km radius of the site, 33.1% is classified as urban and the remaining 66.9% is sea. As the sea roughness is typically given a value of 0.01 cm and urban was assumed to be 370 cm, an area averaged roughness height of 123 cm was used. This accounted for the low turbulence over the sea water, and also the very large turbulence generated due to nearby large structures.

Dust Emission Factors

Dust emissions include Total Suspended Particulates (TSP), Respirable Suspended Particulates (RSP) and Fine Suspended Particulates (FSP). Prediction of dust emissions was based on emissions factors from the *Compilation of Air Pollution Emission Factors (AP-42), 5th Edition* published by USEPA. The emission factor for a typical heavy construction activity is 2.69 megagrams (Mg)/hectare/month according to *Section 13.2.3.3* of *AP-42*. The number of working days for a month and number of working hours per day of the Project were anticipated to be 26 days and 10 hours, respectively. Thus, these assumptions have been adopted in the model calculation. Based on *Table 11.9-4* of *AP-42*, the emission factor for wind erosion of 0.85 Mg/hectare/year was adopted.

Cement solidification is proposed to decontaminate soils contaminated with HM. In the cement solidification process soils are mixed with water and cement (or other binding material) in a fully enclosed vessel. Solidification takes place inside the vessel prior to reinstatement in the ground. As the process is wet and the vessel is fully enclosed it is therefore assumed that there are insignificant dust emissions from the cement solidification process.

The dust emission factors adopted in the FDM are summarised in **Table 3.7**.

With reference to the USEPA document *Estimating Particulate Matter Emissions from Construction Operations, 1999*; a typical ratio of 0.3:1 was used for RSP:TSP. Therefore, the RSP emission rates for heavy construction activities and wind erosion were estimated as 30% of the corresponding TSP emission rates. Based on the USEPA's *Examination of the Multiplier Used to Estimate $PM_{2.5}$ Fugitive Dust Emissions from PM_{10}, April 2005*, FSP emission from heavy construction activities and wind erosion were estimated as 3% of the corresponding TSP emissions. Details of these emission factors are given in **Table 3.7**.

Table 3.7: Key Dust Emission Factors Adopted in the Assessment

Activities	Emission Factors	Reference
Heavy construction activities including all above ground and open construction works, excavation and slope cutting works(1)	TSP Emission Factor = 2.69 Mg/hectare/month	Section 13.2.3.3 AP-42, 5th Edition
	RSP Emission Factor = 2.69 x 30% Mg/hectare/month	USEPA document *Estimating Particulate Emissions from Construction Operations, 1999 (pg 4-2)*
	FSP Emission Factor = 2.69 x 3% Mg/hectare/month	Thompson G. Pace, USEPA. *Examination of the Multiplier Used to Estimate $PM_{2.5}$ Fugitive Dust Emissions from PM_{10}, April 2005 (Table 2)*

Activities	Emission Factors	Reference
Wind erosion from heavy construction	TSP Emission Factor = 0.85 Mg/hectare/year	Table 11.9-4. AP-42, 5th Edition
	RSP Emission Factor = 0.85 x 30% Mg/hectare/year	USEPA document *Estimating Particulate Emissions from Construction Operations, 1999 (pg 4-2)*
	FSP Emission Factor = 0.85 x 3% Mg/hectare/year	Thompson G. Pace, USEPA. *Examination of the Multiplier Used to Estimate $PM_{2.5}$ Fugitive Dust Emissions from PM_{10}, April 2005 (Table 2)*

(1) For this Project, 'heavy construction activity' refers to 'heavy activities associated with decontamination works'.

(2) The particle size multipliers for TSP, RSP and FSP are made reference to Section 13.2.4.3 of the USEPA Compilation of Air Pollution Emission Factors (AP-42), 5th Edition (Jan 2011 edition).

For the mitigated scenario, the active decontamination areas were assumed to have ground watering applied once every 2.5 hours or four times per day. This gives rise to an estimated dust suppression efficiency of 91.7% (refer to **Appendix 3.3** for detailed calculations). The unmitigated scenario did not employ any watering for dust suppression.

Concurrent projects were assumed to have emissions from heavy construction activities and wind erosion. Detailed construction plans were not available so no stockpiles on the concurrent project sites have been modelled.

Heavy Metal Concentration from RSP Results

In order to estimate the air-borne HM concentrations that would be inhaled and the associated health impacts due to the Project, the maximum RSP concentration for all ASR for the entire model year as predicted by the FDM results was multiplied with the HM concentrations of soil samples obtained from the SI. RSP concentrations were chosen to estimate the air-borne HM levels as they are fine enough to penetrate further into the lungs than TSP and therefore may be potentially associated with more severe health impacts than coarser particles such as TSP.

HM concentrations of the soil samples at different zones were determined from borehole information of the soil laboratory testing performed during the various SI and used to determine the average concentration of HM of the soil in each zone, as shown in **Table 3.8** (refer to **Figure 3.2** and **Appendix 3.4a**).

Some high concentrations of pollutants were found in localised areas of the site. The average concentrations for each zone were determined. This approach is considered as reasonably conservative.

Cement solidification is proposed to decontaminate soils contaminated with HM. In the cement solidification process, water and a binder is added to the soil within a contained vessel. Solidification occurs within the vessel, and the solidified material is backfilled. Therefore HM emissions from the cement solidification process were considered insignificant.

Table 3.8: Average HM Concentrations of Soil at Different Zones

	Average Concentration (mg pollutant/kg RSP)			
Pollutant	Zone 1A and Zone 3	Zone 2	Zone 4, 5A and 5B	Zone 1Band Zone 1C
Arsenic (As)	8.82	10.67	7.90	16.29

			Average Concentration (mg pollutant/kg RSP)	
Pollutant	Zone 1A and Zone 3	Zone 2	Zone 4, 5A and 5B	Zone 1Band Zone 1C
Barium (Ba)	66.03	120.86	110.38	133.68
Cadmium (Cd)	2.74	0.47	0.56	0.21
Cobalt (Co)	3.92	4.96	4.38	4.48
Chromium (Cr) (1)	20.22	15.98	18.52	10.12
Copper (Cu)	136.26	70.20	31.25	170.86
Molybdenum (Mo)	2.61	2.23	1.92	2.25
Nickel (Ni)	6.71	8.22	5.12	10.04
Lead (Pb)	376.80	222.05	213.46	316.39
Tin (Sn)	17.01	31.62	47.07	19.85
Zinc (Zn)	657.43	411.29	153.41	405.24
Mercury (Hg)	2.40	2.99	7.10	3.88

(1) Both Chromium (VI) and Chromium metal and Chromium (III)are assumed to have the same concentration as shown in the table. The table value is for Total Chromium.

3.4.4 Hydrocarbon Assessment

Model Description – ISCST3

ISCST3 dispersion model was used to model the air pollutant concentrations due to HC volatilisation from contaminated soils at the Project site. ISCST3 is a steady state Gaussian plume model and is one of the models prescribed by the EPD's *Guidelines on Choice of Models and Model Parameters*. It should be noted that ISCST3 and all Gaussian based dispersion models have limited ability to predict dispersion in the situations as described previously in **Section 3.4.2**.

Assumptions and Inputs – ISCST3

Hourly meteorological data for a full year as extracted from the PATH model released by EPD in December 2012 (meteorological data year 2010, grid 25, 25) was used in ISCST3. The data was considered to be the most up to date data available. PATH data has been observed to have a lower mixing height for some hours, when compared to the measured mixing height. The minimum mixing height recorded by HKO in 2010 is 121.3 m, whereas the PATH minimum mixing height is 40 m. The HKO minimum mixing height of 121.3 m was used to replace any MM5 mixing height below this value. This approach was considered appropriate as minimises over-estimation due to lower mixing heights. The PATH data with the above modification is considered to be representative of the site wind data at Kennedy Town CDA site.

Modelling Scenarios

As with the dust modelling in FDM different modelling approaches were used to assess hourly and daily concentration and annual concentrations for the HC assessment.

For short-term modelling it was assumed only 1,200 m^2 will be excavated in each zone grouping at one time (refer to **Section 3.3.5**). The excavation area was placed as close to the Project boundary as possible. Hourly and daily average concentrations were determined by short-term modelling.

Long-term modelling was applied to annual average concentrations. As the excavation works will be spread over the entire site, the 1,200 m^2 excavated in each zone group was assumed to be spread over the entire zone group. That is, the annual average active area percentage was calculated by 1,200 m^2 multiplied by the number of zone groups excavated within the same part, divided by the total zone group area and then corrected by the percentage of time that the area will be subject to excavation. For example for Scenario A, zone 2, part 2, the zone group area is 8,500 m^2, the excavation area is 1,200 m^2 and the total excavation time for the zone area is 11 months; then the annual average active area percentage can be calculated as:

$$\frac{1{,}200\ m^2(Excavtionarea)}{8{,}500\ m^2(Totalzone\ grouparea)} \times \frac{11\ months(Total\ excavation\ time)}{12\ months\ (For\ annual\ average)} = 13\%$$

This annual average active area percentage multiplied by the emission rate as calculated in short-term modelling and applied to the whole zone group area for the entire year. Annual average was calculated for the concentrations at the ASRs.

Excavation at the Kennedy Town CDA site is the main sources of HC emissions during the Project. The Project was modelled using the three Reprovisioning Options for the existing temporary community facilities (car park, Refuse Collection Point (RCP) and garden) within the Project site, which are described, as follows.

Reprovisioning Option A – 13-year Project duration, to take place in two stages: Stage 1 involves decontamination of approximately 80% area of the site (the whole site except Cadogan Street Temporary Garden), and on-site reprovisioning (by others) of the existing car park and RCP; Stage 2 involves decontamination of the remaining area of the site (Cadogan Street Temporary Garden) after reprovisioning of the temporary garden at a decontaminated area of the site (by others). Planned ASRs (KT-P2 and KT-P3) as shown in **Table 3.6** are expected to be active after Stage 1 is complete. The active periods of each zone is generally staggered, and according to **Section 3.3.5**, approximately only 1,200 m^2 will be excavated in each zone grouping at one time and was used in the HC models. As described in **Section 3.4.4** above, HC emissions were assumed to occur during excavation only. Under this Reprovisioning Option, the different parts of works are as follows and are as shown in **Figure 3.5** for short-term and long-term modelling:

Reprovisioning Option A, Part 1 – Heavy construction including excavation of Zones 1A, 1B and 1C, this is expected to commence from 2016. ASRs KT-P2 and KT-P3 are excluded from assessment;

Reprovisioning Option A, Part 2 – Heavy construction including excavation of Zone 2, this is expected to commence from 2018. ASRs KT-P2 and KT-P3 are excluded from assessment;

Reprovisioning Option A, Part 3 – Heavy construction including excavation of Zone 3, this will commence from 2021. ASRs KT-P2 and KT-P3 are excluded from assessment, and;

Reprovisioning Option A, Part 4 – Heavy construction including excavation of Zones 4, 5A and 5B, this is expected to commence from 2024. ASRs KT-P2 and KT-P3 are included in assessment.

Reprovisioning Option B – 7-year Project duration, involving removal of the existing public car park, temporary garden, and RCP, and decontamination of the whole site in a single stage. Only public car park

and RCP would be reprovisioned on-site (by others) during the ground decontamination works. The active periods of each zone is generally staggered, and according to **Section 3.3.5**, approximately only 1,200 m^2 will be excavated at each zone grouping at one time and was used in the HC models. Planned ASRs (KT-P2 and KT-P3) as shown in **Table 3.6** will not be active until the entire programme is completed and therefore were excluded from the assessment. Under this Reprovisioning Option, the different parts of works are as follows and are as shown in **Figure 3.6** for short-term and long-term modelling:

Reprovisioning Option B, Part 1 – Heavy construction including excavation of Zones 1A, 1B and 1C, this is expected to commence from 2015;

Reprovisioning Option B, Part 2 – Heavy construction including excavation of Zones 4, 5A and 5B, this is expected to commence from 2016;

Reprovisioning Option B, Part 3 – Heavy construction including excavation of Zone 2, which will commence from 2018; and,

Reprovisioning Option B, Part 4 – Heavy construction including excavation of Zone 3, this is expected to commence from 2020.

Reprovisioning Option C – 4.5-year Project duration involving removal of the existing public car park, temporary garden and RCP, and decontamination of the whole site in a single stage. The active periods of each zone is generally staggered, and according to **Section 3.3.5**, approximately only 1,200 m^2 in each zone grouping will be excavated at one time and was used in the HC models. Planned ASRs (KT-P2 and KT-P3) as shown in **Table 3.6** will not be active until the entire programme is completed and therefore were excluded from the assessment. Under this Reprovisioning Option, the different parts of works are as follows and are as shown in **Figure 3.7** for short-term and long-term modelling:

Reprovisioning Option C, Part 1 – Heavy construction including excavation of Zones 1A, 1B, 1C, 2 and 3, this is expected to commence from 2015; and,

Reprovisioning Option C, Part 2 – Heavy construction including excavation of Zones 4, 5A and 5B, this is expected to commence from 2017. This part is assumed to have 2,400 m^3 active area over the entire zone group.

Hydrocarbon Emission Factors

The major activities that may have HC emissions include the following:

- Excavation activities;
- Movement of mobile plant and vehicles on site;
- Stockpiling of contaminated soils for decontamination, and stockpiling of clean fill;
- Outlet emissions from the biopiles;
- Cement stabilisation/solidification, and;
- Backfilling activities.

Emissions from each of the major processes are assumed as follows:

Excavation activities

HC emissions were assumed to occur via two processes during the excavation phase. The first process refers to emissions during the excavation during working hours and the second is when the exposed ground is left undisturbed during non-working hours. The methodology for estimating working hour and non-working hour emissions is described as follows.

Working hours – HC may be volatilised or adhere to dust particles and subsequently disperse during the excavation activities. Average pollutant concentrations for the zones were determined from borehole information and used as a basis to determine the HC emissions during excavation. Zones are grouped together for determination of excavation areas during assessment and pollutant concentrations. The zone groupings are: Zone 1A and Zone 3; Zone 2; Zone 4, 5A and 5B, and; Zone 1B and Zone 1C (refer to **Figure 3.2** and **Appendix 3.4a**).

During the excavation, the HC emission rate (measured in $g/m^2/s$) is calculated as the average HC concentration of the soil multiplied by the average excavation rate, divided by the total area of the zone. This was considered to give conservative emission rates as it assumed all HCs are volatilised during the excavation. Excavation rate is determined by the total soil volume requiring excavation for each zone divided by the total working days for excavation for that zone. Detailed calculations for the emission rate can be found in **Appendix 3.5**. From engineering estimates, it was assumed that no more than three individual works areas of 20 m by 20 m will be in operation at once per zone group, giving a maximum excavation area of 1,200 m^2 per zone group at any one time.

As it was assumed that all HCs are volatilised during excavation, only these gaseous emissions are required to be modelled. Modelling of HCs attached to dust particles was not required as it was assumed that all HCs would be released during excavation and hence there would be no such contaminants left to be dispersed with the dust component. This was considered as a conservative approach to model the HC emissions during excavation.

Non-working hours - HC emissions from volatilisation of contaminated soils when the ground is undisturbed were modelled to assess the potential air quality effects on the local ASRs due to the Project during non-working hours. Based on *Part 3: Models for Detailed Assessment* of *Soil Screening Guidance: Technical Background Document, 1996, USEPA EPA/540/R-95/128*, contaminant flux at ground surface can be calculated Jury's equation as follows:

$$J_s = C_o(D_A/ \pi.t)^{1/2} \times [1 - \exp (-d_s^2 / 4.D_A.t)]$$

where	J_s	=	contaminant flux at ground surface (g/cm^2-s)
	C_o	=	uniform contaminant concentration at t=0 (g/cm^3)
	D_A	=	apparent diffusivity (cm^2/s)
	T		time (s)
	d_s		depth of uniform soil contamination at t = 0 (cm)

The following assumptions were applied:

- Uniform soil properties (e.g., homogeneous average soil water content, bulk density, porosity, and fraction organic carbon)
- Instantaneous linear equilibrium adsorption
- Linear equilibrium liquid-vapour partitioning (Henry's law)
- Uniform initial contaminant incorporation at t=0
- Chemicals in a dissolved form only (i.e., soil contaminant concentrations are below Csat)
- No boundary layer thickness at ground level (no stagnant air layer)
- No water evaporation or leaching
- No chemical reactions, biodegradation, or photolysis
- d_s is much greater than $(4D_At)^{1/2}$

Jury's equation should be solved for a time dependent contaminant flux averaged over the Project period. USEPA/Office of Research and Development's (ORD's) National Centre for Environmental Assessment has a model developed for the purpose of calculating the time averaged flux, Exposure Model for Soil-Organic Fate and Transport (EMSOFT). To determine the contaminant flux at the beginning of each reprovisioning option, EMSOFT was used, and the calculated flux was applied to the entire reprovisioning option period.

According to *Demolition of Buildings and Structures in Proposed Kennedy Town Comprehensive Development Area Site - Environmental Report for VEP Application*, April 2007, physical properties data and calculations are shown in **Appendix 3.6**.

The emissions from contaminated soils were assessed based on contaminated soil laboratory testing. Some high concentrations of pollutants are found in localised areas of the site. The average emission rate for the entire zone was modelled. This approach was considered conservative for passive effects.

The modelling shows the emissions for each reprovisioning option when the soil has not been broken. Once the soil is placed in the stockpile, emission rates will quickly return to that of the undisturbed soils, as volatilisation occurs through exposed surface area to air. However as all HC was assumed to be volatilised during excavation, stockpile emissions were not modelled.

Movement of mobile plant and vehicles on site

Although some passive emissions could be expected while moving contaminated soil around the site, all HC was modelled as having volatilised during excavation and therefore to avoid double-counting, no HC emissions were modelled during transportation.

Stockpiling of contaminated soils for decontamination, and stockpiling of clean fill

Although some active and passive emissions could be expected during biopile formation, all HC was modelled as having volatilised during excavation and therefore to avoid double-counting, no HC emissions

were modelled during stockpiling of contaminated soils for decontamination. Cleanfill soils are not contaminated and therefore do not emit any HC. Therefore no HC emissions were modelled during this process.

Outlet emissions from the bio-piles

Biopiling is proposed to decontaminate soils contaminated with HC. Biopiles are covered by impervious materials and negative pressure is applied to prevent fugitive emissions. Emissions from biopiles are passed through an activated carbon filter which removes approximately 99% of the HC before being vented to atmosphere. Biopile emissions are expected to be insignificant, as described in **Section 3.3.5** and were not assessed further. Therefore no HC emissions were modelled during this process.

Cement solidification

Any soils that require both HC and heavy metal decontamination will be first treated for HC and then for heavy metals. Therefore, soil that is treated by cement solidification will no longer be contaminated with HC and therefore do not emit any HC. Therefore no HC emissions were modelled during this process.

Backfilling activities

Only decontaminated soils or soil not requiring decontamination are used for backfilling. Therefore, no HC emissions were modelled during this process.

3.4.5 Odour Assessment

According to approved EIA, *Demolition of Buildings and Structures in the Proposed Kennedy Town Comprehensive Development Area Site (EIA-064/2001)*, during the intrusive site investigations there was no odour issue associated with any of the borehole samples. Similarly, no odour issue was observed in the site investigation (SI) carried out during Contamination Confirmatory Investigation and the additional SI at the bus depot. Therefore quantitative assessment of odour was considered not necessary.

3.4.6 Health Impact Assessment

The major pathways for exposure to contaminated vapour and particulates are through, inhalation, ingestion and dermal contact. The exposure pathway “by direct contact with soil” is not relevant to the current assessment as all receptors will be outside the work site at the time of decontamination works. All necessary PPE including liquid tight gloves will be provided to the workers and would therefore not come into direct contact with contaminated materials. Therefore, dermal contact was not assessed further. Ingestion occurs through food or water that has direct contact with the contaminated soil. No food is grown on the site and municipal supply of drinking water is not sourced near the Kennedy Town CDA, therefore ingestion was not considered as an exposure pathway. Emissions from the site are either gases or suspended particulates; therefore inhalation was identified as an exposure pathway only. On the other hand, occupational health risk and the preventive measures to onsite are mentioned in **Chapter 7**.

The risk level methodology determines the carcinogenic risk as well as the acute and chronic non-carcinogenic health effects. Acute effects reference short term effects (1 hour average and 24 hour

average), chronic effects generally refer to those that occur over a lifetime, however for this assessment it refers to annual average.

Pollutants are divided into the categories of criteria, non-criteria carcinogenic and non-criteria non-carcinogenic for health assessment.

Health Risks of Criteria Pollutants

The major processes onsite are related to excavation and decontamination. As the Project is based around excavation and soil decontamination activities and the associated emissions, the Project is not expected to generate significant NO_2, SO_2, CO, O_3 from dust emissions, cement solidification or biopiling processes. Therefore only particulate matter was assessed for health impacts under the criteria pollutants. As lead is also a TAP, the risk assessment for lead followed the methodology as detailed for non-criteria pollutants.

Short- and long-term mortality and morbidity risks associated with exposure to particulate matter were assessed. For this assessment short-term changes refer to the maximum 24-hour average concentrations and long-term refers to annual average concentration. As for the Third Runway EIA and as derived from the European Commission (European Commission, 2005) the risk associated with the increase in particulate matter generated by the project was calculated by:

$$I_e = I_{HK} \times AP$$

where	I_e	=	Total instances of hospital admissions or death from cardiopulmonary or respiratory causes due to a change in the air pollution concentration of 10 µg/m^3
	I_{HK}	=	Total instances of hospital admissions or death from cardiopulmonary or respiratory causes for all of Hong Kong
	AP	=	Attributable proportion, that is, the ratio of hospital admissions or deaths that can be a attributed to a concentration increase of 10 µg/m^3 of the criteria pollutant

and

$$AP = \left(\frac{ER \times P}{RR \times P}\right)$$

where	ER	=	Excess risk percentage attributable to a 10 µg/m^3 increase in air pollutant
	P	=	Percentage of population exposed
	RR	=	Relative risk (ER + 1)

and

$$I_{KTCDA} = \frac{\Delta Conc}{10\mu g/m^3} \times AP \times Pop_{KTCDA} \times \frac{I_{HK}}{Pop_{HK}}$$

where I_{KTCDA} = The absolute number of instances of mortality or morbidity cases attributed to air pollution emissions from carrying out of the Kennedy Town CDA

ΔConc = Change in concentration of the criteria pollutant due to the carrying out of the project

AP = Attributable proportion, that is, the number of hospital admissions or deaths that can be a attributed to a concentration increase of 10 µg/m^3 of the criteria pollutant

Pop_{KTCDA} = Population of area affected by pollutant emissions due to project. In this case the 500 m study boundary

I_{HK} = Total instances of hospital admissions or death from cardiopulmonary or respiratory causes for all of Hong Kong

Pop_{HK} = Total population of Hong Kong

The absolute number of instances of mortality or morbidity cases attributed to air pollution emissions from carrying out of the Kennedy Town CDA project (I_{KTCDA}) was then divided by the population of Kennedy Town CDA to determine the relative increase in mortality or morbidity due to all causes from the assessed pollutant.

Short and long term mortality and morbidity risks associated with exposure to particulate matter as well as hospital illness and mortality data are referenced from the Third Runway EIA and summarised in **Table 3.9** to **Table 3.12**.

Table 3.9: Excess Risk (ER) of short-term mortality and morbidity attributable to an increase of 10 µg/m^3 of air pollutant (95% confidence interval)

Air Pollutant	All causes mortality	Cardiovascular mortality	Respiratory mortality	Cardiovascular morbidity	Respiratory morbidity
RSP(1)	0.51%	0.63%	0.69%	0.58%	0.60%

(1) (Wong, et al., 2010)

Table 3.10: Excess Risk (ER) of long-term mortality attributable to an increase of 10 µg/m3 of air pollutant (95% confidence interval)

Air Pollutant	All causes mortality	Cardiopulmonary mortality	Lung Cancer mortality
RSP(1) (2)	5.0% (not statistically significant)	16.3% (not statistically significant)	28.5% (not statistically significant)
FSP(3)	4%	6%	8%

(1) (McDonnell, 2000)

(2) Evidence for a separate RR of mortality for long-term exposure to RSP is insufficient

(3) (Pope, 2002)

Table 3.11: Summary of parameters for hospital illnesses health outcome

Health Outcome		RR (per 10 µg/m^3)	AP (per 10 µg/m^3)	I_{HK} (1)	I_e (2) (per 10 µg/m^3)
Short term hospital illness effects from RSP	Cardiovascular (3) (4)	1.0058	0.00577	155,299	895.5
	Respiratory (3) (5)	1.0060	0.00596	169,071	1,008.4

(1) Numbers of in-patient discharges in hospitals for cardiovascular or respiratory disease

(2) Total population in Hong Kong in mid-2012 = 7,154,600 (Census and Statistics Department)

(3) (Wong, et al., 2010)

(4) In HK in 2012, numbers of in-patient discharges of cardiovascular diseases in hospitals (ICD10:I00-I99) = 155,299 (Hong Kong Department of Health, 2013)

(5) In HK in 2012, numbers of in-patient discharges of respiratory diseases in hospitals (ICD10:J00-J99) = 155,299 (Hong Kong Department of Health, 2013)

Table 3.12: Summary of parameters for premature death mortality health outcome

Health Outcome		RR (per 10 µg/m^3)	AP (per 10 µg/m^3)	I_{HK} (1)	I_e (2) (per 10 µg/m^3)
Long term mortality effects of FSP	All causes mortality (3) (4)	1.0400	0.03846	42,017	1,616.0
	Cardiopulmonary (3) (5)	1.0600	0.05660	19,952	1,129.4
	Malignant Neoplasm of trachea, bronchus and lung (3) (6)	1.0800	0.07407	3,893	288.4
Short term mortality effects of RSP	All causes mortality (4) (5)	1.0051	0.00507	42,017	213.2
	Cardiovascular (5) (7)	1.0063	0.00626	10,320	64.6
	Respiratory (5) (7)	1.0069	0.00685	9,632	66.0

(1) Numbers of deaths in hospitals in hospitals for cardiovascular or respiratory disease.

(2) Total population in Hong Kong in mid-2012 = 7,154,600 (Census and Statistics Department)

(3) (Pope, 2002)

(4) In HK in 2012, numbers of deaths in hospitals for all causes = 43,672; numbers of deaths in hospital from external causes of morbidity and mortality = 1655. Hence, total number of natural deaths in hospital = 43,672 – 1,655 = 42,017(Hong Kong Department of Health, 2013)

(5) In HK in 2012, numbers of deaths in hospitals from cardiovascular diseases (ICD10:I00-I99) = 10,320; numbers of deaths in hospital from respiratory diseases (ICD10:J00-J99) = 9,632. Hence, total number of cardiopulmonary deaths in 2012 in hospital in HK = 10,320 + 9,632 = 19,952 (Hong Kong Department of Health, 2013)

(6) In HK in 2012, numbers of deaths in hospitals from Malignant Neoplasm of trachea, bronchus and lung (ICD10:C33-C34) = 3,893 (Hong Kong Department of Health, 2013)

(7) (Wong, et al., 2010)

Health Risks of Non-Criteria Pollutants

Acute and Chronic Non-Carcinogenic Health Risks

Acute and chronic non-carcinogenic health risks from inhalation were evaluated against the reference values as identified in **Table 3.2** where if the cumulative concentrations predicted at the ASR are less than the corresponding reference values, then the health effects are not anticipated.

Carcinogenic Health Risks

For those pollutants that are identified as carcinogens, the risk is measured in the increase in the number of cancer cases per million population that is attributable to the identified pollutants. With reference to USEPA document *Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment), 2009*, the incremental lifetime cancer risk was calculated as:

Incremental Lifetime Cancer Risk = EC x IUR

where EC = time-weighted average concentration (i.e. concentrations due to the Project excluding background concentration) (µg/m^3)

IUR = the corresponding inhalation unit risk estimate for that TAP (refer to **Table 3.2**)

and

$$EC = \frac{CA \times ED}{AT}$$

where CA = change in annual average contaminant concentration in air due to the project (µg/m^3)

ED = exposure duration (years)

AT = averaging time (lifetime in years)

For pollutants that are identified as having chronic carcinogenic risks, the Inhalation Unit Risk (IUR) factors are summarised in **Table 3.2**, which is referenced from the Third Runway EIA. The cancer risk guidelines from the Third Runway EIA are also presumed, as shown in **Table 3.13**. Conservative concentrations were predicted in the air quality modelling and were used for calculation of the health risks.

Table 3.13: Incremental Lifetime Cancer risk guidelines

Risk Value	Description
Incremental lifetime cancer risks less than or equal to one in a million (1 x 10^{-6})	Negligible
Incremental lifetime cancer risks fall between 1 x 10^{-4} and 1 x 10^{-6}	Considered by the New Jersey Department of Environmental Protection Division of Air Quality (DAQ) risk management committee on a case-by-case basis. Sources with risk falling within this range must take steps to minimise the projected risk before a Pre-Construction Permit can be issued
Incremental lifetime cancer risks greater than or equal to one in ten thousand (1 x 10^{-4})	Unacceptable

3.5 Evaluation of the Air Quality and Health Impacts

3.5.1 Dust

Tier 1 Results

The Tier 1 scenario assumed that the entire site is active at one time and is considered conservative. The Tier 1 screening results for unmitigated and mitigated scenarios including the concurrent projects and background contribution are tabulated in **Appendix 3.10**. The locations of the dust sources are shown in **Figure 3.4**. The unmitigated and mitigated results are summarised in **Table 3.14**. Note that the AQOs for daily RSP and daily FSP allow for exceedance of the corresponding criteria for not more than nine times per year, therefore the predicted 10th maximum daily RSP and FSP levels at the ASRs are compared with the corresponding criteria for the purpose of identifying any non-compliance with the AQOs.

Under the Tier 1 unmitigated scenario the results show that there would be exceedance of: the hourly TSP limit of 500 µg/m^3, the AQO for daily RSP of 100 µg/m^3, the AQO for annual RSP of 50 µg/m^3 and the AQO for annual FSP of 35 µg/m^3 at some ASRs. Under the Tier 1 unmitigated scenario the AQO for daily FSP would be in compliance at all ASRs.

With the recommended mitigation measures in place, all ASRs would comply with the hourly TSP criterion as well as the AQO for daily RSP, daily FSP, annual RSP and annual FSP throughout the construction period.

Cumulative concentration contours for unmitigated TSP maximum hourly average, unmitigated 10th highest daily RSP, unmitigated 10th highest daily FSP, unmitigated annual average RSP and unmitigated annual average FSP are shown in **Figures 3.8** to **Figure 3.12** respectively. Cumulative concentration contours for mitigated TSP maximum hourly average, mitigated 10th highest daily RSP, mitigated annual average RSP and mitigated annual average FSP are shown in **Figures 3.13** to **Figure 3.16** respectively.

Some staff are expected to be on shift duty at the reprovisioned RCP (approximately 8 hours/day), and a guard is expected at the reprovisioned carpark, which occurs under Reprovisioning Option A and Reprovisioning Option B. The reprovisioned RCP is expected to be located in the north western corner of the site and the carpark is expected to be located in the north eastern corner of the site with access to the carpark along the eastern boundary.

Figure 3.13 shows only a very small area with exceedance and therefore the reprovisioned RCP site and carpark receptor onsite is considered to be in compliance for TSP. **Figure 3.15** shows RSP exceedance of annual average does not occur in north eastern portion of the site, therefore the guard-post ASR in the carpark would be compliant. However, **Figure 3.15** shows partial exceedance of the presumed location of the proposed RCP (north-western corner of the site) with the concentration ranging from approximately 48 µg/m^3 to 52 µg/m^3 across the RCP location. Therefore Tier 2 assessment was required for annual average RSP.

It should be noted that the results are considered to be conservative as the actual active area is expected to be much smaller than those modelled, as described in **Section 3.4.3**.

Table 3.14: Summary of predicted Cumulative TSP, RSP and FSP Concentrations for All ASRs (Tier 1)

Pollutant	Averaging Period and Criteria	Tier 1 Unmitigated Scenario ($\mu g/m^3$)	Tier 1 Mitigated Scenario ($\mu g/m^3$)
TSP	Maximum hourly concentration, 500 $\mu g/m^3$	159 - 2891	159 - 326
RSP	10th highest daily average concentration, 100 $\mu g/m^3$	76 - 199	76 - 86
	Annual average concentration, 50 $\mu g/m^3$	41 - 116	41 - 48
FSP	10th highest daily average concentration, 75 $\mu g/m^3$	57 - 68	Not modelled as compliant under Tier 1 unmitigated
	Annual average concentration, 35 $\mu g/m^3$	31 - 38	31*

Note (1) Asterisk (*) means the concentrations at all ASR are equal to the value stated.

(2) The results represent any of the three Reprovisioning Options A, B and C, as explained in **Section 3.4.3**.

Tier 2 Results

With the recommended mitigation measures in place, under Tier 1, all ASRs would comply with the hourly TSP criterion as well as the AQO for daily RSP, daily FSP, annual RSP and annual FSP throughout the construction period, however the proposed RCP is predicted to be subject to some exceedance under the Tier 1 RSP annual average mitigated scenario. Therefore Tier 2 mitigated modelling was conducted for annual average RSP contours.

Figure 3.17 shows cumulative mitigated Tier 2 annual average RSP concentrations for the assessment area. The Kennedy Town CDA site including the reprovisioned carpark and RCP are shown to be compliant.

3.5.2 Health assessment

Criteria Pollutants

Both short-term and long-term health effects from criteria pollutants were assessed based on changes in concentration and attributable proportion, as detailed in **Section 3.4.6**. Criteria pollutants assessed were RSP and FSP. The increases in mortality and morbidity due to the project are shown in **Table 3.15**. For RSP there are only risk factors associated with short-term health effects and for FSP there are only risk factors associated with long-term effects. The average increases of concentrations or mortality and morbidity are shown in the table, the range calculated for the area based on maximum and minimum concentrations. The RSP concentrations and associated health risk were based on increase in maximum 24-hour concentration, whereas the FSP concentrations and associated health risk were based on the increase in annual average concentration.

Table 3.15: Summary of incremental change in health risk associated with Kennedy Town CDA.

Pollutant	Average concentration change due to project ($\mu g/m^3$)	Relative increase mortality and morbidity per 100,000 population due to Project		
		All causes mortality	Cardiovascular morbidity	Respiratory morbidity

Short-term RSP	2.8 ($4.6x10^{-4}$ – 18.2)	0.83 ($1.4 x 10^{-4}$– 5.4)	3.5 ($5.7 x 10^{-4}$– 23)	3.9 ($6.5 x 10^{-4}$– 26)
Long-term FSP	0.0047 ($3.4x10^{-7}$ – 0.68)	0.11 ($7.8 x 10^{-7}$ – 1.5)	N/A	N/A

Note (1) The ranges of the concentrations are shown in brackets

(2) The results represent any of the three Reprovisioning Options A, B and C, as explained in **Section 3.4.3**.

The average mortality and morbidity figures are reported for this study as the calculations (shown in **Appendix 3.13**) are based on the concentrations at each ASR and assumed to apply to the entire population base.

The average mortality and morbidity figures are considered to be conservative because:

- There will be no permanent increase in the ambient air particulate matter concentration due to the remediation works, as defined within the scope of this project, at the Kennedy Town CDA. The concentrations attributable to the project reduce to zero once project is complete.
- Only the closest ASRs to the Project site are assessed. Increased horizontal and vertical distance from the site show decreasing concentration and therefore decreasing health risk. Populations that are further away from the Kennedy Town CDA will have a reduced health risk in comparison to the reported values in **Table 3.15**.
- Short-term RSP was based on the average (for all ASRs) of the maximum 24-hour average concentrations (for all hours) at the site. The average 24-hour average concentration at each ASR would be lower and therefore the risk level would also reduce.

Based on information published in *Tables on Health Status and Health Services 2012* (Hong Kong Department of Health, 2013) and census data from 2012 (refer to **Table 3.12**), the total deaths due to all causes in Hong Kong for 2012 (excluding external causes) is 587 per 100,000 population. The average increases in deaths attributed to the project are 0.83 per 100,000 population for short term RSP exposure and 0.11 per 100,000 population for long term FSP exposure, which represent respectively about 0.14% and 0.02% of the mortality due to all causes in 2012. The total hospital admissions in Hong Kong in 2012 due to cardiovascular diseases or respiratory illness are 2,171 and 2,363 per 100,000 population respectively. The average increases in morbidity attributed to the project are 3.5 per 100,000 population for cardiovascular related hospital admissions (i.e., about 0.16% of the total hospital admission due to cardiovascular diseases) and 3.9 per 100,000 population for respiratory related hospital admissions (i.e., about.0.17% of the total hospital admission due to respiratory illness) due to short term RSP.

As the increase in the mortality and morbidity is shown for the closest ASRs to the site and the risk decreases with increasing distance; the total affected population is approximately 46,000 people; the ambient concentration increases are not permanent, and; the increased mortality and morbidity is small in comparison to the total hospital admissions and deaths in Hong Kong, therefore the increases predicted in mortality and morbidity are considered acceptable.

Non-criteria Pollutants

Carcinogenic Health Risks

Incremental lifetime carcinogenic risks for non-criteria pollutants were calculated based on the change to the ambient air concentrations due to the Project, as detailed in **Section 3.4.6**. For those pollutants that are identified as carcinogenic, the risk is measured in the increase in the number of cancer cases per million population that is attributable to the identified pollutants. The incremental lifetime cancer risks due to the project are summarised in **Table 3.16**. Detailed results are shown in **Appendix 3.14**.

The incremental lifetime cancer risks are determined from the worst case annual average concentration increase due to the project. The incremental lifetime cancer risks were derived from the HC and HM modelling concentrations and the inhalation unit risks (**Table 3.2**). The long-term (annual) HC modelling results are shown in **Appendix 3.12**. The HM levels were estimated based on the relevant SI results and the Tier 1 mitigated RSP concentrations at the ASRs, as described in **Section 3.4.3**, the results of which are detailed in **Appendix 3.11**.

Table 3.16: Summary of incremental lifetime cancer risks due to TAPs associated with the Project

Pollutant	Concentration change due to project ($\mu g/m^3$)	Incremental long-term inhalation exposure concentration ($\mu g/m^3$) (2)	Inhalation Unit Risk, IUR ($(\mu g/m^3)^{-1}$) [Reference]	Incremental Lifetime Cancer Risk
		Column A	Column B	Column C
Reprovisioning Option A				
Naphthalene	3.06E-06	1.02E-07	3.4E-05 [OEHHA]	3.47E-12
Benzo(a)pyrene (BaP) (1)	7.12E-05	2.37E-06	8.7E-02 [WHO]	2.06E-07
Benzene	2.04E-06	6.80E-08	6.0E-06 [WHO]	4.08E-13
Ethylbenzene	3.35E-06	1.12E-07	2.5E-06 [OEHHA]	2.79E-13
Benzo(a)anthracene	5.57E-05	1.86E-06	1.1E-04 [OEHHA]	2.04E-10
Benzo(b)fluoranthene	5.90E-05	1.97E-06	1.1E-04 [OEHHA]	2.16E-10
Benzo(k)fluoranthene	5.08E-05	1.69E-06	1.1E-04 [OEHHA]	1.86E-10
Chrysene	4.24E-05	1.41E-06	1.1E-05 [OEHHA]	1.56E-11
Dibenzo(a,h)anthracene	1.90E-05	6.32E-07	1.2E-03 [OEHHA]	7.59E-10
Indeno(1,2,3-cd)pyrene	3.16E-05	1.05E-06	1.1E-04 [OEHHA]	1.16E-10
Heavy Metals #				
Arsenic	1.10E-04	3.67E-06	1.5E-03 [WHO]	5.50E-09
Cadmium	1.85E-05	6.18E-07	1.8E-03 [IRIS]	1.11E-09
Chromium (VI)	7.30E-05	2.43E-06	4.0E-02 [WHO]	9.74E-08
Nickel	6.79E-05	2.26E-06	3.8E-04 [WHO]	8.59E-10
Lead	2.55E-03	8.49E-05	1.2E-05 [OEHHA]	1.02E-09
Total Incremental Lifetime Cancer Risk (Reprovisioning Scenario A)				**3.14E-07**
Reprovisioning Option B				
Naphthalene	2.92E-06	9.73E-08	3.4E-05 [OEHHA]	3.31E-12
Benzo(a)pyrene (BaP) (1)	7.13E-05	2.38E-06	8.7E-02 [WHO]	2.07E-07
Benzene	1.88E-06	6.27E-08	6.0E-06 [WHO]	3.76E-13
Ethylbenzene	2.82E-06	9.40E-08	2.5E-06 [OEHHA]	2.35E-13
Benzo(a)anthracene	5.58E-05	1.86E-06	1.1E-04 [OEHHA]	2.05E-10
Benzo(b)fluoranthene	5.91E-05	1.97E-06	1.1E-04 [OEHHA]	2.17E-10

Pollutant	Concentration change due to project ($\mu g/m^3$)	Incremental long-term inhalation exposure concentration ($\mu g/m^3$) (2)	Inhalation Unit Risk, IUR ($(\mu g/m^3)^{-1}$) [Reference]	Incremental Lifetime Cancer Risk
		Column A	Column B	Column C
Benzo(k)fluoranthene	5.09E-05	1.70E-06	1.1E-04 [OEHHA]	1.87E-10
Chrysene	4.25E-05	1.42E-06	1.1E-05 [OEHHA]	1.56E-11
Dibenzo(a,h)anthracene	1.90E-05	6.33E-07	1.2E-03 [OEHHA]	7.60E-10
Indeno(1,2,3-cd)pyrene	3.16E-05	1.05E-06	1.1E-04 [OEHHA]	1.16E-10
Heavy Metals #				
Arsenic	1.10E-04	3.67E-06	1.5E-03 [WHO]	5.50E-09
Cadmium	1.85E-05	6.18E-07	1.8E-03 [IRIS]	1.11E-09
Chromium (VI)	7.30E-05	2.43E-06	4.0E-02 [WHO]	9.74E-08
Nickel	6.79E-05	2.26E-06	3.8E-04 [WHO]	8.59E-10
Lead	2.55E-03	8.49E-05	1.2E-05 [OEHHA]	1.02E-09
Total Incremental Lifetime Cancer Risk (Reprovisioning Scenario B)				**3.14E-07**
Reprovisioning Option C				
Naphthalene	4.64E-06	1.55E-07	3.4E-05 [OEHHA]	5.26E-12
Benzo(a)pyrene (BaP) (1)	1.01E-04	3.35E-06	8.7E-02 [WHO]	2.92E-07
Benzene	2.65E-06	8.83E-08	6.0E-06 [WHO]	5.30E-13
Ethylbenzene	4.39E-06	1.46E-07	2.5E-06 [OEHHA]	3.66E-13
Benzo(a)anthracene	6.38E-05	2.13E-06	1.1E-04 [OEHHA]	2.34E-10
Benzo(b)fluoranthene	9.38E-05	3.13E-06	1.1E-04 [OEHHA]	3.44E-10
Benzo(k)fluoranthene	6.07E-05	2.02E-06	1.1E-04 [OEHHA]	2.23E-10
Chrysene	5.79E-05	1.93E-06	1.1E-05 [OEHHA]	2.12E-11
Dibenzo(a,h)anthracene	2.57E-05	8.55E-07	1.2E-03 [OEHHA]	1.03E-09
Indeno(1,2,3-cd)pyrene	4.37E-05	1.46E-06	1.1E-04 [OEHHA]	1.60E-10
Heavy Metals #				
Arsenic	1.10E-04	3.67E-06	1.5E-03 [WHO]	5.50E-09
Cadmium	1.85E-05	6.18E-07	1.8E-03 [IRIS]	1.11E-09
Chromium (VI)	7.30E-05	2.43E-06	4.0E-02 [WHO]	9.74E-08
Nickel	6.79E-05	2.26E-06	3.8E-04 [WHO]	8.59E-10
Lead	2.55E-03	8.49E-05	1.2E-05 [OEHHA]	1.02E-09
Total incremental lifetime cancer risk (Reprovisioning Scenario C)				**3.99E-07***

Note (1) Based on long-term modelling results

(2) Refer to **Section 3.4.6** for the calculation of the incremental long-term inhalation exposure concentration (EC) from the concentration change due to project (CA)

(3) Column C = Column A * Column B (See **Section 3.4.6**)

#: Annual average of heavy metals are the same for all three Reprovisioning options A, B and C. It is calculated based on Tier 1 mitigated RSP annual results which assumed the entire site is active at one time and is considered conservative.

*: maximum of total incremental lifetime cancer risk within Reprovisioning Scenario A, B and C.

The total incremental lifetime cancer risk associated with the KTCDA ground decontamination works was determined to be 3.99×10^{-7}, that is, there are less than four in ten million cancer risks associated with the

heavy metal and hydrocarbon emissions from the Project. The incremental lifetime cancer risks are therefore considered to be negligible (according to **Table 3.13**).

Non-carcinogenic Health Risks

Non-carcinogenic health risks for non-criteria pollutants were calculated based on the cumulative ambient TAP concentrations with the Project, as detailed in **Section 3.4.6**. Non-carcinogenic health risks from inhalation were evaluated against the reference values as identified in **Table 3.2** where if the concentrations predicted at the ASR are less than the corresponding reference values, then the health effects are not anticipated.

The cumulative maximum concentrations due to the project are summarised in **Table 3.17**. Detailed results are shown in **Appendix 3.14**. The worst case hourly, daily or annual HC concentrations for all parts for each Reprovisioning Option for the entire year are presented in **Appendix 3.12** while details of the cumulative HM concentrations are given in **Appendix 3.11**.

Table 3.17: Summary of cumulative maximum TAP concentrations for non-carcinogenic health risks associated with the Project

	Maximum hourly average from Project (µg/m^3)		Maximum daily average from Project (µg/m^3)		Maximum annual average from Project (µg/m^3)	
Pollutant	**Conc.**	**Reference value**	**Conc.**	**Reference value**	**Conc.**	**Reference value**
Reprovisioning Option A (Excluding planned ASR internal to KTCDA)						
Naphthalene	7.21E-01	5.00E+02	5.33E-01	2.25E+01	3.37E-01	1.00E+01
Phenanthrene	4.10E-02	5.00E-01	3.00E-02	7.10E-01	1.79E-02	5.00E-02
Anthracene	5.02E-03	5.00E-01	N/A	-	1.21E-03	5.00E-02
Fluoranthene	1.80E-02	5.00E-01	N/A	-	3.18E-03	5.00E-02
Pyrene	1.81E-02	5.00E-01	5.75E-03	7.10E-01	2.50E-03	5.00E-02
Benzo(a)pyrene	1.19E-02	3.00E-02	N/A	-	2.46E-04	3.00E-04
Benzene	6.60E+00	2.70E+01	4.94E+00	2.90E+01	1.61E+00	3.00E+01
Toluene	2.70E+01	1.50E+04	1.64E+01	3.75E+03	5.42E+00	5.00E+03
Ethylbenzene	6.50E+00	8.67E+04	5.06E+00	2.17E+04	1.34E+00	1.00E+03
Xylenes (Total)	2.36E+01	7.37E+03	1.15E+01	8.82E+03	2.64E+00	1.00E+02
Acenaphthylene	2.08E-02	1.00E+00	N/A	-	6.87E-03	1.00E-01
Acenaphthene	7.03E-02	1.00E+00	N/A	-	2.41E-02	1.00E-01
Fluorene	1.91E-02	1.00E+01	N/A	-	6.20E-03	1.00E+00
Chrysene	8.49E-03	3.60E-01	2.11E-03	2.40E-01	4.21E-04	5.00E-02
Benzo(a)anthracene	1.12E-02	5.00E-01	1.85E-03	3.60E-01	2.74E-04	5.00E-02
Benzo(b)fluoranthene	1.05E-02	3.60E-01	N/A	-	3.66E-04	5.00E-02
Benzo(k)fluoranthene	8.48E-03	5.00E-01	N/A	-	1.77E-04	5.00E-02
Dibenzo(a,h)anthracene	2.97E-03	5.00E-01	N/A	-	4.23E-05	5.00E-02
Indeno(1,2,3-cd)pyrene	6.17E-03	5.00E-01	N/A	-	2.87E-04	5.00E-02
Benzo(g,h,i)perylene	8.28E-03	5.00E-01	N/A	-	3.67E-04	5.00E-02
Reprovisioning Option A (Planned ASRs internal to KTCDA only)						

Pollutant	Maximum hourly average from Project (µg/m^3)		Maximum daily average from Project (µg/m^3)		Maximum annual average from Project (µg/m^3)	
	Conc.	Reference value	Conc.	Reference value	Conc.	Reference value
Naphthalene	7.21E-01	5.00E+02	5.33E-01	2.25E+01	3.37E-01	1.00E+01
Phenanthrene	3.71E-02	5.00E-01	2.95E-02	7.10E-01	1.79E-02	5.00E-02
Anthracene	3.39E-03	5.00E-01	N/A	-	1.19E-03	5.00E-02
Fluoranthene	1.23E-02	5.00E-01	N/A	-	3.11E-03	5.00E-02
Pyrene	1.08E-02	5.00E-01	4.78E-03	7.10E-01	2.46E-03	5.00E-02
Benzo(a)pyrene	8.10E-03	3.00E-02	N/A	-	2.32E-04	3.00E-04
Benzene	6.60E+00	2.70E+01	4.94E+00	2.90E+01	1.61E+00	3.00E+01
Toluene	2.70E+01	1.50E+04	1.64E+01	3.75E+03	5.42E+00	5.00E+03
Ethylbenzene	6.50E+00	8.67E+04	5.06E+00	2.17E+04	1.34E+00	1.00E+03
Xylenes (Total)	2.36E+01	7.37E+03	1.15E+01	8.82E+03	2.64E+00	1.00E+02
Acenaphthylene	1.93E-02	1.00E+00	N/A	-	6.86E-03	1.00E-01
Acenaphthene	7.01E-02	1.00E+00	N/A	-	2.41E-02	1.00E-01
Fluorene	1.81E-02	1.00E+01	N/A	-	6.20E-03	1.00E+00
Chrysene	5.68E-03	3.60E-01	1.71E-03	2.40E-01	4.08E-04	5.00E-02
Benzo(a)anthracene	6.57E-03	5.00E-01	1.24E-03	3.60E-01	2.49E-04	5.00E-02
Benzo(b)fluoranthene	7.96E-03	3.60E-01	N/A	-	3.60E-04	5.00E-02
Benzo(k)fluoranthene	5.49E-03	5.00E-01	N/A	-	1.65E-04	5.00E-02
Dibenzo(a,h)anthracene	2.14E-03	5.00E-01	N/A	-	4.00E-05	5.00E-02
Indeno(1,2,3-cd)pyrene	4.76E-03	5.00E-01	N/A	-	2.83E-04	5.00E-02
Benzo(g,h,i)perylene	7.90E-03	5.00E-01	N/A	-	3.75E-04	5.00E-02
Heavy Metals #						
Barium	1.25E-02*	5.00E+00	2.44E-03*	2.50E+00	1.51E-02	5.00E-01
Cobalt	4.65E-04*	2.00E-01	9.05E-05*	7.10E-02	3.35E-05*	1.00E-01
Chromium (III)	N/A	-	2.66E-04*	5.00E-01	2.38E-03	1.10E-01
Copper	1.60E-02*	1.00E+02	3.12E-03*	3.60E+00	4.62E-02	2.40E+00
Molybdenum	2.45E-04*	3.00E+01	4.76E-05*	1.10E+01	1.76E-05*	3.00E+00
Tin	4.41E-03*	2.00E+01	8.59E-04*	1.00E+01	3.18E-04*	2.00E+00
Zinc	6.16E-02*	2.00E+01	N/A	-	1.93E-01	2.00E+00
Mercury	6.66E-04*	6.00E-01	1.30E-04*	3.00E-01	2.64E-04	1.00E+00
Arsenic	1.53E-03*	2.00E-01	2.97E-04*	3.60E-02	4.39E-03	1.50E-02
Cadmium	2.57E-04*	1.00E-01	5.00E-05*	3.00E-02	1.03E-03	1.00E-02
Chromium (VI)	1.23E-03	8.50E-03	3.23E-04	3.00E-01	1.75E-04	1.00E-01
Nickel	9.41E-04*	2.00E-01	1.83E-04*	2.00E-01	6.25E-03	9.00E-02
Lead	N/A	-	6.87E-03*	1.50E-01	5.95E-02	5.00E-01
Reprovisioning Option B						
Naphthalene	7.21E-01	5.00E+02	5.33E-01	2.25E+01	3.37E-01	1.00E+01
Phenanthrene	4.15E-02	5.00E-01	3.01E-02	7.10E-01	1.79E-02	5.00E-02
Anthracene	5.27E-03	5.00E-01	N/A	-	1.21E-03	5.00E-02

Pollutant	Maximum hourly average from Project (µg/m^3) Conc.	Reference value	Maximum daily average from Project (µg/m^3) Conc.	Reference value	Maximum annual average from Project (µg/m^3) Conc.	Reference value
Fluoranthene	1.90E-02	5.00E-01	N/A	-	3.18E-03	5.00E-02
Pyrene	1.94E-02	5.00E-01	5.91E-03	7.10E-01	2.50E-03	5.00E-02
Benzo(a)pyrene	1.30E-02	3.00E-02	N/A	-	2.46E-04	3.00E-04
Benzene	6.60E+00	2.70E+01	4.94E+00	2.90E+01	1.61E+00	3.00E+01
Toluene	2.70E+01	1.50E+04	1.64E+01	3.75E+03	5.42E+00	5.00E+03
Ethylbenzene	6.50E+00	8.67E+04	5.06E+00	2.17E+04	1.34E+00	1.00E+03
Xylenes (Total)	2.36E+01	7.37E+03	1.15E+01	8.82E+03	2.64E+00	1.00E+02
Acenaphthylene	2.67E-02	1.00E+00	N/A	-	6.87E-03	1.00E-01
Acenaphthene	7.15E-02	1.00E+00	N/A	-	2.41E-02	1.00E-01
Fluorene	2.23E-02	1.00E+01	N/A	-	6.20E-03	1.00E+00
Chrysene	3.25E-02	3.60E-01	4.94E-03	2.40E-01	4.21E-04	5.00E-02
Benzo(a)anthracene	3.54E-02	5.00E-01	4.71E-03	3.60E-01	2.74E-04	5.00E-02
Benzo(b)fluoranthene	7.29E-02	3.60E-01	N/A	-	3.67E-04	5.00E-02
Benzo(k)fluoranthene	1.93E-02	5.00E-01	N/A	-	1.77E-04	5.00E-02
Dibenzo(a,h)anthracene	1.14E-02	5.00E-01	N/A	-	4.23E-05	5.00E-02
Indeno(1,2,3-cd)pyrene	2.35E-02	5.00E-01	N/A	-	2.87E-04	5.00E-02
Benzo(g,h,i)perylene	3.21E-02	5.00E-01	N/A	-	3.68E-04	5.00E-02
Heavy Metals #						
Barium	1.25E-02*	5.00E+00	2.44E-03*	2.50E+00	1.51E-02	5.00E-01
Cobalt	4.65E-04*	2.00E-01	9.05E-05*	7.10E-02	3.35E-05*	1.00E-01
Chromium (III)	N/A	-	2.66E-04*	5.00E-01	2.38E-03	1.10E-01
Copper	1.60E-02*	1.00E+02	3.12E-03*	3.60E+00	4.62E-02	2.40E+00
Molybdenum	2.45E-04*	3.00E+01	4.76E-05*	1.10E+01	1.76E-05*	3.00E+00
Tin	4.41E-03*	2.00E+01	8.59E-04*	1.00E+01	3.18E-04*	2.00E+00
Zinc	6.16E-02*	2.00E+01	N/A	-	1.93E-01	2.00E+00
Mercury	6.66E-04*	6.00E-01	1.30E-04*	3.00E-01	2.64E-04	1.00E+00
Arsenic	1.53E-03*	2.00E-01	2.97E-04*	3.60E-02	4.39E-03	1.50E-02
Cadmium	2.57E-04*	1.00E-01	5.00E-05*	3.00E-02	1.03E-03	1.00E-02
Chromium (VI)	1.23E-03	8.50E-03	3.23E-04	3.00E-01	1.75E-04	1.00E-01
Nickel	9.41E-04*	2.00E-01	1.83E-04*	2.00E-01	6.25E-03	9.00E-02
Lead	N/A	-	6.87E-03*	1.50E-01	5.95E-02	5.00E-01
Reprovisioning Option C						
Naphthalene	7.22E-01	5.00E+02	5.33E-01	2.25E+01	3.37E-01	1.00E+01
Phenanthrene	4.21E-02	5.00E-01	3.02E-02	7.10E-01	1.79E-02	5.00E-02
Anthracene	5.68E-03	5.00E-01	N/A	-	1.22E-03	5.00E-02
Fluoranthene	2.17E-02	5.00E-01	N/A	-	3.25E-03	5.00E-02
Pyrene	2.26E-02	5.00E-01	6.17E-03	7.10E-01	2.52E-03	5.00E-02
Benzo(a)pyrene	1.61E-02	3.00E-02	N/A	-	2.76E-04	3.00E-04

Pollutant	Maximum hourly average from Project (µg/m^3)		Maximum daily average from Project (µg/m^3)		Maximum annual average from Project (µg/m^3)	
	Conc.	Reference value	Conc.	Reference value	Conc.	Reference value
Benzene	6.60E+00	2.70E+01	4.94E+00	2.90E+01	1.61E+00	3.00E+01
Toluene	2.70E+01	1.50E+04	1.64E+01	3.75E+03	5.42E+00	5.00E+03
Ethylbenzene	6.50E+00	8.67E+04	5.06E+00	2.17E+04	1.34E+00	1.00E+03
Xylenes (Total)	2.36E+01	7.37E+03	1.15E+01	8.82E+03	2.64E+00	1.00E+02
Acenaphthylene	2.67E-02	1.00E+00	N/A	-	6.87E-03	1.00E-01
Acenaphthene	7.15E-02	1.00E+00	N/A	-	2.41E-02	1.00E-01
Fluorene	2.23E-02	1.00E+01	N/A	-	6.20E-03	1.00E+00
Chrysene	3.25E-02	3.60E-01	4.94E-03	2.40E-01	4.36E-04	5.00E-02
Benzo(a)anthracene	3.54E-02	5.00E-01	4.71E-03	3.60E-01	2.82E-04	5.00E-02
Benzo(b)fluoranthene	7.29E-02	3.60E-01	N/A	-	4.01E-04	5.00E-02
Benzo(k)fluoranthene	1.93E-02	5.00E-01	N/A	-	1.87E-04	5.00E-02
Dibenzo(a,h)anthracene	1.14E-02	5.00E-01	N/A	-	4.90E-05	5.00E-02
Indeno(1,2,3-cd)pyrene	2.35E-02	5.00E-01	N/A	-	2.99E-04	5.00E-02
Benzo(g,h,i)perylene	3.21E-02	5.00E-01	N/A	-	3.80E-04	5.00E-02
Heavy Metals #						
Barium	1.25E-02*	5.00E+00	2.44E-03*	2.50E+00	1.51E-02	5.00E-01
Cobalt	4.65E-04*	2.00E-01	9.05E-05*	7.10E-02	3.35E-05*	1.00E-01
Chromium (III)	N/A	-	2.66E-04*	5.00E-01	2.38E-03	1.10E-01
Copper	1.60E-02*	1.00E+02	3.12E-03*	3.60E+00	4.62E-02	2.40E+00
Molybdenum	2.45E-04*	3.00E+01	4.76E-05*	1.10E+01	1.76E-05*	3.00E+00
Tin	4.41E-03*	2.00E+01	8.59E-04*	1.00E+01	3.18E-04*	2.00E+00
Zinc	6.16E-02*	2.00E+01	N/A	-	1.93E-01	2.00E+00
Mercury	6.66E-04*	6.00E-01	1.30E-04*	3.00E-01	2.64E-04	1.00E+00
Arsenic	1.53E-03*	2.00E-01	2.97E-04*	3.60E-02	4.39E-03	1.50E-02
Cadmium	2.57E-04*	1.00E-01	5.00E-05*	3.00E-02	1.03E-03	1.00E-02
Chromium (VI)	1.23E-03	8.50E-03	3.23E-04	3.00E-01	1.75E-04	1.00E-01
Nickel	9.41E-04*	2.00E-01	1.83E-04*	2.00E-01	6.25E-03	9.00E-02
Lead	N/A	-	6.87E-03*	1.50E-01	5.95E-02	5.00E-01

Note (1) N/A means Not Assessed

(2) Dash (-) means no relevant reference value identified

(3) Asterisk (*) means no background data available (refer to **Table 3.5**)

#: Hourly, daily and annual average concentrations of heavy metals are the same for all three Reprovisioning options A, B and C. They are calculated based on Tier 1 mitigated RSP annual results which assumed the entire site is active at one time and is considered conservative.

It can be seen from **Table 3.17** that the cumulative maximum concentrations for all non-criteria pollutants from the Project are less than their corresponding reference values and therefore the associated non-carcinogenic health risks are considered to be acceptable.

The four indicator pollutants (benzene, toluene, ethylbenzene and total xylenes) used to represent the most volatile TPH, i.e. those within the C6-C8 carbon range, are all compliant with their respective reference values. As explained in **Section 3.2.6**, it is anticipated that the potential health impact due to TPH would not be significant.

For those HM concentrations where background data was not available, the pollutant concentrations are substantially lower (from 2 to 6 orders of magnitude lower) than their respective reference values. Hence, the contributions of such HM from the Project and the associated health impacts are insignificant. It should be noted that the HM results are considered to be conservative, as the actual active area is expected to be much smaller than the areas which have been modelled, as described in **Section 3.4.3**.

Only the closest ASRs to the Project site are assessed. Increased horizontal and vertical distance from the site shows a decreasing pollutant concentration and therefore decreasing health risk. Populations that are further away from the Kennedy Town CDA will have a reduced health risk. According to the 2011 Hong Kong Census data the approximate population in the study area is 46,000 people.

There will be no permanent increase in the ambient air particulate matter concentration due to the remediation works, as defined within the scope of this project, at the Kennedy Town CDA. The concentrations attributable to the project reduce to zero once project is completed. The project is expected to take 4.5 – 13 years to complete.

Annual average concentration was based on the programme and associated excavation areas and volumes. Emission rates assumed that all HCs are volatilised during excavation and a passive emission rate was assumed during non-working hours. The emissions rates are considered conservative.

The results are considered to be conservative and therefore the actual increase is likely to be less than the predicted values.

3.6 Mitigation Measures

3.6.1 Health and Safety Measures for on-site personnel

Project site activities may give rise to the health and safety risks to on-site personnel. Detailed mitigation measures can be found in **Section 7**. When all of the measures detailed in **Section 7** are properly implemented, the risks to human health (in terms of both carcinogenic and non-carcinogenic risks) would be considered to be acceptable.

3.6.2 General Dust Control Measures

To reduce dust nuisance during the carrying out of the Project, the relevant requirements stipulated in the *Air Pollution Control (Construction Dust) Regulation* as well as the good practices for dust control should be implemented to reduce the dust impact from dust and HM. The dust control measures are detailed as follows:

Dust emissions could be suppressed at the site by regular water spraying. In general, water spraying twice a day could reduce dust emission from active area by 50%. However, for this Project, more frequent water spraying, i.e., ground watering applied once every 2.5 hours or four times per day, which gives rise to dust

suppression of 91.7% can be applied to reduce the dust impacts (refer to **Appendix 3.3** for detailed calculations on dust suppression).Project activities include excavation; movement of mobile plant and vehicles on site; stockpiling of clean fill and contaminated soils for decontamination.

3.6.3 Best Practices for Dust Control

In addition to implementing the dust control measures recommended above, it is also recommended that the relevant best practices for dust control as stipulated in the *Air Pollution Control (Construction Dust) Regulation* should also be adopted to further reduce the construction dust impacts of the Project. These best practices include:

Good Site Management

Good site management is important to help reduce potential air quality impacts to an acceptable level. As a general guide, the Contractor should maintain a high standard of housekeeping to prevent emission of fugitive dust. Loading, unloading, handling and storage of raw materials, wastes or by-products should be carried out in a manner so as to minimise the release of dust emissions. Accumulated materials on or around the work areas should be cleaned up regularly. Cleaning, repair and maintenance of all plant within the work areas should be carried out in a manner which minimises emissions of fugitive dust. Materials should be handled properly to prevent fugitive dust emission before cleaning.

Disturbed Parts of Roads

- Each and every main temporary access should be paved with concrete, bituminous hard core materials or metal plates and kept clear of dusty materials; or
- Unpaved parts of the road should be sprayed with water or a dust suppression chemical so as to keep the entire road surface wet.

Exposed Earth

Exposed earth should be properly treated by compaction, hydro seeding, vegetation planting or seating with latex, vinyl, bitumen within six months after the last decontamination activity on the site or part of the site where the exposed earth lies.

Loading, Unloading or Transfer of Dusty Materials

All dusty materials should be sprayed with water immediately prior to any loading or transfer operation so as to keep the dusty material wet.

Debris Handling

Debris should be covered entirely by impervious sheeting or stored in a debris collection area sheltered on the top and three sides.

Before debris is dumped into a chute, water should be sprayed so that it remains wet when it is dumped.

Transport of Dusty Materials

Vehicle used for transporting dusty materials/spoils should be covered with tarpaulin or similar material. The cover should extend over the edges of the sides and tailboards.

Where a vehicle leaving the Project site is carrying a load of dusty materials, the load should be covered entirely by clean impervious sheeting to ensure that the dusty materials do not leak from the vehicle.

Wheel Washing

Vehicle wheel washing facilities should be provided at each Project site exit. Immediately before leaving the Project site, every vehicle should be washed to remove any dusty materials from its body and wheels.

Use of Vehicles

The speed of vehicles within the site should be controlled to about 10km/hour in order to reduce adverse dust impacts.

Site Hoarding

Where a site boundary adjoins a road, street, service lane or other area accessible to the public, hoarding of not less than 2.4 m high from ground level should be provided along the entire length of that portion of the site boundary except for a site entrance or exit.

3.6.4 Solidification and Biopile Measures

The mitigation measures to be implemented during cement solidification and biopiling are detailed as follows:

Cement Solidification

The handling of dusty materials including soil and cement shall follow the *Air Pollution Control (Construction Dust) Regulation* to limit dust emissions. The cement solidification process is to be fully enclosed and associated storage bins or storage piles shall be covered as much as practicable.

Biopiling

During biopile formation, stockpiled soils shall be covered with tarpaulin or other impermeable material to minimise fugitive dust, HM and HC emissions.

During biopile operation the biopile shall be fully covered to control the extraction of HC. An activated carbon filter shall be fitted to the outlet of the biopile and shall have an installed efficiency of at least 99% removal efficiency.

The activated carbon filter system shall be regularly monitored to check the performance. Spent activated carbon filter shall be replaced regularly so that the Volatile Organic Compound (VOC) emission rate from the system is acceptable (i.e. the measured Total VOC is below 20 ppm). The biopile operation shall be terminated when unacceptable air quality is monitored at the site boundary. Resumption of biopiling will only be allowed after confirmation and implementation of appropriate mitigation measured (e.g.

replacement of the activated carbon filter). Monitoring of HC at the outlet of the biopile should be monitored on a real-time basis.

3.7 Residual Impacts

With the implementation of the proposed dust control measures, the TSP, RSP and FSP concentrations around the Project site were predicted to be within the relevant air quality criteria, and therefore no adverse residual impacts are anticipated. All HC and HM levels were predicted to be below the relevant reference values and therefore no adverse residual impacts are anticipated for these pollutants.

3.8 Environmental Monitoring and Audit

Regular dust monitoring and monitoring of the VOC at the biopile exhaust is considered necessary during the carrying out of the Project and regular site audits are also required to ensure the dust control measures are properly implemented. Details of the Environmental Monitoring and Audit (EM&A) programme will be presented in the stand-alone EM&A Manual.

3.9 Conclusions

The effects to air quality from Project activities were assessed under the three Reprovisioning Options. TSP, RSP, FSP and HM and HC concentrations were modelled using the FDM and ISCST3 models. For fugitive dust impact assessment, the hypothetical Tier 1 screening scenario (for hourly TSP, daily RSP/FSP and annual RSP/FSP) with the assumption of 100% active area at all times and the Tier 2 modelling scenario (for annual RSP) which also had conservative assumptions, e.g. active areas are located closest to ASR assessed for annual RSP averages, are very conservative approaches, the results of which can represent any of three Reprovisioning Options for different sequencing and phasing of the works. With implementation of the recommended mitigation measures, i.e. dust suppression by regular water spraying as well as the relevant control requirement as stipulated in *Air Pollution Control (Construction Dust) Regulation*, it has been assessed that even under the very conservative modelling approach there would not be non-compliance at the ASRs with any of the Air Quality Objectives for RSP/ FSP or the TSP criterion for any of three Reprovisioning Options.

In addition, the cumulative maximum concentrations of all identified TAPs (hydrocarbon and heavy metals) have been assessed for different modelling scenarios that represent different excavation rates under the three Reprovisioning options. The predicted cumulative maximum concentrations for all non-criteria pollutants under each of the three Reprovisioning Options are lower than their corresponding reference values and therefore the associated non-carcinogenic health risks are considered to acceptable. The total incremental lifetime cancer risks associated with the KTCDA ground decontamination works have been estimated as 3.14×10^{-7} to 3.99×10^{-7} for the three Reprovisioning options. In other words, there would be less than four in ten million cancer risks associated with the heavy metal and hydrocarbon emissions from the Project, which is well below the risk guideline value of one in million. Hence, the incremental cancer risks due to the Project are considered to be negligible.

3.10 References

Agency for Toxic Substances and Disease Registry, U. D. (1999). *TOXICOLOGICAL PROFILE FOR TOTAL PETROLEUM HYDROCARBONS (TPH)*. Retrieved from http://www.atsdr.cdc.gov/toxprofiles/tp123.pdf

ASTM International. (n.d.). *Standard Guide for Risk-Based Corrective Action (E-2801).* Retrieved August 07, 2014, from http://www.astm.org/Standards/E2081.htm

Environmental Protection Agency, O. o. (2009, January). *Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment).* Retrieved from Environmental Protection Agency: http://www.epa.gov/oswer/riskassessment/ragsf/pdf/partf_200901_final.pdf

European Commission, A. (2005). *Air Pollution and Health: A European Information System (APHEIS), Health Impact Assessment of Air Pollution and Communication Strategy.*

Hong Kong Department of Health. (2013, December). *Tables on Health Status and Health Services 2012*. Retrieved July 30, 2014, from Department of Health: http://www.dh.gov.hk/english/pub_rec/pub_rec_ar/pdf/1213/supplementary_table2012.pdf

Hong Kong Environmental Protection Department. (2006, April 28). *Guidelines on Choice of Models and Model Parameters*. Retrieved August 07, 2014, from http://www.epd.gov.hk/epd/english/environmentinhk/air/guide_ref/guide_aqa_model_g1.html

Hong Kong Environmental Protection Department. (2007). *Guidance Manual for Use of Risk–based Remediation Goals for Contaminated Land Management .* Hong Kong: Hong Kong Environmental Protection Department.

Hong Kong Environmental Protection Department. (2011, August). *Practice Guide for Investigation and Remediation of Contaminated Land.* Retrieved August 06, 2014, from http://www.epd.gov.hk/epd/english/environmentinhk/waste/guide_ref/files/pg_conland_eng_2011.pdf

Hong Kong Environmental Protection Department. (2011, April 18). *Technical Memorandum on Environmental Impact Assessment Process (Environmental Impact Assessment Ordinance, Cap. 499, S. 16)*. Retrieved August 5, 2014, from http://www.epd.gov.hk/eia/english/legis/index3.html

Hong Kong Environmental Protection Department. (2012, May 30). *Guidelines on the Estimation of PM2.5 for Air Quality Assessment in Hong Kong*. Retrieved August 06, 2014, from http://www.epd.gov.hk/epd/english/environmentinhk/air/guide_ref/guide_aqa_model_g5.html

Hong Kong Environmental Protection Department. (2013, March). *Guidelines on Assessing the 'TOTAL' Air Quality Impacts*. Retrieved August 06, 2014, from http://www.epd.gov.hk/epd/english/environmentinhk/air/guide_ref/guide_aqa_model_g2.html

Hong Kong Environmental Protection Department. (2014, June 26). *Air Quality Annual Report*. Retrieved August 06, 2014, from http://www.aqhi.gov.hk/en/download/air-quality-reportse469.html?showall=&start=1

Hong Kong Environmental Protection Department. (n.d.). Air Pollution Control Ordinance (Cap. 311). Hong Kong: Hong Kong Environmental Protection Department.

Maunsell Environmental Management Consultants Ltd. (2002). *Agreement No. CE 68/99 Infrastructure for Penny's Bay Development Engineering Design and Construction - Decommissioning of Cheoy Lee Shipyard at Penny's Bay. EIA Report (Final).*

Maunsell Environmental Management Consultants Ltd. (2007a). *Agreement No. CE 35/2006(CE) Kai Tak Development Engineering Study cum Design and Construction of Advance Works – Investigation, Design and Construction, Decommissioning of the Former Kai Tak Airport other than the North Apron, Environmental Impact Assess.*

Maunsell Environmental Management Consultants Ltd. (2007b). *Demolition of Buildings and Structures in Proposed Kennedy Town Comprehensive Development Area Site, Environmental Report for VEP Application.* Hong Kong.

McDonnell, W. (2000). Relationships of mortality with fine and coarse fractions of long-term ambient PM10 concentrations in nonsmokers. *Journal of Exposure Analysis and Environmental Epidemiology*, 427-436.

Mott MacDonald. (2014). *Expansion of Hong Kong International Airport into a Three-Runway System - Environmental Impact Assessment Report.* Hong Kong: Airport Authority Hong Kong.

National Institute of Water and Atmospheric Research, Aurora Pacific Limited and Earth Tech Incorporated. (2004). *Good Practice Guide for Atmospheric Dispersion Modelling.* Wellington, New Zealand: Ministry for the Environment.

Pace, T. (2005). Examination of the Multiplier Used to Estimate PM2.5 Fugitive Dust Emissions from PM10. *EPA Emission Inventory Conference.* Las Vegas, NV.

Pope, A. (2002). Lung Cancer, Cardiopulmonary Mortality, and Long-term Exposure to Fine Particulate Air Pollution. *Journal of the American Medical Association*.

Superfund Health Risk Technical Support Center, U. (2009). *Provisional Peer-Reviewed Toxicity Values for Complex Mixtures of Aliphatic and Aromatic Hydrocarbons (CASRN Various)*. Retrieved from U.S. Environmental Protection Agency: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/documents/TPH.pdf

TPHCWG, T. P. (1999). *Human Health Risk-Based Evaluation of Petroleum Release Sites: Implementing the Working Group Approach.* Massachusetts: Amherst Scientific Publishers.

U.K. Health Protection Agency. (2010). *HPA Contaminated Land Information Sheet - Risk Assessment Approaches for Polycyclic Aromatic Hydrocarbons (PAHS).* U.K. Health Protection Agency.

U.S. Environmental Protection Agency. (1986, July). *Guideline on Air Quality model (revised) (EPA-450/2-78-027R).* Retrieved August 07, 2014, from http://nepis.epa.gov/Exe/ZyNET.exe/2000JO4P.TXT?ZyActionD=ZyDocument&Client=EPA&Index=1976+Thru+1980&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&

U.S. Environmental Protection Agency. (1988). *Report on Carbon Adsorption for Control of VOC Emissions: Theory and Full Scale System Performance (EPA-450/3-88-012).* United States Environmental Protection Agency.

U.S. Environmental Protection Agency. (1996, July). *Soil Screening Guidance: Technical Background Document Table of Contents - EPA Document Number: EPA/540/R-95/128.* Retrieved from EPA United States Environmental Protection Agency: http://www.epa.gov/superfund/health/conmedia/soil/toc.htm

U.S. Environmental Protection Agency. (1999, Sept 30). *Estimating Particulate Matter Emissions From Construction Operations Final Report.* Retrieved August 07, 2014, from http://nepis.epa.gov/Exe/ZyNET.exe/9100KK1W.TXT?ZyActionD=ZyDocument&Client=EPA&Index=1995+Thru+1999&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&

U.S. Environmental Protection Agency. (2005, April). *Estimation of Multipler Used to Estimate PM2.5 Fugitive Dust Emissions from PM10.* Retrieved August 07, 2014, from U.S. Environmental Protection Agency: http://www.epa.gov/ttnchie1/conference/ei14/session5/pace.pdf

U.S. Environmental Protection Agency. (2011a, January). *AP-42, Fifth Edition - Complilation of Air Pollution Emission Factors, Volume 1: Stationary Point and Area Sources*. Retrieved August 07, 2014, from U.S. Environmental Protection Agency: http://www.epa.gov/ttnchie1/ap42/

U.S. Environmental Protection Agency. (2011b, August 09). *Soil Screening Guidance: Technical Background Document (EPA/540/R-95/128)*. Retrieved August 07, 2014, from U.S. Environmental Protection Agency: http://www.epa.gov/superfund/health/conmedia/soil/toc.htm

U.S. Environmental Protection Agency. (2012, August 10). *Integrated Risk Information System - Benz[a]anthracene (CASRN 56-55-3)*. Retrieved from U.S. Environmental Protection Agency: http://www.epa.gov/iris/subst/0454.htm#woe

U.S. Environmental Protection Agency. (2012, August 10). *Integrated Risk Information System - Benz[a]anthracene (CASRN 56-55-3)* . Retrieved from U.S. Environmental Protection Agency: http://www.epa.gov/iris/subst/0454.htm#woe

U.S. Environmental Protection Agency. (2012b, August 9). *Integrated Risk Information System - Benzo[a]pyrene (BaP) (CASRN 50-32-8).* Retrieved from U.S. Environmental Protection Agency: http://www.epa.gov/iris/subst/0136.htm

U.S. Environmental Protection Agency. (2013a, September 25). *Mid-Atlantic Brownfields & Land Revitalization - Semi-Volatile Organic Compounds*. Retrieved from U.S. Environmental Protection Agency: http://www.epa.gov/reg3hwmd/bf-lr/regional/analytical/semi-volatile.htm

U.S. Environmental Protection Agency. (2013b, September 25). *Mid-Atlantic Brownfields & Land Revitalization - Volatile Organic Compounds*. Retrieved from U.S. Environmental Protection Agency: http://www.epa.gov/reg3hscd/bf-lr/regional/analytical/volatile.htm

U.S. Environmental Protection Agency. (2013c, October 18). *Technology Transfer Network - Air Toxics Web Site - Health Effects Glossary*. Retrieved from U.S. Environmental Protection Agency: http://www.epa.gov/ttn/atw/hlthef/hapglossaryrev.html

Wong, C., Thach, T., Chau, P., Chan, E., Chung, R., Ou, C.-Q., . . . Hedley, A. (2010). *Public Health and Air Pollution in Asia (PAPA): Coordinated studies of short-term exposure to air pollution and daily mortality in four cities. Part 4: Interaction between air pollution and respiratory viruses: time series study of daily mortality and hos.* Boston, MA, U.S.A.: Research Report No. 154, Health Effects Institute.