1 ASSESSMENT OF THE RISKS ASSOCIATED WITH EXPOSURES TO PCDD/FS: SUPPLEMENTARY NOTE

1.1 INTRODUCTION

This *Supplementary Note* presents an risk-based approach to the assessment of human exposures to emissions of polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs) from proposed waste incineration facilities in the Hong Kong SAR.

The *Main Report*[1] presents a discussion of the various routes of potential human exposures to these compounds and produces a preliminary estimation of the level of exposure likely to be experienced by individual members of the Hong Kong population. The estimates are considered preliminary in nature due to the absence of detailed information on the concentrations of PCDD/Fs in foodstuffs consumed in the Hong Kong SAR. However, the assumptions used will tend to lead to a conservative estimate of exposures and hence a worst case evaluation.

In the evaluation presented in the *Main Report*, the estimated exposures were compared with the range of Tolerable Daily Intakes (TDI) promulgated by the World Health Organisation (WHO). Further details of the WHO standards and their derivation are presented in *Annex B* of the *Main Report*.

It should be noted that the Hong Kong SAR Government has not yet established standards for PCDD/F exposures; however, there are a range of other controls which contribute to limiting human exposures to these substances, for example:

- the Environmental Protection Department (EPD) has adopted the 0.1 ng I-TEQ Nm^{-3} standard for new waste incineration facilities[2];
- the Department of Health (DoH) utilises standards set by the United States Environmental Protection Agency (US EPA) to control the levels of these compounds in foodstuffs.

The *Technical Memorandum on Environmental Impact Assessment Process (TM-EIAO)*[3] provides additional guidance on the assessment of risks associated with emissions to the atmosphere. *Annex 4* of the *TM-EIAO* gives an acceptable individual risk guideline value of 1 in 100,000 per annum or 1 x

10^{-5}. As a supplement to the assessment of exposures using the WHO TDI as a benchmark, this assessment compares the estimated levels of exposure with the *TM-EIAO* criterion.

1.2 RISK-BASED APPROACH TO THE ASSESSMENT OF PCDD/F EXPOSURES

A risk-based approach to the assessment of incremental exposures to PCDD/Fs due to emissions from the proposed facilities includes the following four stages:

- *hazard identification:* the process of determining whether or not exposures to PCDD/Fs could create an increase in adverse health conditions. For the purposes

(1) Environmental Resources Management (2000) *An Assessment of Dioxins Emissions in Hong Kong*

(2) Note that the Chemical Waste Treatment Centre has been operating to this standard since the early 1990's.

(3) Hong Kong Environmental Protection Department (1997) *Technical Memorandum on Environmental Impact Assessment Process (Environmental Impact Assessment Ordinance, Cap. 499, S.16)*

of this evaluation exposure to PCDD/Fs has been assumed to constitute a possible risk to human health.

- *dose-response evaluation:* which is the process by which the relationship between the degree of exposure to PCDD/Fs and the extent of harm or injury is quantified. A discussion on the toxicity of PCDD/Fs is presented in *Section B3* of *Annex B* of the *Main Report.* For this assessment we have utilised the risk-based dose-response relationship described in *Section B3.3.2.*
- *exposure assessment:* this process results in an estimate of the intake of PCDD/Fs to a hypothetical individual (typically, a worst case scenario is used). In this assessment we have made an estimate of worst case exposures via inhalation and extrapolated these to provide a preliminary estimate of total exposures.
- *risk characterisation:* this stage of the assessment process combines estimates from the dose-response evaluation and the exposure assessment to produce an estimate of the overall health risk to an individual. The estimated risk is then compared with the criterion in the *TM-EIAO* to determine whether or not it is acceptable.

The first two stages of this assessment are described in the *Main Report,* and will not be repeated in this *Supplementary Note.*

1.2.1 *Exposure Assessment*

Inhalation

Inhalation exposures were estimated using the following equation:

$$\textbf{INH (mg kg}^{-1} \textbf{ day}^{-1}) = \frac{\textbf{(Ca x IR x ET x EF x ED x ABS)}}{\textbf{(BW x AT)}}$$
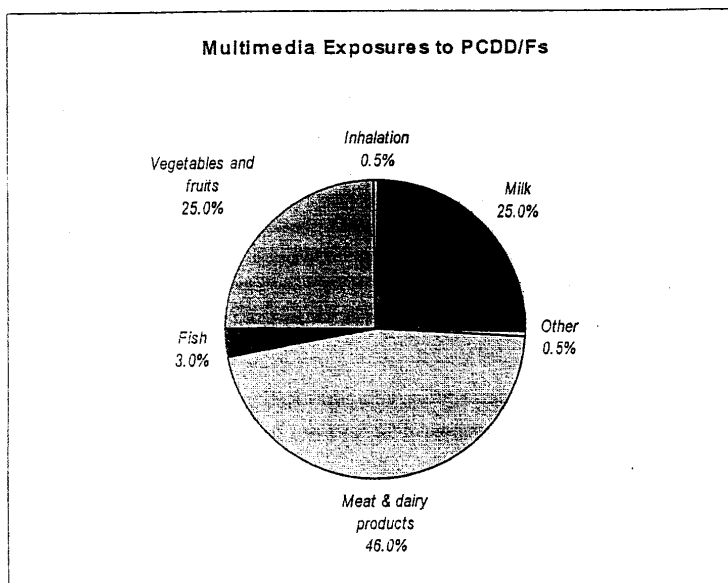
Where:

- INH=inhalation exposure (mg kg-1 day-1)
- *Ca=concentration in air (mg I-TEQ m^{-3})*
- IR=inhalation rate (m3 hr-1), assumed to be 0.83 m3 hr-1
- *ET=exposure time (hr day-1), assumed to be 24 hr day-1*
- *EF=exposure frequency (days a-1), assumed to be 330 days a-1*
- *ED=exposure duration (a), assumed to be 70 a*
- *ABS=absorption fraction (unitless), assumed to be 1*
- BW=body weight (kg), assumed to be 70 kg
- AT=averaging time (day), assumed to be 25,550 days

The assumptions shown in *italics* are considered to represent an upper bound worst case estimate, resulting in the estimated exposures being somewhat greater than is probable in reality.

Ingestion

In the absence of available food surveillance data, it is necessary to make a preliminary estimation of ingestion exposures based upon the extrapolation of data from the quantitative estimate of inhalation exposures described above.

Section 6.4.1 of the *Main Report*, indicates that inhalation generally contributes in the order of 0.5% of the total individual exposure to PCDD/Fs, the remaining exposures are summarised in the following figure.

Multimedia Exposures to PCDD/Fs

Inhalation 0.5%
Vegetables and fruits 25.0%
Milk 25.0%
Fish 3.0%
Other 0.5%
Meat & dairy products 46.0%

As the majority of the food consumed in the SAR is imported, it is considered likely that attributing 0.5% of the total exposures to inhalation may be an under-estimate. Therefore, the effect of assuming that inhalation constitutes 2% of the total exposure has also been addressed.

If the calculated inhalation exposures represent 0.5% of the total, multiplying the estimated inhalation exposure by 200 will provide a preliminary estimate of the total exposure from all pathways. If inhalation is assumed to represent 2% of the total exposure, a factor of 50 should be employed. It should be noted that it has been assumed that the dietary exposure responds in a manner directly proportional to increases in inhalation exposures. This is a conservative estimate in the Hong Kong context, as it implies that all of the diet of an individual is produced in the area at which the emissions have their maximum impact. Hong Kong imports a significant proportion of all of the major foodstuffs consumed by the resident population.

1.2.2   *Risk Characterisation*

The lifetime risks associated with a given exposure are determined using the following equation:

$$\text{Lifetime risk} = \text{Slope factor} \times \text{Exposure}$$

The slope factor describes the relationship between exposure and carcinogenic risk and is considered a conservative approach, as it assumes that any degree of exposure, however small, carries with it a degree of risk.

To determine the annual individual risk, the lifetime risk should be divided by 70, equivalent to the Averaging Time (AT). This allows comparison of the estimate with the acceptable risk standards promulgated by the Hong Kong EPD in the *TM-EIAO*.

1.3 RESULTS

The following tables summarise the annual individual risks associated with the maximum predicted increases in ground level PCDD/F concentrations associated with emissions from the proposed waste incineration facilities. *Table 1.3a* assumes that inhalation is attributable for 0.5% of the total exposure and *Table 1.3b*. assumes that 2% of the total exposure is due to inhalation.

As described in *Section 6.3* of the *Main Report*, the maximum increase in annual average PCDD/F concentrations due to emissions from a large scale Waste-to-Energy Incineration Facility (WEIF) is approximately 1×10^{-3} pg I-TEQ m^{-3}. A range of concentrations are presented to give an indication of the incremental ground level concentration necessary to produce a breach of the *TM-EIAO* criterion (1×10^{-5}).

Table 1.3a: ***Preliminary Estimates of Incremental Risks from PCDD/F Exposures Assuming that Inhalation Contributes 0.5% of the Total***

Ground level concentration (pg I-TEQ m^{-3})	Annual risk due to inhalation	Annual risk from all exposure pathways(b)
1×10^{-5}	3.7×10^{-12}	7.4×10^{-10}
1×10^{-4}	3.7×10^{-11}	7.4×10^{-9}
$1 \times 10^{-3(a)}$	3.7×10^{-10}	7.4×10^{-8}
1×10^{-2}	3.7×10^{-9}	7.4×10^{-7}
1×10^{-1}	3.7×10^{-8}	7.4×10^{-6}
1	3.7×10^{-7}	7.4×10^{-5}

Notes:
(a)Maximum predicted ground level concentration for the proposed Waste-to-energy Incineration Facilities
(b)Assumes that inhalation represents 0.5% of the total exposure to PCDD/Fs

Table 1.3b ***Preliminary Estimates of Incremental Risks from PCDD/F Exposures Assuming that Inhalation Contributes 2% of the Total***

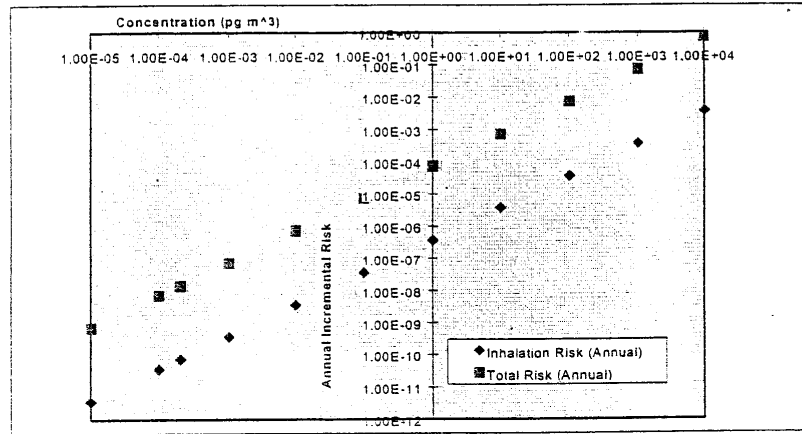| Ground level concentration (pg I-TEQ m^{-3})	Annual risk due to inhalation	Annual risk from all exposure pathways[b]
1×10^{-5}	3.7×10^{-12}	1.8×10^{-10}
1×10^{-4}	3.7×10^{-11}	1.8×10^{-9}
$1 \times 10^{-3(a)}$	3.7×10^{-10}	1.8×10^{-8}
1×10^{-2}	3.7×10^{-9}	1.8×10^{-7}
1×10^{-1}	3.7×10^{-3}	1.8×10^{-6}
1	3.7×10^{-7}	1.8×10^{-5}

Notes:
(a)Maximum predicted ground level concentration for the proposed Waste-to-energy incineration Facilities
(b)Assumes that inhalation represents 2% of the total exposure to PCDD/Fs

Based upon the above analysis, it is evident that incremental ground level concentrations of PCDD/Fs due to emissions from the WEIFs would have to be two to three orders of magnitude greater than those predicted for there to be the potential for a breach of the EPD criterion.

The following figure shows the sensitivity of annual risks to changing incremental increases in ground level concentrations due to emissions from the proposed incineration facilities. The total exposures are considered worst case as they are based on inhalation only contributing 0.5% of the total.

Figure 1.3a : *Sensitivity Analysis*

To put this finding into the context of the current situation in Hong Kong, the existing annual average ground level concentrations (approximately 0.1 pg I-TEQ m^{-3}) would have to more than double due to the emissions from the proposed facilities before there is a breach of the *TM-EIAO* criterion. This implies that emissions would have to be consistently significantly in excess of the emission standard.