



■ Table 23C Predicted Indoor Air Concentrations for Plume Area

Target Volatile Chemical	Source Concentration (Average)		Indoor Air Concentration (ug/m <sup>3</sup> )		
	Groundwater (µg/L)	Soil (mg/kg)	Groundwater Source	Soil Source	Total
Benzene	114	0	0.32	0	0.32
Toluene	0	0	0	0	0
Ethylbenzene	37	0	0.102	0	0.102
Xylenes	73	0.3	0.205	6.06	6.27
Naphthalene	229	51.3	0.133	12.8	12.9
Acenaphthene	3	9.4	6.52E-4	0.18	0.181
Fluorene	3	38.8	2.93E-4	0.156	0.146
Pyrene	0	155.1	0	0.011	0.011
Chrysene	0	51.6	0	6.48E-04	6.48E-04
Benzo(b,k) fluoranthene	0	100.1	0	1.69E-04	1.69E-04

Target Volatile Chemical	Source Concentration (Maximum)		Indoor Air Concentration (ug/m <sup>3</sup> )		
	Groundwater (µg/L)	Soil (mg/kg)	Groundwater Source	Soil Source	Total
Benzene	704	0	1.98	0	1.98
Toluene	0	0	0	0	0
Ethylbenzene	213	0	0.585	0	0.585
Xylenes	417	3	1.17	60.6	60.7
Naphthalene	1460	280	0.848	32.0	32.8
Acenaphthene	14	33	3.04E-03	0.633	0.636
Fluorene	15	120	1.46E-03	0.221	0.222
Pyrene	2	600	2.84E-05	0.020	0.020
Chrysene	0	200	0	6.48E-04	6.48E-04
Benzo(b,k) fluoranthene	0	310	0	1.69E-04	1.69E-04

Note:

Refer **Table 17B** for shallow groundwater source concentrations and **Table 17C** for shallow unsaturated soil source concentrations



■ Table 23D Predicted Indoor Air Concentrations for Outside Plume Area

Target Volatile Chemical	Source Concentration (Average)		Indoor Air Concentration (ug/m <sup>3</sup> )		
	Groundwater (µg/L)	Soil (mg/kg)	Groundwater Source	Soil Source	Total
Benzene	0	0.2	0	11.1	11.1
Toluene	0	0.4	0	13.3	13.3
Ethylbenzene	0	1.6	0	35.3	35.3
Xylenes	0	5.1	0	103	103
Naphthalene	0	43.9	0	10.9	10.9
Acenaphthene	0	3.3	0	6.33E-02	6.33E-02
Fluorene	0	8.8	0	3.54E-02	3.54E-02
Pyrene	0	39.9	0	2.83E-03	2.83E-03
Chrysene	0	14.0	0	6.48E-04	6.48E-04
Benzo(b,k) fluoranthene	0	28.3	0	1.69E-04	1.69E-04

Target Volatile Chemical	Source Concentration (Maximum)		Indoor Air Concentration (ug/m <sup>3</sup> )		
	Groundwater (µg/L)	Soil (mg/kg)	Groundwater Source	Soil Source	Total
Benzene	0	4.6	0	256	256
Toluene	0	5	0	167	167
Ethylbenzene	0	26	0	574	574
Xylenes	0	48	0	970	1018
Naphthalene	5	650	2.90E-03	32.0	32.0
Acenaphthene	14	41	3.04E-03	7.86E-04	3.83E-03
Fluorene	15	120	1.46E-03	0.221	0.222
Pyrene	2	600	2.84E-05	2.01E-02	2.01E-02
Chrysene	0	200	0	6.48E-04	6.48E-04
Benzo(b,k) fluoranthene	0	210	0	1.69E-04	1.69E-04

Note:

Refer **Appendix B** for shallow groundwater source concentrations and **Table 23b** for shallow unsaturated soil source concentrations



The computer analyses indicate that the highest indoor volatile concentrations would be produced in most contaminant scenarios by xylenes, benzene and naphthalene.

The computer analyses indicate that the highest indoor air volatile concentrations would be generated in the area of the site where the shallow unsaturated soils are most contaminated rather than where the shallow groundwater aquifer is most contaminated. This is because the soils are able to contain a much greater amount of volatile contaminants compared to groundwater where only dissolved phase contamination is present. Furthermore, the analysis has assumed that the contamination in the shallow soils is distributed throughout the soil layer and occurs at the underside of building foundations, whereas the shallow groundwater is located at a depth of 1.5m. Consequently, the highest indoor air concentrations are predicted to occur Outside the Plume Area, since the levels of BTEX and PAH contamination in the soils Outside the Plume Area are higher than in the Plume Area.

The indoor air concentrations predicted by the computer analysis for all contaminant scenarios are less than the occupational air exposure standards given in **Section 8.3** by several orders of magnitude. This is shown in **Table 23E**, which compares the predicted indoor air concentrations given in **Tables 23C** and **23D** with the occupational exposure standards from **Table 15**.

■ **Table 23E Comparison of Predicted Indoor Air Concentrations with Occupational Exposure Standards**

Target Volatile Chemical	Plume Area		Outside Plume Area		Occupational TWA ( $\mu\text{g}/\text{m}^3$ )
	Average Source Levels	Maximum Source Levels	Average Source Levels	Maximum Source Levels	
Benzene	0.32	1.98	11.1	256	16,000
Toluene	0	0	13.3	167	377,000
Ethylbenzene	0.102	0.585	35.3	574	434,000
Xylenes	6.27	60.7	103	1018	350,000
Napthalene	12.9	32.8	10.9	32.0	52,000
Acenaphthene	0.181	0.636	6.33E-02	3.83E-03	200 (1)
Fluorene	0.146	0.222	3.54E-02	0.222	
Pyrene	0.011	0.020	2.83E-03	2.01E-02	
Chrysene	6.48E-04	6.48E-04	6.48E-04	6.48E-04	
Benzo(b,k) fluoranthene	1.69E-04	1.69E-04	1.69E-04	1.69E-04	

Notes

(1) Based on Worksafe TWA for coal tar pitch volatiles



Since the predicted indoor air concentrations are well below the occupational exposure standards, the risks posed by the volatilisation and vapour transport to on-site workers are considered to meet current regulatory requirements. Consequently, no further analysis of this exposure pathway has been undertaken in this site-specific risk assessment.

### **Scenario 2 – Off-site Residents**

This exposure scenario examines the impacts of volatilisation and vapour transport from contaminated groundwater and soils to off-site residents on properties bordering the Former Gasworks site along the eastern side of Burren Street. The most critical condition for this exposure scenario would be impacts to the indoor air quality from soil and groundwater contamination situated near the common boundary between the Former Gasworks site and the residential properties. The boreholes and wells that would define these levels of contaminants are MW9S, MW10S, MW11S and MW19S.

Soil vapours generated in other parts of the Former Gasworks site should pose a low risk to the adjacent residential properties since the investigation has found that groundwater flows in the shallow and deep aquifer at the site are directed to the south and south-east away from the residential properties (**Section 10.3**). Furthermore, analyses predict that typical leaks in tanked basements constructed at the residential properties should not cause any significant change in these groundwater flow directions (**Section 11.3.2**).

The four wells located along the residential boundary measured non-detectible levels of the target BTEX and PAHs chemicals in the shallow aquifer. The soil samples collected from the fill layer at these locations also showed non-detectible BTEX concentrations but elevated PAH concentrations at some locations, which are summarised in **Table 23F**.

■ **Table 23F PAH Concentrations Measured in Fill Layer Along Site Boundary with Residential Properties**

Investigator	CH2M HILL	CH2M HILL	CH2M HILL	CH2M HILL	Average
SAMPLE ID	MW09S	MW10S	MW11S	MW19S	
Date of Sampling	Oct 2001	Oct 2001	Oct 2001	Oct 2001	
Depth (m)	1.3-1.4	0.9-1.1	0.6-0.8	1.2-1.3	
Benzene	nd	nd	nd	nd	nd
Toluene	nd	nd	nd	nd	nd
Ethylbenzene	nd	nd	nd	nd	nd
Total Xylenes	nd	nd	nd	nd	nd
Naphthalene	nd	nd	nd	nd	nd
Acenaphthene	nd	nd	nd	nd	nd
Fluorene	nd	nd	nd	nd	nd
Pyrene	nd	12	4.9	3.6	6.8
Chrysene	nd	6.7	2.4	1.8	3.6
Benzo[b,k]fluoranthene	nd	9	3	3	5.0

All units in mg/kg



In this study, the maximum PAH soil concentrations measured in these soil samples have been taken to represent the PAH concentrations in soils that would rest against basement walls that may be constructed along the common boundary with the Former Gasworks site.

The soil profile used in the computer analysis is the same as was adopted for Scenario 1. The analysis has modelled the vertical basement wall as a horizontal slab founded directed over the soil, which should over-estimate the indoor air concentrations. The results of the computer analysis are summaries in **Table 23G**.

■ **Table 23G Predicted Indoor Air Concentrations for Residential Basement**

Target Volatile Chemical	Source Concentration (Average)		Indoor Air Concentration (ug/m <sup>3</sup> )		
	Groundwater (µg/L)	Soil (mg/kg)	Groundwater Source	Soil Source	Total
Benzene	0	0	0	0	0
Toluene	0	0	0	0	0
Ethylbenzene	0	0	0	0	0
Xylenes	0	0	0	0	0
Naphthalene	0	0	0	0	0
Acenaphthene	0	0	0	0	0
Fluorene	0	0	0	0	0
Pyrene	0	12	0	8.51E-04	8.51E-04
Chrysene	0	6.7	0	6.48E-04	6.48E-04
Benzo(b,k) fluoranthene	0	9	0	1.69E-04	1.69E-04

Ambient air quality criteria for the target PAHs are not available from Australian while the WHO (2000) guidelines only provide a criteria for benzo(a) pyrene. However, the US EPA (2005) provides Preliminary Remedial Goals (PRGs) for the target PAH chemicals in ambient air. These criteria are:

- Pyrene = 110 µg/m<sup>3</sup>
- Chrysene = 0.92 µg/m<sup>3</sup>
- Benzo(b,k)fluoranthene = 0.0092 – 0.092 µg/m<sup>3</sup>

The results show that the predicted indoor air quality in basements on residential properties would be well below the US EPA PRGs by a factor of 10<sup>2</sup> to 10<sup>7</sup> times. Since the predicted indoor air concentrations are well below the occupational exposure standards, the risks posed by the volatilisation and vapour transport to residents on adjacent properties are considered to meet



current regulatory requirements. Consequently, no further analysis of this exposure pathway has been undertaken in this site-specific risk assessment.

#### 11.3.4 Contaminated Surface Soils

The assessment of soil contamination data at the Former Gasworks site (**Section 5.7.1**) showed that exposure concentrations from soil contaminants at the site are determined by the fill layer since the contaminant levels in the underlying natural soils are generally lower and are at greater depth. The data indicate that the fill layer is mainly contaminated with high levels of PAHs and TPH C<sub>10</sub>-C<sub>36</sub> distributed over much of the site. This is indicated by the 95% UCL estimates of the true mean, which are:

- Total PAHs = 586 mg/kg (SAC = 100 mg/kg)
- Benzo(a)pyrene = 38.7 mg/kg (SAC = 5 mg/kg)
- TPH C<sub>10</sub>-C<sub>36</sub> = 8,010 mg/kg (SAC = 1,000 mg/kg)

Hot-spots are considered to be present at individual sampling locations where the contaminant concentration exceeds 250% of the *Soil Investigation Level*, as recommended in the NEHF (1998) guidelines. In the fill layer, hot-spots were found to be contaminated by benzene and xylenes in addition to PAHs and TPH C<sub>10</sub>-C<sub>36</sub>.

Contamination in the fill layer was found to be highest in samples located near to the former tar tanks and gasholders (SB03, SB04, SB06, SB07), retorts and gas converter (TP44, TPA, BH13, BH15) and the gas scrubbers (SB18), as shown in **Figure 7**.

**Section 11.2** identified the potential receptors of contaminants from the on-site soils to be Site Workers and Construction/Maintenance Workers. The exposure concentrations for Site Workers are considered to be best represented by the 95% UCL true mean estimates, since the exposure period is a relatively long period of time (ie. 30 year exposure period as given by NEPC, 1999e). On the other hand, the exposure concentrations for Construction/Maintenance Workers are considered to be best represented by the maximum hot-spot concentrations due to the shorter exposure period. A summary of these exposure concentrations for the two potential receptors of on-site soil contamination is provided in **Table 24**.





■ Table 24 Exposure Concentrations for Receptors Exposed to Surface Soils

Substance	Human Health Industrial Criteria (mg/kg)	Hot-spot Criteria (mg/kg)	Soil Concentrations (mg/kg)	
			Site Worker	Construction/ Maintenance Worker
Total PAHs	100	250	586	3953
Benzo(a)pyrene	5	12.5	39	220
TPH (C10-C36)	1,000	2,500	8010	38,400
Benzene	1	2.5	0.8	7
Total Xylenes	25	62.5	21	210

The five contaminants listed in the table correspond to those found to exceed either the HIL F Industrial soil criteria or the hot-spot criteria. When considered together, these contaminants should account for risks posed by chemical mixtures. The other potential contaminants of concern were found to be much lower concentrations and have not been considered further in the contaminated soil exposure scenario.

### 11.3.5 Leaching to Groundwater & Migration

The potential exposure intakes from contaminants leaching into the groundwater from impacted soils and buried wastes are considered to be accounted for in the exposure intakes due to other migration pathways associated with groundwater from the Former gasworks site. These other exposure pathways comprise groundwater transport (**Section 11.3.1**) and intercepted/extracted groundwater (**Sections 11.3.2 & 11.4.1**). This is because leaching to groundwater has been occurring since the Macdonaldtown Triangle area was first developed by RailCorp more than 100 years ago and gasworks operations ceased in the mid-1970's (refer **Section 4**). The groundwater quality across the Former Gasworks site would have reached a steady-state condition for the more persistent contaminants (eg. heavy metals, benzo(a)pyrene, heavy-end TPHs), while the concentrations of contaminants having a higher degradation potential (eg. BTEX, naphthalene, light-end TPHs) should be gradually decreasing.

This steady-state or gradually degrading condition of contaminants at the Former Gasworks site is demonstrated by the fact that the groundwater investigation data indicate that the contaminant plume is contained within railway-owned land and has not migrated into the residential properties to the west of the site or south of Railway Parade.

On account of these factors, no further consideration of this migration pathway has been made in this site-specific risk assessment.



## 11.4 Estimates of Exposure Intakes

### 11.4.1 Methodology

The NEPC (1999e) “*Guideline on Exposure Scenarios and Exposure Settings*” specifies default exposure settings to be used for a range of land uses that were adopted in the NEPM guidelines. The land uses that are most relevant to this study are ‘Standard’ residential (NEPM A) and commercial/industrial (NEPM F) land uses, with a summary of the default settings provided in Table 25A.

■ Table 25A Default NEPM Exposure Settings

‘Standard’ Residential Land Use (NEPM A)	Commercial/Industrial Land Use (NEPM F)
24 hours/day	8 hours/day
365 days/year	5 days/week
70 years occupancy duration	48 weeks/year
	30 years duration

The NEPC (1999) “*Guideline on Health Risk Assessment Methodology*” allows a site-specific risk assessment to adopt different exposure settings provided they are appropriate and ensure that transient (short term) and other important exposure scenarios are not obscured by the use, for example, of average lifetime exposures. This is important in the Australian context where Acceptable Daily Intake values from the WHO have been used to establish Health-based Investigation Levels. The duration and magnitude of exceedances of the ADIs must be obvious in exposure assessments<sup>6</sup>.

Exposure frequency and duration are used to estimate the total time of exposure. Recommended default exposure values provided in the technical literature have been adopted in this site-specific risk assessment where appropriate and available for each receptor. An example of such a publication is the US EPA (July 2004) “*Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)*”, which supersedes the earlier US EPA (January 1992) guideline.

Where default exposure values are not appropriate or available, professional judgement has been used together with activity factors available from the technical literature such as the US EPA publication “*Exposure Factors Handbook Volume III, Activity Factors*” (US EPA, August 1997).

<sup>6</sup> Refer Section 6.5 in NEPC (1999a)