



contaminants of concern. These contaminants and their individual hazard quotients are presented in **Table 35**.

■ **Table 35 Hazard Quotients for On-site Construction Workers at Former Gasworks Site**

Substance	Total Daily Intake (µg/day)	Reference Dose (µg/day)	Hazard Quotient
Total PAHs (as equivalent BaP)	36	9.5	3.79
TPH C ₁₀ -C ₃₆	4252	2,100	2.02
Benzene	171	210	0.81
Toluene	7.3	14,000	5.2E-04
Ethylbenzene	24.4	7,000	3.5E-03
Total Xylenes	60.2	49,000	1.2E-03
TOTAL			6.6

The results indicate that on-site construction/maintenance workers at the Former Gasworks site have the potential to being exposed to a high risk of health impacts from ground contamination if working in an unremediated environment with no personal protective equipment (PPE) or special work procedures. The main health risks are posed by workers exposed to PAHs and petroleum hydrocarbon contamination, which occurs both in the shallow soils and groundwater.

In order to mitigate these risks, it will be necessary for work procedures to be adopted by on-site construction/maintenance workers at the Former Gasworks site that will minimise/avoid:

- Dermal contact with contaminated groundwater;
- Physical contact with the surface soils;
- Dust generation; and
- Require high levels of hygiene and decontamination.

A program of environmental monitoring should also be undertaken when any construction work or significant maintenance work is undertaken at the Former Gasworks site. Alternatively, consideration should be given to capping the contaminated soils with a clean-soil cover or pavement.

13.2 Risks to Long-Term Site Workers

The results of the data and exposure assessment presented in **Section 11.2** indicate that the health risks to long-term Site Workers from contamination at the Former Gasworks site are low for the exposure pathways involving:



- Inhalation of vapours emitted into the outdoor air and indoor air (within buildings) generated by contaminated soils in the unsaturated zone above the shallow aquifer (**Section 11.3.3**);
- Inhalation of vapours emitted into the outdoor air and indoor air (within buildings) generated by contaminated groundwater in the shallow aquifer(**Section 11.3.3**); and
- Ingestion or have dermal contact with contaminated groundwater (**Section 11.2**).

The results of the data and exposure assessment (**Section 11.3.4**) indicate that the main health risks to long-term Site Workers from ground contamination at the Former Gasworks site are associated with exposure to contaminated surface soils. The contaminants of concern are total PAHs, BaP, TPH (C₁₀-C₃₆), benzene and total xylenes.

The human health risks associated with each of these exposure scenarios have been estimated using the estimates of contaminant intakes given in **Section 11.4.6** together with the toxicological data provided in **Section 12**. The daily doses in mg/kg body weight per day have been converted into daily intake amounts in mg using a body weight of 70kg, as recommended in the NEPM (1999) Schedule B(4) guidelines.

The main exposure routes are considered to comprise:

- Ingestion of contaminants in surface soils; and
- Dermal contact with contaminants in surface soils.

A summary of the estimated contaminant intakes to a long-term Site Worker for the contaminants of concern are summarised in **Table 36**.

■ **Table 36 Daily Contaminant Intakes by Long-Term Site Workers**

Substance	Daily Contaminant Intake (µg)		Total Daily Intake (µg)
	Ingestion of Surface Soil	Dermal Contact with Surface Soil	
Total PAHs	14.7	111	126
Benzo(a)pyrene	0.975	7.39	8.37
Naphthalene	--	--	--
TPH C ₁₀ -C ₃₆	200	1168	1368
Benzene	0.020	0.117	0.137
Toluene	--	--	--
Ethylbenzene	--	--	--
Total Xylenes	0.525	3.06	3.59



The results show that dermal contact with the highly contaminated soils that occur in the tar tank/gasholder area would be the main exposure pathway for long-term Site Workers.

Health Risks from PAHs

The health risk posed by PAHs has been assessed by expressing all forms of PAH exposure in terms of BaP using the same approach as described in **Section 13.1**. The results in **Table 34** predict that the level of total PAH contamination in the fill at the Former Gasworks site can be converted into an equivalent BaP by multiplying the total PAH concentration by a factor of 0.108. Such a factor could also be applied to contaminant intakes. Using this approach, a total PAH intake of 126 µg is equivalent to a BaP intake of 13.6 µg, which is nearly double the concentration if only the BaP intake of 8.37 µg was used.

Combining the ingestion and dermal intakes for total PAHs and BaP gives a total equivalent BaP intake of 22.0 µg per day for a long-term Site Worker at the Former Gasworks site. This daily intake of BaP is 2.3 times the guidance dose of 9.5 µg per day recommended by Fitzgerald (1998), as previously discussed in **Section 12.1**. The hazard quotient for exposure to PAHs is greater than 1, which indicates an unacceptable risk to human health if no remedial works were to be undertaken at the Former Gasworks site.

Health Risks from TPHs

The data provided in **Table 36** estimate that the total amount of TPH intake for a long-term Site Worker at the Former Gasworks site from both ingestion and dermal contact with contaminated soil is 1,368 µg per day. This level of TPH C₁₀-C₃₆ intake is less than the acceptable daily intake of 2,100 µg. The hazard quotient for exposure to TPH C₁₀-C₃₆ is 0.65, which is less than 1 and indicates that potential exposure to TPHs at the Former Gasworks site is within acceptable limits if C₁₀-C₃₆ was the only contaminant at the site.

Health Risks from Benzene

The data provided in **Table 36** estimate that the total amount of benzene intake for a long-term Site Worker at the Former Gasworks site from both ingestion and dermal contact with contaminated soil is 0.137 µg per day. This level of benzene intake is much less than the acceptable daily intake of 210 µg, with the hazard quotient being 6.5E-04.

Health Risks from Xylenes

The data provided in **Table 36** estimate that the total amount of xylene intake for a long-term Site Worker at the Former Gasworks site from both ingestion and dermal contact with contaminated soil is 3.59 µg per day. This level of xylene intake is much less than the acceptable daily intake of 49,000 µg, with the hazard quotient being 7.3E-05.



Total Health Risk to Long-Term Site Workers

The total risk to long-term Site Workers from ground contamination at the Former Gasworks site has been estimated by the summation of the hazard quotients for the main contaminants of concern. These contaminants and their individual hazard quotients are presented in **Table 37**.

■ **Table 37 Hazard Quotients for Long-Term Site Workers at Former Gasworks Site**

Substance	Total Daily Intake (µg/day)	Reference Dose (µg/day)	Hazard Quotient
Total PAHs (as equivalent BaP)	22.0	9.5	2.3
TPH C ₁₀ -C ₃₆	1368	2,100	0.65
Benzene	0.137	210	6.5E-04
Toluene	--	14,000	--
Ethylbenzene	--	7,000	--
Total Xylenes	3.59	49,000	7.3E-05
TOTAL			2.95

The results indicate that long-term Site Workers at the Former Gasworks site could be exposed to an unacceptable health risk from ground contamination if working in an unremediated environment with no personal protective equipment (PPE) or special work procedures. The main health risks are posed by workers exposed to high concentration of PAHs and TPH C₁₀-C₃₆ that have been detected in fill materials in the tar tank/gasholder area on the Former Gasworks site.

In order to mitigate these risks, it will be necessary for work procedures to be adopted by long-term Site Workers at the Former Gasworks site that will minimise/avoid:

- Physical contact with the surface soils;
- Dust generation; and
- Require high levels of hygiene and decontamination.

Alternatively, consideration should be given to capping the contaminated soils with a clean-soil cover or pavement.

13.3 Risks to Nearby Residents and Off-site Construction Workers

The exposure pathway assessment (**Section 11.2**) concluded that the feasible exposure pathways for nearby residents at properties surrounding the Former Gasworks site are:

- Ingestion and dermal contact with contaminated near-surface soils at the Former Gasworks site;



- Ingestion and dermal contact with contaminated groundwater;
- Inhalation of vapours emitted into the outdoor air and indoor air (within buildings) generated by contaminated soils in the unsaturated zone above the shallow aquifer; and
- Inhalation of vapours emitted into the outdoor air and indoor air (within buildings) generated by contaminated groundwater in the shallow aquifer.

The risk assessment concluded (**Section 11.2**) that nearby residents would face a low risk from ingestion and dermal contact with contaminated near-surface soils at the Former Gasworks site because:

- It is understood that RailCorp has removed contaminated soils from the properties adjacent to the western site boundary under a remediation program completed in 2005; and
- Access to the Former Gasworks site is restricted to authorised personnel, who would largely be on-site workers.

A long-term SMP will also need to be placed on the Former gasworks site in order to ensure that the risk to the surrounding residential community from on-site soil contamination remains low. Restrictions that would need to be part of an SMP include the erection and maintenance of security fencing and controlling site access. These recommendations are included in **Section 14.2** of this report.

The risk assessment concluded (**Sections 11.3.1 & 11.3.2**) that nearby residents would face a low risk from ingestion and dermal contact with contaminated groundwater because:

- It is unlikely that licensed groundwater extraction would occur at either the Former Gasworks site or a nearby off-site area;
- Contaminated groundwater at the Former Gasworks site flows in a south to south-easterly direction away from the adjacent residential properties to the west of the site. Monitoring programs also confirm that there is no evidence of groundwater contamination having migrated from the Former Gasworks site into adjacent residential properties or off railway-owned land to the south of the site; and
- There would be minimal leakage through a tanked basement wall or other type of underground structure if constructed below the water table. Calculations indicate that the amount of groundwater seepage that would occur through typical cracks in a tanked structure would correspond to 1 to 2% of the total amount of groundwater that currently flows through a residential property, which is considered to be negligible and not cause contaminated groundwater to migrate towards residential properties.

The risk assessment concluded (**Section 11.3.3**) that nearby residents would face a low risk from the inhalation of vapours emitted into the outdoor air and indoor air (within buildings) generated by



contaminated soils or groundwater at the Former Gasworks site. The results of computer modelling predicted that indoor air quality in basements on residential properties would be well below the US EPA PRGs by a factor of 10^2 to 10^7 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. The predicted impacts to outdoor air quality would be even lower.

However, the site-specific risk assessment (**Section 11.3.2**) did identify an exposure pathway involving construction workers at a residential property subjected to dermal exposure to groundwater when working on a deep excavation. This exposure scenario would arise through the digging of a deep excavation that needs to be temporarily dewatered during the construction period.

In this exposure scenario, the risk assessment has conservatively assumed that the deep excavations would remain open for a relatively long period of time sufficient to cause the temporary migration of contaminated groundwater from the Former Gasworks site onto the residential property. The estimated contaminant intakes to an on-site construction worker from dermal contact with groundwater have used the average groundwater concentrations measured at the Former Gasworks site in order to account for the attenuation that would occur if groundwater from the Former gasworks site was drawn towards a residential property. The daily contaminant intakes for such a construction worker in dermal contact with groundwater are presented in **Table 26B**. Using these daily intakes, the risks posed to an off-site construction worker are presented in **Table 38**.

■ **Table 38 Hazard Quotients for Off-site Construction Worker**

Substance	Total Daily Intake ($\mu\text{g/day}$)	Reference Dose ($\mu\text{g/day}$)	Hazard Quotient
Total PAHs (as equivalent BaP)	0.0422	9.5	4.44E-03
TPH C ₁₀ -C ₃₆	262	2,100	0.125
Benzene	17.2	210	0.0819
Toluene	0.862	14,000	6.16E-05
Ethylbenzene	3.36	7,000	4.80E-04
Total Xylenes	8.30	49,000	1.69E-04
TOTAL			0.212

The results indicate that off-site construction workers should face a low risk from working in deep excavations at nearby residential sites and that no restrictions should be required to manage construction works at these properties.



13.4 Risks to Freshwater Ecosystems

The results of the data and exposure assessment presented in **Section 11.2** indicate that the main health risks to the nearest freshwater aquatic receptor (Alexandra Canal) from ground contamination at the Former Gasworks site would be associated with the extraction and discharging of contaminated groundwater to the stormwater system that would in turn be discharged into the headwaters of Alexandra Canal.

The risk assessment concluded (**Sections 11.3.1 & 11.3.2**) that the freshwater aquatic ecosystem at the headwaters of Alexandra Canal would face a low risk from contaminated groundwater present at the Former Gasworks site because:

- Contaminated groundwater at the Former Gasworks site flows in a south to south-easterly direction away from the adjacent residential properties to the west of the site. Monitoring programs also confirm that there is no evidence of groundwater contamination having migrated from the Former Gasworks site into adjacent residential properties or off railway-owned land to the south of the site; and
- There would be minimal leakage through a tanked basement wall or other type of underground structure if constructed below the water table. Calculations indicate that the amount of groundwater seepage that would occur through typical cracks in a tanked structure would correspond to 1 to 2% of the total amount of groundwater that currently flows through a residential property, which is considered to be negligible and not cause contaminated groundwater to migrate towards residential properties.

This conclusion is dependent on the requirement for groundwater to be retained and managed on-site if it was to be intercepted during construction work at the Former Gasworks site. A long-term SMP will need to be placed on the Former Gasworks site in order to ensure that any intercepted groundwater is retained and managed on-site. These recommendations are included in **Section 14.2** of this report.

13.5 Phytotoxic Impacts to Future Landscaping at the Site

The Former Gasworks site is to continue to be used as a commercial/industrial site, although it is not known what site activities will occur or if any structures/ buildings will be established on the site. While the NSW EPA (1999) Site Auditor Guidelines consider that ecological receptors need not be considered at a commercial/industrial site, there may be a need as part of this development to include landscaped areas. This section of the report provides an assessment of the potential phytotoxic effects of contaminants due to ground contamination that exists at the site.

The statistical analysis of the fill layer that is presented in **Table C** shows that some of the 95% UCL average values marginally exceed the Ecological Investigation Levels (EILs) given in the NEPC (1999d) guidelines. These contaminants and their exceedances are:



- Arsenic 95% UCL = 29mg/kg (EIL = 20mg/kg);
- Copper 95% UCL = 106mg/kg (EIL = 100mg/kg);
- Zinc 95% UCL = 267 mg/kg (EIL = 200mg/kg).

These exceedances indicate there is a minor risk that some heavy metal contaminants may affect the health of plants that are grown at the Former Gasworks site in the fill soils. To address these risks it is recommended that:

- Landscaping areas be formed in areas where there is a 1-2m thick layer of clean soil that is conditioned to be suitable for plant growth; and/or
- Native plants should be used at the site having a tolerance of elevated heavy metal concentrations.

These recommendations should be included in a long-term SMP that will need to be placed on the Former Gasworks site. This recommendation is included in **Section 14.2** of this report.

13.6 Aesthetic Assessment

As previously indicated in **Section 8.4**, the aesthetic criteria of most relevance to the Former Gasworks site in its present condition are considered to be:

- No malodorous materials exposed at ground surface;
- No malodorous gases emanating from the ground; and,
- No floating product to remain on groundwater or surface waters at the Site.

Inspections of the Former Gasworks site undertaken by SKM during the investigation found no physical evidence at the ground surface of:

- Visible signs of contamination;
- Visible signs of plant distress to vegetation;
- Odours; or
- Waste materials, although scrap metal from rail operations was observed at several locations across the site.

However, it is likely that some areas of the Site not examined by the investigation may contain localised areas of odorous or stained material.

Aesthetically unacceptable materials are known to occur below the ground surface. These materials include:

- Highly odorous soils and waste materials, particularly in the area of the former tar tanks, retorts and gasholders;