considered to have odours which members of the public may consider to be similar. On this basis, potential additive effects will need to be considered for the assessment of odours. For the purposes of this assessment, it has been assumed that malodorous constituents are restricted to the constituents listed in **Table 6.4**. The relative levels at which these constituents may occur has been based on the percentages summarised in **Table 6.1**. **Table 6.5** summarises the relative percentage of each speciated contaminant following as per the relative levels that each of the constituents occur as compared to other malodorous constituents in the soil samples.

Table 6.5: Summary of Adopted Relative Levels of Constituents in 'Tar Impacted Samples' and Adopted Odour Thresholds

Constituent	Relative Proportion (%) to all contaminants in tar sample	Relative Proportion (%) to sum of malodourous contaminants in tar sample	Adopted Odour Threshold (mg/m^3)
Benzene	0.01	0.5	5
Ethylbenzene	0.02	0.8	0.8
Toluene	0.1	4.3	1
Xylene (total)	0.15	6.5	0.2
Cresols	0.8	34.5	0.0003
Acenaphthene	0.04	1.7	0.5
Naphthalene	1.0	43.1	0.35
Phenol	0.2	8.6	0.02
SUM	2.32%	100%	

The adopted proportion of each constituent was used in the characterisation of soils for the derivation of soil based criteria for the protection of malodorous impacts during remediation works. While the list of malodourous contaminants has been based on speciated compounds detected in samples of free tar source material from the site it is noted that several other aliphatic or aromatic malodorous constituents may be present in impacted soils but have not been identified potentially causing the malodorous extent of the soils to be underestimated.

The assessment of soil data to the derived soil criteria is proposed to be undertaken by comparison of each constituent level to the constituent specific criteria. It is inconceivable that all malodourous constituents will be simultaneously present at concentrations at the full extent of the derived criteria. On this basis, where one constituent is at a concentration at the extent of the criteria, it is likely that the majority of the remaining constituents will be at levels below, and potentially well below, the adopted proportion of the constituent in a malodorous soil. This will be sufficient to account for potential malodorous effects of other constituents which have not been identified in **Table 6.5**.

6.3 Maximum Allowable Rate of Odour Emission

Dispersion modelling was completed assessing a series of Zones on the site that may be used for stockpiling of soil to determine the minimum dilution of a unit odour emission from the area / activity to the nearest receptor, as present on the site boundary. Each of the zones adopted are shown in **Figure 9** and summarised in **Table 6.6**.

Table 6.6: Summary of Stockpile Zone Details

Stockpile Zone	SW Corner Easting	SW Corner Northing	Length (m)	Width (m)
Zone 1	332359.35	6247736.66	32.00	25.00
Zone 2	332338.29	6247710.05	45.00	25.00
Zone 3	332278.29	6247729.67	50.00	10.00
Zone 4	332294.54	6247673.88	15.00	15.00
Zone 5	332284.68	6247633.20	20.00	20.00

The modelling scenarios undertaken are summarised in **Table 6.7** following. Modelling has considered daytime and night time conditions, and daytime and night time site boundaries as shown on **Figure 11.**

Table 6.7: Summary of Odour Release Scenarios

Stockpile Zone	Description	Odour Sources
1	Placement of malodorous fill materials on Zone 1	VHZ1AO, VHZ1BO
	Fugitive emissions from uncovered stockpiles on Zone 1	VFZ1AO, VFZ1BO
2	Placement of uncovered malodorous fill materials on Zone 2	VHZ2AO, VHZ2BO
	Fugitive emissions from uncovered stockpiles on Zone 2	VFZ2AO, VFZ2BO
3	Placement of uncovered malodorous fill materials on Zone 3	VHZ3AO, VHZ3BO
	Fugitive emissions from uncovered stockpiles on Zone 3	VFZ3AO, VFZ3BO
4	Placement of uncovered malodorous fill materials on Zone 4	VHZ4AO, VHZ4BO
	Fugitive emissions from uncovered stockpiles on Zone 4	VFZ4AO, VFZ4BO
5	Placement of uncovered malodorous fill materials on Zone 5	VHZ5AO, VHZ5BO
	Fugitive emissions from uncovered stockpiles on Zone 5	VFZ5AO, VFZ5BO

Modelling has been undertaken for daytime and night time receptor location scenarios. This has included two model runs using receptor locations for each of the daytime and night time conditions respectively. Daytime receptor locations have been assessed against emissions occurring during the hours of 6am to 7pm for the duration of the modelling.

The minimum dilutions, as assessed based on inclusion of peak to mean ratios, and reported at a 99.0% confidence level, have been calculated for each of the sub-areas. The reciprocal of these values is the maximum total odour emission (OU/s) that is permitted to occur from each area. Maximum total odour emissions are summarised in **Table 6.8** following as per odour emissions from the compacted soils, and odour emissions from soil handling and stockpiling activities within each zone. Spreadsheet calculations are provided as **Appendix G**.

Table 6.8: Summary of Minimum Odour Emission Dilutions

Site Area	Soil Handling (Minimum Odour Dilution Factor)	Fugitive / Area Emissions (Minimum Odour Dilution Factor)
Zone 1	17	2020
Zone 2	17	2010
Zone 3	9	1965
Zone 4	13	1986
Zone 5	13	2030

6.4 Rate of Odour Emission Calculated Based on Levels of Soil Impact

Full details of the characterisation of air emissions are provided in **Section 5**. The rate of vapour release for surface soils and soil handling activities in **Table 5.6** was adopted as a flux ($g/cm^2/s$) as based on a unit concentration of each constituent. Additionally the relative level of malodorous constituents within impacted soils, as summarised in **Table 5.5,** was adopted for the odour emission rate. The allowable level of total odour that can be discharged from each of the soil zones can be calculated by the odour emission dilution factors provided in **Table 6.8**. Only the lowest of the odour dilutions for the handling emissions has been used in the calculations.

Results are presented in **Table 6.9** for the maximum allowable levels of malodorous constituents to be stockpiled onsite uncovered based on soil modelling results. The criteria are based on calculations using both the handling and fugitive emissions soil modelling results.

Table 6.9: Summary of Maximum Allowable Levels of Malodorous Constituents

Constituent	Criteria (mg/kg)	Comments
Benzene	2.5	-
Ethylbenzene	5	-
Toluene	10	-
Xylene (total)	10	-
Cresols	_	Non volatile, no limits requiring covering from odour potential

Acenaphthene	35	-
Naphthalene	25	-
Phenol	40	-

It is noted that malodorous materials may potentially be present in soils placed across the site, and being handled as soils being received at the same time. Soil criteria for each scenario have been based on an acceptable level of odour of 2 OU/m^3 at the external receptor locations Where contaminants in soils are present at the acceptable levels in handled and emplaced soils, there is a potential that significant combined odour effects may occur. However, this is considered unlikely to cause the acceptable level of odour to be exceeded. Handling activities can only occur during daytime periods. By comparison of the worst case 99.0 percentile daytime and night time levels of odour dilution as predicted from diffuse sources, the worst case 99.0 percentile night time level is found to be four times higher than the day time level. Hence, a soil criterion based on the night time level of dilution of odours is considered not likely to pose significant levels of odour emission during daytime periods, and additive handling emissions during daytime periods would not be anticipated to be present at the adopted assessment criteria.

While the criteria provided in **Table 6.9** are inclusive of stockpiles placed in Zone 5 (i.e. closest to the adjacent Burren Street residences), in practice it is considered that placement of uncovered stockpiles in Zone 5 will not be acceptable. In particular if uncovered stockpiles are placed in Zone 5 for an extended period it will be difficult to control particulate emissions from this area impacting the adjacent residences during unfavourable wind conditions. Accordingly the controls for stockpiles external to the enclosure described in **Section 8** and **Appendix B** require any stockpiles placed in Zone 5 to be covered at all times.

7 Estimation of Air Quality Impacts

Based on the characterisation of potential emissions described in **Section 5**, the following sections detailed the methods used for dispersion modelling and the assessment of impacts on nearfield receptors.

DEC (2005) nominates three levels of modelling that can be used to assess air quality impacts. A level 1 assessment has been undertaken here. The level 1 assessment is characterised as being a preliminary assessment, using worst case meteorological data and conservative estimates of air emissions. Maximum levels only as reported by the modelling are compared to air quality criteria.

7.1 Modelling

AUSPLUME v.6 is the DEC (2005) approved dispersion model for use in most simple near-field applications in NSW, where coastal effects and complex terrain are of no concern. AUSPLUME is a Gaussian plume model, based on the assumption that cross-sections through elevated plumes from point sources of pollution have a Gaussian (or normal) distribution of concentration.

A number of limitations are noted for AUSPLUME in DEC (2005) which are not considered to apply for the modelling undertaken on the site. To limit the potential for these limitations to distort assessment of the proposed works, the AUSPLUME modelling was restricted to impacts over short distances only.

7.1.1 Meteorological Data

Modelling has been undertaken using two years of hourly meteorological data as collected at the OEH operated meteorological station located at Randwick, approximately 4km south-east of the site. The data has been supplemented with some records as collected at Sydney Airport meteorological station. The preparation and analysis of the meteorological data is detailed in **Appendix A**.

This Randwick meteorological station is the closest available meteorological station to the Macdonaldtown site. The meteorological data collected at this site is considered appropriately representative of meteorological conditions at the Macdonaldtown site, and considered appropriate for the level of modelling and air quality assessment completed here.

7.1.2 Terrain Data

The terrain of the Macdonaldtown Site and the surrounding area has been characterised by the preparation of a broad grid based terrain file on the basis of historical orthophoto maps and immediate surrounding area. Orthophoto maps are provided with 2m contour intervals. The modelling grid has been set over a sufficient area to comprise each of the individual receptor locations nominated in **Table 6.1**.

7.2 Identification of Near-Field Receptors

The site and surrounding area have been reviewed. An aerial photo showing the site is shown on **Figure 10** with each of the receptor locations relative to the site dimensions shown. The following receptors, summarised in **Table 7.1**, are identified in proximity of the site, as shown by corresponding numbers on **Figure 10**.

Table 7.1: Summary of Receptors

Receptor No.	Description	Distance from Site	Easting	Northing
1	1 Leamington St Erskineville	100m North	332244	6247859
2	Railway Offices, within Stabling Shed	20m North	332263	6247744
3	Railway Workshops, nearest to site	60m East	332269	6247645
4	95 Railway Pde Erskineville	100m South	332342	6247537
5	15 Burren St Erskineville	10m West	332265	6247624
6	31 Burren St Erskineville	10m West	332252	6247669

Modelling has been undertaken to determine potential impacts in to outdoor air at each of the receptors.

7.3 Air Impact Assessment Methodology

The air quality impact assessment has been undertaken by the following process:

- Air quality controls have been nominated in **Section 4** for each activity which is found to have potentially unacceptable air emissions;
- Particulate and/or odour emission rates for each activity which will potentially cause air emissions under controlled conditions has been individually modelled for each receptor to determine maximum 1 second, 1 hour, 24 hour and annual concentrations as appropriate for each of the constituents. Emission rates adopted for each activity that may generate air emissions were identified in **Table 5.6** and are listed in **Tables 7.2** to **7.6** as per the parameters that have been used to characterise the activity in AUSPLUME; and
- Levels of particulates / odours / chemical constituents as emitted for each activity and predicted at each of the identified discrete receptors under the controlled conditions have been directly compared to the applicable air quality criteria (**Table 5.1**) are summarised in **Table 7.9**. This includes consideration of the background level of the constituent;
- The calculations, for total particulate levels, have also been used with chemical specific emission factors in **Section 10** to complete the health impact assessment for the works.

7.4 Modelling of Each Release Scenario

Each of the sources of air emissions modelled and modelling parameters has been summarised in **Tables 6.2** to **6.8** with results calculated for each of the discrete receptors as listed in **Table 6.1,** in close proximity of the site. Co-ordinates are provided in MGA56 and heights in m AHD as interpreted from orthophoto maps. All modelling results are summarised in **Appendix D**.

It is noted that each of the modelling scenarios has assumed that air quality controls are enforced on the site. Derivation of the appropriate air quality controls required assessment of air emissions during uncontrolled, or worst case conditions. The particulate and/or odour emission rates and modelling results for all worst case conditions are summarised in **Appendix E**.

Table 7.2: Summary of Modelling Parameters – Surface Soils Excavation

Source ID / Type	Pollutant	AUSPLUME ID	Type	X Length	Y Length	Angle	X Co-Ord	Y Co-Ord	Elevation	Time of Occurrence	Emission Rate ($g/m^2/s$)
Surface soils, excavation and stockpiling	TSP	VEX1T	Area	20m	20m	45	332314	6247685	16.5	7am – 5pm (10 hours)	$3.30*10^{-4} * U^{1.3}$
	PM_{10}	VEX1P	Area	20m	20m	45	332314	6247685	16.5	7am – 5pm (10 hours)	$1.56*10^{-4} * U^{1.3}$
	Benzene (max)	VEX1BE	Area	20m	20m	45	332314	6247685	16.5	7am – 5pm (10 hours)	Particulates $1.38*10^{-10} * U^{1.3}$
	B(a)P (max)	VEX1BP	Area	20m	20m	45	332314	6247685	16.5	7am – 5pm (10 hours)	Particulates $1.12*10^{-7} * U^{1.3}$
Surface soils, fugitive emissions from stockpiles	TSP	F1T	Area	10m	10m	0	332314	6247685	16.5	Continuous	$7.02*10^{-7}$
	PM_{10}	F1P	Area	10m	10m	0	332314	6247685	16.5	Continuous	$3.46*10^{-7}$
	Benzene (max)	F1BEP F1BEV	Area	10m	10m	0	332314	6247685	16.5	Continuous	Particulates $2.86 * 10^{-12}$ Vapours $7.02 * 10^{-12}$
	B(a)P (max)	F1BPP	Area	10m	10m	0	332314	6247685	16.5	Continuous	Particulates $1.83*10^{-10}$

Table 7.3: Summary of Modelling Parameters – Fill Materials Behind Retaining Wall Excavation

Source ID / Type	Pollutant	AUSPLUME ID	Type	X Length	Y Length	Angle	X Co-Ord	Y Co-Ord	Elevation	Time of Occurrence	Emission Rate ($g/m^2/s$ or $OU/m^2/s$)
Fill materials behind retaining wall, excavation and stockpiling	TSP	VEX2T	Area	5	5	80	332271	6247720	18	7am – 5pm (10 hours)	$3.17*10^{-4} * U^{1.3}$
	PM_{10}	VEX2P	Area	5	5	80	332271	6247720	18	7am – 5pm (10 hours)	$1.50*10^{-4} * U^{1.3}$
	Benzene (max)	VEX2BE	Area	5	5	80	332271	6247720	18	7am – 5pm (10 hours)	Particulates $4.75*10^{-9} * U^{1.3}$
	B(a)P (max)	VEX2BP	Area	5	5	80	332271	6247720	18	7am – 5pm (10 hours)	Particulates $4.75*10^{-8} * U^{1.3}$
	Odour	VEX2OU	Area	5	5	80	332271	6247720	18	Continuous	7.3
Fill materials behind retaining wall, fugitive emissions from stockpiles	TSP	F2T	Area	10	10	0	332283	6247718	17.5	Continuous	$7.02*10^{-7}$
	PM_{10}	F2P	Area	10	10	0	332283	6247718	17.5	Continuous	$3.46*10^{-7}$
	Benzene (max)	F2BEP F2BEV	Area	10	10	0	332283	6247718	17.5	Continuous	Particulates $1.07*10^{-11}$ Vapours $2.52*10^{-11}$
	B(a)P (max)	F2BPP	Area	10	10	0	332283	6247718	17.5	Continuous	Particulates $1.07*10^{-10}$
	Odour	F2OU	Area	10	10	0	332283	6247718	17.5	Continuous	7.3

Table 7.4: Summary of Modelling Parameters – Northern Gasholder Excavation

Source ID / Type	Pollutant	AUSPLUME ID	Type	X Length	Y Length	Angle	X Co-Ord	Y Co-Ord	Elevation	Time of Occurrence	Emission Rate (g/m2/s or OU/m2/s)
Northern Gasholder, excavation and stockpiling	TSP	VEX3T	Area	20	20	0	332276	6247697	17.5	7am – 5pm (10 hours)	$2.54*10^{-6} * U^{1.3}$
	PM_{10}	VEX3P	Area	20	20	0	332276	6247697	17.5	7am – 5pm (10 hours)	$1.20*10^{-6} * U^{1.3}$
	Benzene (max)	VEX3BE	Area	20	20	0	332276	6247697	17.5	7am – 5pm (10 hours)	Particulates $3.81*10^{-11} * U^{1.3}$
	B(a)P (max)	VEX3BP	Area	20	20	0	332276	6247697	17.5	7am – 5pm (10 hours)	Particulates $3.81*10^{-10} * U^{1.3}$
	Odour	VEX3OU	Area	20	20	0	332276	6247697	17.5	Continuous	0.073
Northern gasholder, fugitive emissions from stockpiles	TSP	F3T	Area	10	10	0	332296	6247702	17.5	Continuous	$2.7*10^{-8}$
	PM_{10}	F3P	Area	10	10	0	332296	6247702	17.5	Continuous	$1.4*10^{-8}$
	Benzene (max)	F3BEP F3BEV	Area	10	10	0	332296	6247702	17.5	Continuous	Particulates $4.1*10^{-13}$ Vapours $9.7*10^{-13}$
	B(a)P (max)	F3BPP	Area	10	10	0	332296	6247702	17.5	Continuous	Particulates $4.1*10^{-12}$
	Odour	F3OU	Area	10	10	0	332296	6247702	17.5	Continuous	0.073

Table 7.5: Summary of Modelling Parameters – Former Gasworks Area Excavation

Source ID / Type	Pollutant	AUSPLUME ID	Type	X Length	Y Length	Angle	X Co-Ord	Y Co-Ord	Elevation	Time of Occurrence	Emission Rate ($g/m^2/s$ or $OU/m^2/s$)
Former gasworks area, excavation and stockpiling	TSP	VEX4T	Area	15	15	0	332296	6247695	17.5	7am – 5pm (10 hours)	$9.02*10^{-6} * U^{1.3}$
	PM_{10}	VEX4P	Area	15	15	0	332296	6247695	17.5	7am – 5pm (10 hours)	$4.27*10^{-6} * U^{1.3}$
	Benzene (max)	VEX4BE	Area	15	15	0	332296	6247695	17.5	7am – 5pm (10 hours)	Particulates $1.8*10^{-10} * U^{1.3}$
	B(a)P (max)	VEX4BP	Area	15	15	0	332296	6247695	17.5	7am – 5pm (10 hours)	Particulates $4.01*10^{-9} * U^{1.3}$
	Odour	VEX4OU	Area	15	15	0	332296	6247695	17.5	Continuous	0.073
Former gasworks area, fugitive emissions from stockpiles	TSP	F4T	Area	10	10	0	332296	6247695	17.5	Continuous	$2.7*10^{-8}$
	PM_{10}	F4P	Area	10	10	0	332296	6247695	17.5	Continuous	$1.4*10^{-8}$
	Benzene (max)	F4BEP F4BEV	Area	10	10	0	332296	6247695	17.5	Continuous	Particulates $5.4*10^{-13}$ Vapours $1.3*10^{-11}$
	B(a)P (max)	F4BPP	Area	10	10	0	332296	6247695	17.5	Continuous	Particulates $1.2*10^{-11}$
	Odour	F4OU	Area	10	10	0	332296	6247695	17.5	Continuous	0.073

Table 7.6: Summary of Modelling Parameters – Haulage Roads Within Site

Source ID / Type	Pollutant	AUSPLUME ID	Type	X Length	Y Length	Angle	X Co-Ord	Y Co-Ord	Elevation	Time of Occurrence	Emission Rate ($g/m^2/s$)
Haulage roads	TSP	HAT	Area	5	60	0	332312	6247672	16	7am – 5pm (10 hours)	$2.86*10^{-5}$
	PM_{10}	HAP	Area	5	60	0	332312	6247672	16	7am – 5pm (10 hours)	$1.79*10^{-5}$

Table 7.7: Summary of Modelling Parameters – Soil Treatment / Remediation Activities

Source ID / Type	Pollutant	AUSPLUME ID	Type	X Length	Y Length	Angle	X Co-Ord	Y Co-Ord	Elevation	Time of Occurrence	Emission Rate ($g/m^2/s$ or $OU/m^2/s$)
Bioremediation of soils[1]	TSP	T2T	Area	65	15	60	332338	6247714	17	Continuous	$3.15*10^{-8}$
	PM_{10}	T2PM	Area	65	15	60	332338	6247714	17	Continuous	$1.4*10^{-8}$
	Benzene (max)	T2BEP T2BEV	Area	65	15	60	332338	6247714	17	Continuous	Particulates $5.4*10^{-13}$ Vapours $1.3*10^{-12}$
	B(a)P (max)	T2BPP	Area	65	15	60	332338	6247714	17	Continuous	Particulates $1.2*10^{-13}$
	Odour	T2OU	Area	65	15	60	332338	6247714	17	Continuous	0.073

Note: 1. Also accounts for potential emissions from stockpiled soils associated with the stabilisation / immobilisation works

Table 7.8: Summary of Modelling Parameters – Groundwater Emissions and Water Treatment

Source ID / Type	Pollutant	AUSPLUME ID	Type	X Length	Y Length	Angle	X Co-Ord	Y Co-Ord	Elevation	Time of Occurrence	Emission Rate (g/s, g/m^2/s, OU/s or OU/m^2/s)
Groundwater treatment	Benzene (max)	WTBE	Point	-	-	-	332298	6247702	17.5	Continuous during working hours	$9.7*10^{-5}$
	B(a)P (max)	WTBP	Point	-	-	-	332298	6247702	17.5	Continuous during working hours	$8.0*10^{-7}$
	Odour	WTOU	Point	-	-	-	332298	6247702	17.5	Continuous during working hours	0.3
Pooled water evaporation	Benzene (max)	PWBE	Area	20	20	0	332293	6247716	15	Continuous	$7.8*10^{-7} * U^{0.8}/T^{1.47}$
	B(a)P (max)	PWBP	Area	20	20	0	332293	6247716	15	Continuous	$1.6*10^{-7} * U^{0.8}/T^{1.47}$
	Odour	PWOU	Area	20	20	0	332293	6247716	15	Continuous	0.3

Table 7.9: Summary of Modelled Air Pollutant Levels Under Controlled Site Conditions (µg/m^3 or OU)

Scenario	Pollutant	Averaging Time	Criteria	Receptor ID					
				1	2	3	4	5	6
Surface soils remediation	TSP	Annual	90	3.02E+00	9.11E+00	1.31E+01	1.19E+00	1.14E+01	1.15E+01
	PM_{10}	24 hour	50	1.40E+01	3.70E+01	2.92E+01	5.91E+00	2.00E+01	2.46E+01
	PM_{10}	Annual	30	1.42E+00	4.28E+00	6.17E+00	5.59E-01	5.37E+00	5.44E+00
	Benzene	1 hour	29	3.16E-03	1.16E-02	1.16E-02	3.18E-03	9.67E-03	1.16E-02
	Benzo(a)pyrene	1 hour	0.4	2.30E-02	8.41E-02	8.45E-02	2.31E-02	6.92E-02	8.43E-02
Fill materials behind northern retaining wall remediation	TSP	Annual	90	3.80E+00	3.87E+01	2.09E+01	8.29E-01	8.68E+00	4.23E+01
	PM_{10}	24 hour	50	1.81E+00	3.31E+01	2.63E+00	4.48E-01	1.69E+00	4.51E+00
	PM_{10}	Annual	30	1.86E+00	1.89E+01	1.02E+01	4.17E-01	4.28E+00	2.07E+01
	Benzene	1 hour	29	1.26E-02	1.24E-02	8.09E-03	8.41E-04	4.70E-03	9.26E-03
	Benzo(a)pyrene	1 hour	0.4	1.25E-01	1.19E-01	7.44E-02	6.96E-03	4.11E-02	8.89E-02
	Odour	1 second	2 OU	1.92E-01	1.06E+00	3.85E-01	1.29E-01	3.01E-01	6.32E-01
Northern gasholder remediation	TSP	Annual	90	5.30E-02	4.69E-01	1.61E-01	9.15E-03	8.22E-02	3.37E-01
	PM_{10}	24 hour	50	2.59E-02	5.99E-03	3.41E-03	6.53E-04	3.15E-03	5.82E-03
	PM_{10}	Annual	30	1.73E-01	1.92E+00	3.02E-01	4.56E-02	1.79E-01	6.19E-03
	Benzene	1 hour	29	1.75E-05	1.54E-04	6.55E-05	8.44E-06	3.87E-05	1.03E-04
	Benzo(a)pyrene	1 hour	0.4	1.71E-04	1.52E-03	6.40E-04	8.05E-05	3.76E-04	1.01E-03
	Odour	1 second	2 OU	3.30E-02	1.79E-01	1.11E-01	2.93E-02	8.28E-02	1.45E-01
Former gasworks area remediation	TSP	Annual	90	9.44E-02	4.74E-01	3.51E-01	1.89E-02	2.14E-01	4.90E-01
	PM_{10}	24 hour	50	3.84E-01	1.78E+00	6.40E-01	1.08E-01	4.12E-01	1.06E+00
	PM_{10}	Annual	30	4.51E-02	2.26E-02	1.68E-01	9.04E-03	1.02E-01	2.34E-01
	Benzene	1 hour	29	3.25E-04	1.69E-03	1.28E-03	3.10E-04	9.56E-04	2.10E-04
	Benzo(a)pyrene	1 hour	0.4	9.38E-04	5.49E-03	3.40E-03	5.32E-04	2.48E-03	4.35E-03
	Odour	1 second	2 OU	1.00E-01	4.90E-01	3.70E-01	9.93E-02	2.82E-01	4.69E-01
Haulage roads	TSP	Annual	90	3.59E-01	1.26E+00	2.22E+00	6.02E-01	2.15E+00	1.93E+00
	PM_{10}	24 hour	50	1.72E+00	6.83E+00	9.83E+00	2.43E+00	6.79E+00	7.99E+00
	PM_{10}	Annual	30	2.25E-01	7.91E-01	1.39E+00	3.77E-01	1.35E+00	1.21E+00
Soil treatment	TSP	Annual	90	7.70E-04	1.60E-03	2.74E-03	3.16E-03	3.00E-03	2.12E-03
	PM_{10}	24 hour	50	3.08E-03	7.31E-03	9.55E-03	9.14E-03	1.21E-02	8.32E-03

Scenario	Pollutant	Averaging Time	Criteria	Receptor ID					
				1	2	3	4	5	6
(bioremediation)	PM_{10}	Annual	30	3.99E-04	8.29E-04	1.42E-03	1.64E-03	1.56E-03	1.15E-03
	Benzene	1 hour	29	5.58E-06	1.26E-05	3.21E-06	7.86E-06	8.47E-06	9.20E-06
	Benzo(a)pyrene	1 hour	0.4	3.64E-05	8.02E-05	5.75E-05	5.12E-05	5.52E-05	6.00E-05
	Odour	1 second	2 OU	2.21E-01	4.94E-01	3.50E-01	3.12E-01	3.36E-01	3.65E-01
Groundwater pooling and treatment	Benzene	1 hour	29	4.50E-01	3.74E+00	1.76E+00	2.60E-01	1.08E+00	2.67E+00
	Benzo(a)pyrene	1 hour	0.4	7.21E-03	6.42E-02	2.71E-02	3.40E-03	1.59E-02	4.26E-02
	Odour	1 second	2 OU	9.98E-04	1.71E-03	1.56E-03	3.47E-04	5.36E-04	1.02E-03

BOLD denotes exceedance of criteria at receptor location

7.5 Source / Activity Specific Modelling Results

Modelling results are summarised in **Table 7.9**, with further detailed results of each AUSPLUME modelled source provided in **Appendix D**. Results are provided for each source of air emissions for 1 second, 1 hour, 24 hour and 90 day averaging times (used for comparison to annual based criteria) as appropriate to the corresponding assessment criterion. The maximum of all results calculated at each receptor location is summarised in **Table 7.9**. Assessment criteria were not exceeded for each proposed activity under the controlled conditions.

The proposed program of air quality controls appears adequate to protect against adverse air quality impacts occurring as a results of the remediation works, and noting the following conservativism built into the modelled scenarios:

- The maximum levels, as modelled using the 2 years of meteorological data have only been reported, and consequently account for worst case weather and atmospheric conditions;
- With respect to the results of modelling of particulate levels, assessed as TSP and PM_{10} concentrations and generally based on annual levels, it noted that many of the sources assessed are short term in nature with durations substantially less than a year. For the purposes of the screening exercise conducted with this modelling it was assumed that each of these sources will be continuous throughout the modelling period, with the maximum 90 day (three month) concentration reported and compared to the 'annual' criteria. This approach was applied to ensure a conservative approach to the assessment.
- No correction factor has been applied to account for no work occurring on Sundays for the duration of the project; and
- Use of maximum concentrations of constituents in assessing contaminant emission rates.

Particulate (TSP and PM_{10}) criteria are provided as annual averages. To provide a conservative assessment, the maximum three monthly concentration has been predicted using the model for comparison to the annual criteria. No correction factor has been applied to the three monthly concentration even though works on site will only occur 6 days a week, rather than the modelled seven days. The results for TSP and PM_{10} concentrations based on the combined emissions sources indicates that application of the nominated controls will be effective in preventing emissions above the adopted criteria. Dust deposition levels at all receptor locations were also within the assessment criteria, noting that, to maintain a conservative approach, the 1 hour averaging time result has been compared to the one month averaging time assessment criteria. These results confirm the proposed program of air quality controls should be sufficient to prevent unacceptable dust emissions.

Similarly results of benzene and benzo(a)pyrene concentrations at each receptor location are within the adopted criteria and indicate that the nominated controls will be effective in preventing unacceptable emissions. Given these significant levels of conservatism in the modelling and the inclusion of VOC monitoring in air within the AQMP, it is considered that the proposed controls will be sufficient to prevent unacceptable toxin emissions. Further consideration of the impact of air toxin emissions on the exposed populations is provided in the health risk assessment (**Section 10**).

7.6 Assessment of Control Performance

In order to confirm the performance of the proposed air quality controls assessment of the combination of sources that may occur during the works on the site has been conducted.

Table 7.10 summarises the combined predicted emissions at each receptor for each stage of the remediation works (summarised in **Table 3.1**).

Additionally a dust deposition value has been calculated at each receptor based on the combined activities. Results of the anticipated emissions at receptor locations based on these combined sources are provided in **Table 7.10**. Modelling outputs are included in **Appendix D**.

The maximum of all results calculated at each receptor location is summarised in **Table 7.10**. This has included consideration of maximum concentrations of chemical constituents as may occur on the site, as appropriate for comparison to 1 hour modelling criteria.

7.6.1 Particulates

For particulate (TSP and PM_{10}) criteria, it s noted that at Receptors 1, 2, 3, 5and 6 the PM10 concentration (annual averaging period) and background value exceeds the adopted assessment criteria of 30. The air quality controls are considered to be adequately protective of users at Receptors 1, 2, 3, 5and 6 noting that:

- the modelled maximum three monthly average has been compared to the assessment criteria for the annual average;
- The combined total includes the background value; and
- As discussed in **Section 7.5** no correction factor has been applied to the three monthly concentration even though works on site will only occur 6 days a week, rather than the modelled seven days.

Noting also that comparison of the PM10 value for a 24 hour averaging period at Receptors 1, 2, 3, 5and 6 are less than the corresponding criterion, it is considered that the results for TSP and PM_{10} concentrations based on the combined emissions sources indicates that application of the nominated controls will be effective in preventing emissions above the adopted criteria.

7.6.2 Dust

Dust deposition levels at all receptor locations were also within the assessment criteria, noting that, to maintain a conservative approach, the 1 hour averaging time result has been compared to the one month averaging time assessment criteria. These results confirm the proposed program of air quality controls should be sufficient to prevent unacceptable dust emissions.

7.6.3 Benzo(a)pyrene

With the exception of benzo(a)pyrene concentrations at receptors 2 and 6, it is noted that the combined results of benzene and benzo(a)pyrene concentrations at each receptor location are within the adopted criteria and indicate that the nominated controls will be effective in preventing unacceptable emissions. With respect to the benzo(a)pyrene exceedances at Receptors 2 and 6 the impact of the air toxin emissions on the exposed populations is provided in the health risk assessment (**Section 10**). Given these significant levels of conservatism in the modelling and the inclusion of VOC monitoring in

air within the AQMP, it is considered that the proposed controls will be sufficient to prevent unacceptable toxin emissions.

7.6.4 Odour

Calculated odour emissions at all receptor locations are within the assessment criteria. Given the conservatism built into the modelled scenario, it is considered that the proposed controls are sufficient to prevent unacceptable odour emissions. The program of odour controls proposed are considered to be best practice, and while they may not be capable of completely eliminating offensive odours, they will be sufficient to reduce the duration of odour releases and provide a framework for monitoring and refining the odour management during remediation.

Table 7.10: Summary of Combined Emissions Under Controlled Site Conditions (µg/m^3 or OU)

Pollutant	Concentration at Receptor (µg/m^3 unless otherwise specified)						Criteria
	1	2	3	4	5	6	
Remediation Stage 1							
TSP -surface soils	3.02	9.11	13.12	1.19	11.42	11.51	
TSP - northern retaining wall	1.39	20.23	2.79	0.21	1.37	7.30	
TSP - Haulage Roads	0.359	1.26	2.22	0.602	2.15	1.93	**90**
Background Value	30	30	30	30	30	30	
Sum of Combined Emissions	**34.77**	**60.60**	**48.12**	**31.99**	**44.94**	**50.74**	
PM10 (Annual) -surface soils	14.01	37.05	29.17	5.91	19.96	24.56	
PM10 (Annual) - northern retaining wall	1.81	33.14	2.63	0.45	1.69	4.51	
PM10 (Annual) Haulage Roads	1.72	6.83	9.83	2.436	6.79	7.99	**30**
Background Value	14	14	14	14	14	14	
Sum of Combined Emissions	**31.53**	**91.02**	**55.63**	**22.79**	**42.43**	**51.05**	
PM10 (24 hr) -surface soils	1.42	4.28	6.17	0.56	5.37	5.44	
PM10 (24 hr) - northern retaining wall	0.26	4.29	0.50	0.05	0.28	1.10	
PM10 (24 hr) - Haulage Roads	0.225	0.791	1.39	0.377	1.35	1.21	**50**
Background Value	16	16	16	16	16	16	
Sum of Combined Emissions	**17.91**	**25.37**	**24.06**	**16.99**	**23.00**	**23.74**	
Benzene -surface soils	3.16E-03	0.01	0.01	3.18E-03	0.01	0.01	
Benzene - northern retaining wall	1.26E-02	0.01	0.01	8.41E-04	0.00	0.01	**29**
Sum of Combined Emissions	**0.02**	**0.02**	**0.02**	**4.02E-03**	**0.01**	**0.02**	
Benzo(a)pyrene -surface soils	0.02	0.08	0.08	0.02	0.07	0.08	
Benzo(a)pyrene - northern retaining wall	0.01	0.07	0.02	0.00	0.01	0.03	**0.4**
Sum of Combined Emissions	**0.03**	**0.15**	**0.10**	**0.03**	**0.08**	**0.11**	
Odour - northern retaining wall (reported in OU)	**0.19**	**1.06**	**0.39**	**0.13**	**0.30**	**0.63**	**2**
Dust Deposition (g/m2/month)	**0.31**	**1.31**	**1.13**	**0.35**	**1.05**	**1.09**	**2**
Remediation Stage 2							
TSP -northern gasholder	5.30E-02	4.69E-01	1.61E-01	9.15E-03	8.22E-02	3.37E-01	
TSP - former gasholder	9.44E-02	4.74E-01	3.51E-01	1.89E-02	2.14E-01	4.90E-01	
TSP - haulage roads	3.59E-01	1.26	2.22	6.02E-01	2.15	1.93	**90**
Background Value	30	30	30	30	30	30	
Sum of Combined Emissions	**30.51**	**32.20**	**32.73**	**30.63**	**32.45**	**32.76**	
PM10 (Annual) -northern gasholder	2.59E-02	5.99E-03	3.41E-03	6.53E-04	3.15E-03	5.82E-03	
PM10 (Annual) - former gasholder	3.84E-01	1.78	6.40E-01	1.08E-01	4.12E-01	1.06	
PM10 (Annual) - haulage roads	1.72	6.83	9.83	2.43	6.79	7.99	**30**
Background Value	14	14	14	14	14	14	
Sum of Combined Emissions	**16.13**	**22.62**	**24.47**	**16.54**	**21.21**	**23.06**	
PM10 (24 hr) -northern gasholder	1.73E-01	1.92	3.02E-01	4.56E-02	1.79E-01	6.19E-03	
PM10 (24 hr) - former gasholder	4.51E-02	2.26E-02	1.68E-01	9.04E-03	1.02E-01	2.34E-01	
PM10 (24 hr) - haulage roads	1.72	6.83	9.83	2.43	6.79	7.99	**50**
Background Value	16	16	16	16	16	16	
Sum of Combined Emissions	**17.94**	**24.77**	**26.30**	**18.48**	**23.07**	**24.23**	

Pollutant	Concentration at Receptor (µg/m^3 unless otherwise specified)						Criteria
	1	2	3	4	5	6	
Benzene -northern gasholder	1.26E-02	1.24E-02	8.09E-03	8.41E-04	4.70E-03	9.26E-03	29
Benzene - former gasholder	2.25E-01	7.91E-01	1.39	3.77E-01	1.35	1.21	
Benzene - groundwater and water treatment	4.50E-01	3.74	1.76	2.60E-01	1.08	2.67	
Sum of Combined Emissions	**0.69**	**4.54**	**3.15**	**0.64**	**2.44**	**3.89**	
Benzo(a)pyrene -northern gasholder	1.71E-04	1.52E-03	6.40E-04	8.05E-05	3.76E-04	1.01E-03	0.4
Benzo(a)pyrene - former gasholder	9.38E-04	5.49E-03	3.40E-03	5.32E-04	2.48E-03	4.35E-03	
Benzo(a)pyrene - groundwater and water treatment	7.21E-02	6.42E-01	2.71E-01	3.40E-02	1.59E-01	4.26E-01	
Sum of Combined Emissions	**0.07**	**0.65**	**0.28**	**0.03**	**0.16**	**0.43**	
Odour -northern gasholder	3.30E-02	1.79E-01	1.11E-01	2.93E-02	8.28E-02	1.45E-01	2
Odour - former gasholder	1.00E-01	4.90E-01	3.70E-01	9.93E-02	2.82E-01	4.69E-01	
Odour - groundwater and water treatment	9.98E-04	1.71E-03	1.56E-03	3.47E-04	5.36E-04	1.02E-03	
Sum of Combined Emissions (reported in OU)	**0.13**	**0.67**	**0.48**	**0.13**	**0.37**	**0.62**	
Dust Deposition (g/m2/month)	**0.31**	**1.23**	**1.1**	**0.34**	**1.03**	**1.02**	**2**
Stage 3 Remediation Works							
TSP - bioremediation	7.70E-04	1.60E-03	2.74E-03	3.16E-03	3.00E-03	2.12E-03	90
TSP - haulage roads	3.59E-01	1.26	2.22	6.02E-01	2.15	1.93	
Background Value	30	30	30	30	30	30	
Sum of Combined Emissions	**30.36**	**31.26**	**32.22**	**30.61**	**32.15**	**31.93**	
PM10 (Annual) - bioremediation	3.08E-03	7.31E-03	9.55E-03	9.14E-03	1.21E-02	8.32E-03	30
PM10 (Annual) - haulage roads	1.72	6.83	9.83	2.43	6.79	7.99	
Background Value	14	14	14	14	14	14	
Sum of Combined Emissions	**15.72**	**20.84**	**23.84**	**16.44**	**20.80**	**22.00**	
PM10 (24 hr) - bioremediation	3.99E-04	8.29E-04	1.42E-03	1.64E-03	1.56E-03	1.15E-03	50
PM10 (24 hr) - haulage roads	2.25E-01	7.91E-01	1.39	3.77E-01	1.35	1.21	
Background Value	16	16	16	16	16	16	
Sum of Combined Emissions	**16.23**	**16.79**	**17.39**	**16.38**	**17.35**	**17.21**	
Benzene - bioremediation	5.58E-06	1.26E-05	3.21E-06	7.86E-06	8.47E-06	9.20E-06	29
Benzene - groundwater and water treatment	4.50E-01	3.74	1.76	2.60E-01	1.08	2.67	
Sum of Combined Emissions	**0.45**	**3.74**	**1.76**	**0.26**	**1.08**	**2.67**	
Benzo(a)pyrene - bioremediation	3.64E-05	8.02E-05	5.75E-05	5.12E-05	5.52E-05	6.00E-05	0.4
Benzo(a)pyrene - groundwater and water treatment	7.21E-02	6.42E-01	2.71E-01	3.40E-02	1.59E-01	4.26E-01	
Sum of Combined Emissions	**7.21E-02**	**0.64**	**0.27**	**3.41E-02**	**0.16**	**0.43**	
Odour - bioremediation	2.21E-01	4.94E-01	3.50E-01	3.12E-01	3.36E-01	3.65E-01	2
Odour - groundwater and water treatment	9.98E-04	1.71E-03	1.56E-03	3.47E-04	5.36E-04	1.02E-03	
Sum of Combined Emissions (reported in OU)	**0.22**	**0.5**	**0.35**	**0.31**	**0.37**	**0.37**	
Dust Deposition (g/m2/month)	**0.31**	**1.23**	**1.1**	**0.34**	**1.03**	**1.02**	**2**

8 Air Emission Controls

The prediction of air quality impacts in **Section 7** has assumed that the air quality controls as listed in **Table 3.1** are to be employed on the site. Each of the air quality controls and the associated monitoring requirements are described in more detail following.

Table 8.1 Summary of Required Air Quality Controls

Site Area / Activity	Proposed Air Quality Control
Surface soil Excavations	Reduction of exposed *in-situ* materials to 400m^2 Dust suppression by hourly watering of all surfaces
Retaining Wall fill materials	Reduction of exposed *in-situ* materials to 25m^2 Dust suppression by hourly watering of all surfaces
Former gasworks area	Enclosure of excavations works, minimum required extent of enclosure shown on **Figure 6** Treatment of enclosure emissions prior to discharge.
Soil treatment - bioremediation	Enclosure of treatment works Treatment of enclosure emissions prior to discharge
Haulage Road use	Dust suppression by hourly watering of all surfaces
Groundwater	Relocation of water treatment plant to central section of the site as far removed from the Burren Street site frontage as possible, recommended location shown on **Figure 6** Enclosure of any areas used for splash filling of water treatment plant Ventilation from water treatment plant to be filtered Prevention of groundwater accumulating within excavations on the site. This may be achieved by pumping water out of the excavations as it infiltrates or if possible by pumping groundwater from adjacent wells

The descriptions in the following sections are anticipated to inform the preparation of the Air Quality Management Plan (**Appendix B**).

8.1 Particulate Emission Controls

Water will need to be regularly applied to disturbed areas within the remediation site. It is recommended that disturbed surfaces are watered by water cart at hourly intervals throughout the remediation works, and shall include:

- Areas of excavation;
- Areas of stockpiling;
- Areas of exposed soils where fugitive dusts may occur; and
- Haulage roads.

Where fugitive emissions are found to be significant, site operations should be reviewed as per the AQMP to consider whether changes to staging, covering or frequency of watering may results in reductions. Consideration may also be given to a sprinkler system installed around active excavation / soil handling areas to ensure that rates of water application to exposed surfaces are able to be maintained.

Additionally to prevent elevated levels of dusts impacting adjoining receptors during periods of non-favourable meteorological conditions (i.e. strong winds), it is recommended that excavation works external to the enclosure be ceased, or reduced, during periods of non-favourable meteorological conditions as identified during the site monitoring works.

Notwithstanding these recommendations, any works involving the excavation or handling of potential asbestos contaminated soils shall be undertaken subject to constant water application.

8.2 Controls for Reduction in Duration of Odour

The exposure of coal tar impacted materials has the potential to generate significant odour impacts. These odour impacts are unavoidable and are necessary in the disturbance of the contaminated soils and groundwater to effect the required excavation works. Being a tar based material, the odours are not unique and members of the public would be reasonably anticipated to be familiar with the odour characteristics. The following measures will require to be employed to minimise the potential impact of these materials:

- Enclosure of excavation works in areas of significant coal tar impact where the excavations works can be practically implemented. This is considered to at least include the northern gasholder and the tar wells located to the north of the gasholder. The minimum required extent of the enclosure is shown on **Figure 6**.
- Enclosure of works is not required in other areas of the site where lower levels of widespread coal tar impact are present. While these areas would be considered to have a reduced odour generation potential, excavation areas are required to be managed excavation such that:
  - No more than 400m^2 of *in-situ* materials are exposed in surface soil excavations;
  - No more than 25m^2 of *in-situ* materials are exposed in retaining wall fill excavations; and
  - Stockpiled materials to be left uncovered outside the enclosure for an extended period must be demonstrated to be compliant with the odour based criteria (**Section 4**).

  The remaining exposed surfaces in an excavation require control to prevent odour emissions. This may be undertaken by:

  - Covering of exposed malodourous soils by non-malodourous materials, secured plastic sheeting or low permeability geofabric;
  - Use of odour suppressants, or similar binding material (i.e. hydromulch) to 'seal' potentially malodourous surfaces;
  - Management of excavation staging and dimensions; and/or
  - Covering of all tipper loads.

  It is considered that these controls may also be required for validation purposes (i.e. to prevent cross contamination of remediated areas.)
- Install and operate an odour suppression system along the entire works boundary throughout the duration of the works. Odour suppression systems, consisting of the release of odour masking agents, have been found to be highly effective on other projects where substantial malodorous impacts have occurred;
- For works required outside of the enclosure, minimise the quantities of exposed coal tar impacted materials at all times. This can be achieved by the placement of excavations in stages with progressive backfilling, the covering of stockpiles and covering of inactive excavation areas;

- For works required outside of the enclosure, consistent application of an odour suppression agent to exposed surfaces within areas of excavation. This shall be undertaken by mixing of water used to control dust emissions with the odour suppression agent. The odour suppression agents have the effect of binding potentially malodorous emissions to soil particles; and
- For works required outside of the enclosure, dewatering of excavations to maintain water levels below excavation bases. The principal source of coal tar is anticipated to be impacted groundwater present within excavations. Where water levels can be maintained below the base of excavations, the surface soils will be found to rapidly volatilise the malodorous constituents of the coal tar impact, and then cause a reduced odour impact; and
- Any areas of splash filling associated with the water treatment plant require to be enclosed to control emissions. Emissions within the enclosed area require to be filtered through GAC filters.

The application of these controls will have the impact of preventing all odour emissions outside of working hours and restricting the duration of odour emissions that occur during working hours. It is considered unlikely that odour emissions from the works will be able to be eliminated. Odour emissions during the short term periods of vehicle movements into and out of the enclosure are unavoidable, as air releases during entry and exit cannot be completely eliminated. However the duration of these emissions will be minimal.

8.3 Enclosure of Odour Generating Works

The enclosure shall be constructed and operated in such a way that it is maintained under negative pressure. Exhaust fans should be provided to the enclosure so as to control air emissions to controlled points. By the use of exhaust fans at controlled points, air movement (and associated odour movement) at other openings such as the vehicle entry / exit point can be directed into the clad structure. Air emissions from the enclosure would require treatment through bag filters to remove particulates and granular activated carbon (GAC) filters to remove potential malodorous emissions. The GAC filters are effective at the removal of organic malodorous components of air flows.

8.4 Soil Treatment on Site

Where coal tar impacted soils are to be treated on site, treatment and associated soil stockpiling and handling activities shall occur within an enclosure. The enclosure shall be constructed and operated as described in **Section 8.3**. The enclosure shall be sufficiently sized to allow all associated stockpiling of malodorous soils. Stockpiling of malodorous soils undergoing treatment shall not occur outside of the enclosure. Stockpiling of malodours soils outside the enclosure is not preferred but if required may be possible subject to the material complying with the requirements of **Section 4** or by covering all exposed surfaces in a low permeability material that can be secured in place.

Alternately, treatment of malodorous materials may potentially be undertaken at the RailCorp nominated off-site facility at Chullora.

8.5 Performance of Air Emissions

The controls listed above are considered sufficient to allow the remediation to proceed and reduce emissions below criteria. The recommended measures have been categorised as having a ' high' relative effectiveness in suppressing both volatilised contaminants and particulate matter in the '*Engineering Bulletin: Control of Air Emissions from Materials*

handling During Remediation' (USEPA, 1991). The review noted that while temporary control technologies such as use of water sprays and foams were highly effective upon application, the effectiveness was noted to decrease significantly with time. Alternately the use of a physical barrier, such as an enclosure, around the majority of earthworks with collection and treatment of the emissions, was reported to be highly effective over time.

Furthermore the results of a trial excavation at a former landfill site in California, where excavation through mud, tar and 'char' wastes required control of sulphur dioxide and VOC emissions was documented in 1992 (USEPA 1992). The trial utilised the following air emission control technologies:

- An enclosure operated under negative pressure; and
- Use of vapour suppressing foam.

Perimeter monitoring conducted continually during the trial noted that total hydrocarbon concentrations did not exceed the established site criteria. Of the two air emissions suppression technologies used it was noted that the effectiveness of the enclosure did not reduce over time. In the vicinity of the treatment works that the efficiency of the vapour suppression foam reduced significantly as the time after application increased.

8.6 Monitoring

Notwithstanding the recommendations for air emission controls, and their demonstrated efficiency an air monitoring program will be required throughout the duration of the works. This shall include:

- Continual visual assessment of dust emissions during all facets of remediation works. No visible dust should be observed at any stage at site boundaries;
- Periodic particulate monitoring at site boundaries undertaken using real-time aerosol monitor;
- Assessment of odours by use of photo-ionisation detector, field olfactometer and field scientist observations;
- Daily monitoring of volatile constituents in emissions from the carbon filter forming part of the treatment system for the enclosure. When the measured concentrations exceed the nominated screening level the filter requires replacement and work within the enclosure shall be haltered until a new filter has been installed. The screening criteria to be adopted for the carbon filter emission during the remediation program has been nominated in the AQMP (**Appendix B**);
- Respirable fibres monitoring at discrete locations during all works involving the handling of areas of known asbestos impact (asbestos containing materials have been identified in fill materials on the site); and
- Dust deposition gauges maintained at two discrete locations at the site boundaries for the duration of the remediation works.

Full details of the required monitoring program are provided in the AQMP **(Appendix B).** The derivation of the VOC monitoring action criteria referred to in the AQMP has been detailed in **Appendix F**.

9 Greenhouse and Exhaust Emissions Assessment

The greenhouse gas emission assessment provided in the following section follows the methods detailed in the *National Greenhouse and Energy Reporting (Measurement) Technical Guidelines June 2010* (Department of Climate Change and Energy Efficiency) and '*National Greenhouse Accounts (NGA) Factors*' and '*National Greenhouse Accounts (NGA) Factors*' (Department of Climate Change and Energy Efficiency, July 2010).

The guidelines provide reporting boundaries through a series of emission scopes as follows:

- Scope 1 (Direct Greenhouse) Emissions: defined as being *'... produced from sources within the boundary of an organisation and as a result of that organisation's activities*'.
- Scope 2 (Indirect Greenhouse) Emissions: defined as being *'...emissions generated in the wider economy as a consequence of an organisation's activities (particularly from its demand for goods and services). The most important category of indirect emissions is from the consumption of electricity*'.
- Scope 3 (upstream and downstream) Emissions: defined as being other indirect emissions and '*...include upstream emissions generated in the extraction and production of fossil fuels, downstream emissions from transport of an organisation's product to customers, and emissions from contracted/outsourced activities. The appropriate emission factor for these activities depends on the parts of upstream production and downstream use considered in calculating emissions associated with the activity*.'

The greenhouse gas emission estimates provided in the following sections assumes that:

- any soil treatment works required will occur on the Chullora site only; and
- the greenhouse gas emissions of material disposed from the site to landfill, will be included in the emissions of the landfill site and are not attributable to the remediation works.

Accordingly the greenhouse gas and exhaust emissions generated during remediation works on the Macdonaldtown site are anticipated to be substantially generated by fuels during the excavation works.

9.1 Scope 1 Emissions

Scope 1 Emissions can include:

These emissions mainly arise from the following activities:

- generation of energy, heat, steam and electricity, including carbon dioxide and products of incomplete combustion (methane and nitrous oxide);
- manufacturing processes which produce emissions (for example, cement, aluminium and ammonia production);
- transportation of materials, products, waste and people; for example, use of vehicles owned and operated by the reporting organisation;
- fugitive emissions: intentional or unintentional GHG releases (such as methane emissions from coal mines, natural gas leaks from joints and seals); and
- on-site waste management, such as emissions from landfill sites

The main Scope 1 emissions anticipated for the Macdonaldtown site are those relating to vehicle movements and transport.

9.1.1 Fuel Consumption

Earthmoving equipment will be the most significant users of fuel during the excavation works. Earthmoving equipment is anticipated to primarily comprise:

- Excavators or other site plant; and
- Truck-and-dogs trailers.

Excavators are anticipated to be confined to the site, while truck-and-dog trailers are likely to be used to transport excavated materials off-site for disposal and/or treatment.

Further fuel is expected to be consumed by the use of air compressors on site as part of the water treatment system, and by a water cart used for dust suppression.

Fuel consumption estimates for each of item of equipment are detailed following. These are typically based on published values or estimates:

- Excavator or other plant (e.g. pug mill)– 40 litres/hour;
- Truck-and-dog trailer – 0.5 litre/km;
- Air compressor for groundwater pumps and treatment system– 30 litres/hour; and
- Water cart – 0.5 litres/km;

It was assumed that the truck-and-dog trailers will travel to one of two locations:

- Treatment location at Chullora, located 15 km from the site; or
- A waste disposal facility located in Western Sydney. As the disposal facility is yet to be determined, a representative round distance of 120 km per trip has been adopted.

Journeys returning treated material from Chullora to the site, and any remediation tasks completed on the Chullora site, have been included in the Air Quality Assessment completed for the Chullora site.

9.1.2 Mass of Excavated Materials

For the purposes of this assessment, it has been assumed all excavated materials containing asbestos materials and demolition waste will be excavated directly to a waste facility. From **Table 4.1**, this comprises an approximate quantity of materials of 3,765 m^3. From the EPA (2006) *'Standard Volume to Weight Conversion Factors'*, one cubic metre of material is equivalent to 1.4 tonnes, and results in an approximate mass of materials for disposal of 5, 300 tonnes.

Contaminated materials excavated on site are assumed to be transported to the Chullora facility for treatment. From **Table 4.1**, this comprises an approximate quantity of materials of 16, 215 m^3, which based on EPA (2006), results in an approximate mass of 22, 700 tonnes of material.

It is further assumed that surface soils, other than those impacted with free tar, will remain on site.

9.1.3 Greenhouse Gas Emission per Fuel Consumption Unit

The Department of Climate Change (2010) '*National Greenhouse Accounts (NGA) Factors*' reports 2.7 tonnes of CO_2 equivalent is produced per kilolitre of automotive diesel fuel consumed, based on the point source / fuel combustion scope.

9.1.4 Estimate of Scope 1 (Direct) Greenhouse Gas Emissions

For the purposes of this assessment, it has been assumed the carrying capacity of each truck-and-dog trailer approximates 30 tonnes. Therefore, it is anticipated that the following work will be required:

- 2 Excavators (or other plant) operating 9h/day for 154 days (6 months of works);
- 180 Truck-and-dog trailer round trips to a waste facility in west Sydney;
- 550 Truck-and-dog trailer round trips to the Chullora site (allows for delivery of untreated material only, emissions associated with return of treated material are included in the separate emissions assessment for the Chullora site);
- 1 Water Cart travelling 30 km/day * 154 days (6 months of works); and
- 1 Air Compressor operating 9h/day for 154 days (6 months of works).

Based on the above it is estimated that approximately 175 000 litres of diesel fuel will be used by the works. The conservatism of this estimate is considered sufficient to account for incidental uses of diesel fuels which will be generated by the project (i.e. delivery of materials, employee travel to and from site etc). Based on this value it is estimated that the remediation works will generate approximately 534 tonnes of CO_2 equivalent gases in direct emissions.

The calculations corresponding to this estimate are provided in **Appendix H**.

9.1.5 Estimate of Exhaust Emissions

By review of **Section 9.1.4** it is estimated that 175 000 litres of diesel will be used by site vehicles associated with the excavation works. NEPC (2008) summarises techniques for estimating the emissions of combustion engines, and **Section 5.4** outlines the use of emissions factors for emissions calculations. Table 21 of NEPC (2008) presents the emissions factors for heavy diesel powered vehicles, which are reproduced in **Table 9.1**.

A total estimate for emissions generated by exhausts for the site works is also summarised in **Table 9.1**. The calculations corresponding to this estimate are provided in **Appendix H**.

Table 9.1: Summary of Exhaust Emissions

Constituent	Emission Factor (kilograms per litre diesel)	Total Estimated Emission for Remediation Works (kg)
VOCs	0.0018	315
NO_x	0.023	4028
CO	0.0068	1191
PM_{10}	0.0018	315
SO_2	0.000017	2.98

The potential dispersion of these constituents has not been modelled for the site as they are considered insignificant in comparison of the exhaust emissions of the roadways bordering the site.

9.2 Scope 2 Emissions

Scope 2 Emissions comprise emissions generated in the wider economy as a consequence of an organisation's activities (particularly from its demand for goods and services). The most important category of indirect emissions is from the consumption of electricity.

As discussed in **Section 9.1**, all plant and equipment used in the works will be powered by fuel. Consumption of purchased electricity is therefore considered unnecessary for the completion of the physical remediation works.

Given the actual treatment works have been assumed occur solely on the Chullora site, it is considered that no Scope 2 Greenhouse Gas Emissions will be generated by the proposed remediation works.

9.3 Scope 3 Emissions

Scope 3 Emissions comprise other emissions generated in the wider economy as a consequence of an organisation's activities (particularly from its demand for goods and services).

Given that end product of the remediation works will be material suitable to reuse on site or material suitable for disposal to landfill, it is considered that that no major emissions will be generated in the wider community. Emissions from material to be sent to landfill will be incorporated into the greenhouse gas emission calculations for those sites. Emissions from material reused on the site will be generally free of organic matter capable of generating greenhouse gas emissions. Additionally landuse patterns at the site are unlikely to change as a result of the remediation works such that significant greenhouse gas emissions are likely. Therefore it is considered that no Scope 3 Greenhouse Gas Emissions will be generated by the proposed remediation works.

9.4 Total Estimated Greenhouse Gas Emissions

Table 9.2 summarises the estimated Greenhouse gas emissions for the proposed remediation works on the Former Macdonaldtown gasworks site.

Table 9.2: Summary of Estimated Greenhouse Gas Emissions

Emissions Scope	Calculated Emissions (tonnes of CO_2 equivalent gases)
Scope 1 (direct)	473
Scope 2 (indirect)	-
Scope 3 (upstream and downstream)	-
Total	473

The total estimated greenhouse emissions for the site are considered to be relatively minor in comparison to greenhouse gas emissions generated on the roads surrounding the site.

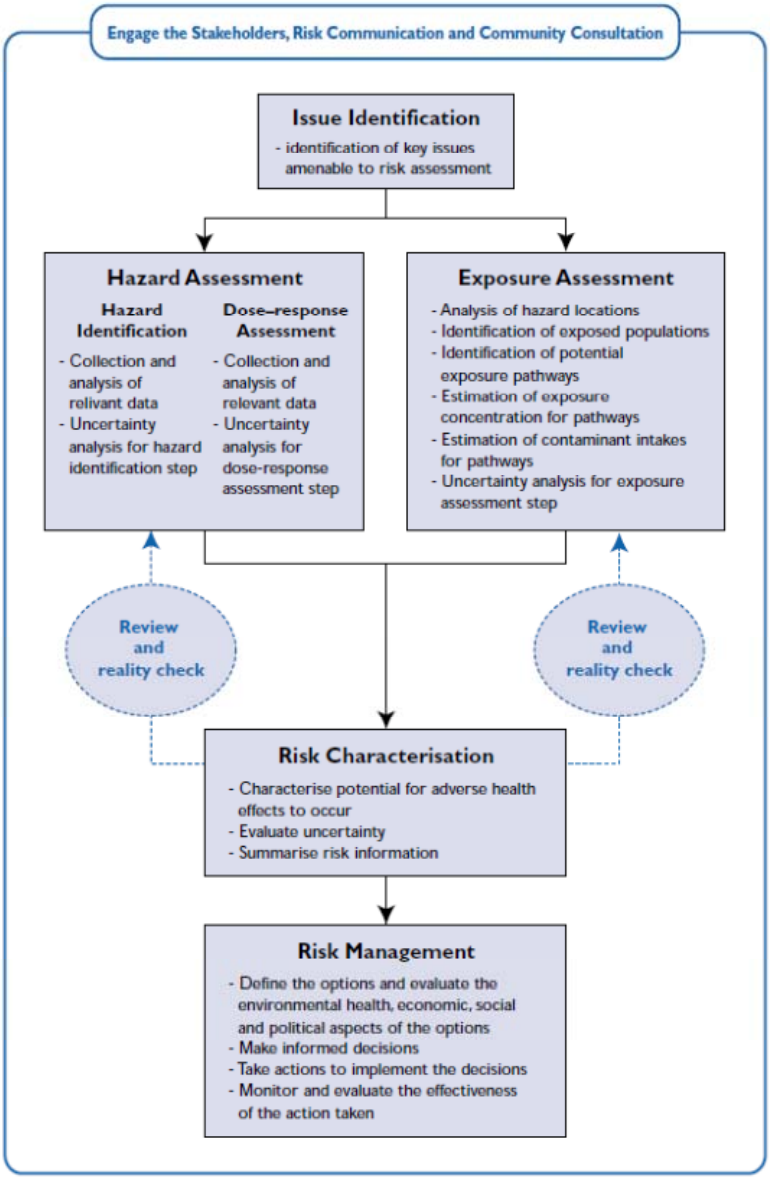
10 Health Risk Assessment

A health risk assessment has been additionally undertaken to estimate the potential quantum impact of the potential chemical atmospheric emissions from the remediation works on the Macdonaldtown Site on the surrounding population. This has been undertaken by the guidance provided to enHealth (2004) 'Environmental Health Risk Assessment Guidelines for assessing human health risks from environmental hazards'. The assessment has been conducted assuming the works are conducted in accordance with the controls measures recommended in **Table 8.1**.

10.1 Risk Assessment Process

Risk assessment is the process of estimating the potential impact of a chemical, physical, microbiological or psychosocial hazard on a specified human population or ecological system under a specific set of conditions and for a certain timeframe. A schematic of the risk assessment process is shown the diagram below (source: enHealth 2004).

- Issue Identification identifies issues amenable to risk assessment and assists in establishing a context for the risk assessment by a process of identifying the problems that the risk assessment needs to address. This includes the selection of Constituents of Potential Concern (COPC's) for the Macdonaldtown Site and each identified potential exposure population;
- Hazard Assessment including toxicological assessment and dose-response assessment. Toxicological assessment involves determining what types of (adverse) health effects might be caused by the agent; and how quickly the adverse health effects might be experienced and their duration. Dose-response assessment considers both qualitative and quantitative toxicity information to determine 'the incidence of adverse effects occurring in humans at different exposure levels';
- Exposure Assessment involves the determination of the frequency, extent, duration and character of exposures in the past, currently, and in the future. There is also the identification of exposed populations and particularly sensitive sub populations, and potential exposure pathways; and
- Risk Characterisation provides a qualitative and / or quantitative estimate, including attendant uncertainties, of the nature, severity and potential incidence of effects in a given population based on the hazard identification, and exposure assessments.



10.2 Issue Identification

Issue identification determines whether risk assessment is useful and establishes a context for the risk assessment by a process of identifying the concerns that the risk assessment needs to address. Issue identification draws on all relevant lines of information.

Issue identification comprises several phases:

1. Identification of environmental health issues (or an individual issue) and determining whether there are hazards amenable to risk assessment. This will involve demarcating 'hazards' from 'issues' and may require environmental sampling;
2. Putting the hazards into their environmental health context (clarification and prioritising of problems and hazards);
3. Identification of potential interactions between agents; and
4. Stating clearly why risk assessment is needed and the scope and objectives of the risk assessment. This will involve identifying problems for which information is,

or can be, available to undertake adequate risk assessments and problems which risk assessment cannot assist.

The health risk assessment is required to provide a definitive assessment of the potential health impacts of the air emissions, associated with the remediation of the Macdonaldtown site, to the surrounding potentially exposed community. Several of the potential speciated emissions have known toxicological effects. The most potentially toxic of these have been identified as benzene and benzo(a)pyrene. Risk assessment has considered each of the speciated constituents of benzene and benzo(a)pyrene as identified and quantified by air modelling as being present in the air emissions from the Macdonaldtown remediation.

10.3 Selection of Constituents of Potential Concern

Constituents of potential concern (COPCs) require to be selected to allow the subsequent risk assessment to be focussed to the most important constituents. This has been undertaken by the air quality assessment identifying benzene and benzo(a)pyrene as the most potentially toxic constituents present in air emissions from the works. Benzene and benzo(a)pyrene have been selected as COPCs for the health risk assessment.

10.4 Hazard Assessment

Enhealth (2002) provides advice as to the quality of toxicological data that is available to be used in risk assessments. Data is categorised as Level 1, 2 or 3 data. Level 1 sources are recommended as the preferred sources of chemical data. Level 1 sources, in the order of preference for which they are recommended to be used, include:

1. National Health and Medical Research Council documents and documents from other joint Commonwealth, State and Territory Health organisations. These may be a source of Australian guidance values. The Australian and New Zealand Environmental and Conservation Council is considered a suitable Commonwealth organisation to be included here;
2. ADI list from the Therapeutic Goods Administration;
3. World Health Organisation (WHO) documents. Australia is a party to the WHO process and has incorporated their material in a variety of environmental health criteria. A range of documents include those from the WHO/ILO/UNEP International Programme on Chemical Safety (IPCS) which produces Environmental Health Criteria monographs and Concise International Chemical Assessment documents (CICADs). Documents detailing international Acceptable Daily Intakes (ADI's), Tolerable Daily Intakes (TDI) or Tolerable Weekly Intakes (TWI) may be found in evaluations by the WHO/FAO Joint Meeting on Pesticide Residues (JMPR) and by the Joint FAO/WHO Expert Committee on Food Additives (JECFA);
4. enHealth Council documents;
5. National Environmental Health Forum documents distributed by the Commonwealth Department of Health and Ageing;
6. International Agency for Research on Cancer (IARC) Monographs;
7. WHO/FAO Joint Meeting on Pesticide Residues (JMPR) Monographs;
8. NICNAS Priority Existing Chemical (PEC) reports;

9. US Agency for Toxic Substances and Disease Registry (ATSDR) documents for general toxicological reviews and Reference Doses;
10. National Toxicology Program (NTP) carcinogenicity appraisals which report in detail the results of carcinogenicity tests on a wide range of chemicals;
11. OECD Standard Information Data Sets (SIDS) and SIDS Initial Assessment Reports (SIAR); and
12. US EPA Reference Doses.

Where a rare substance is being assessed, or insufficient data is available within Level 1 sources, then Level 2 sources may require to be researched. Level 2 sources include:

1. European Centre of Ecotoxicology and Toxicology of Chemicals (ECETOC): Monographs, JACC reports and Technical Reports;
2. Chemical Institute of Toxicology (CIIT) reports; and

Unpublished industry reports submitted for regulatory purposes. These may have restricted availability but information may be available in evaluation reports from regulatory agencies that have reviewed individual reports.

10.4.1 Review of Toxicological Sources

Each of these sources has been reviewed and appropriate toxicological values selected for the potential constituents released from the Macdonaldtown remediation. These are summarised in **Table 10.1** for non-threshold effects, and **Table 10.2** for threshold effects.

Table 10.1: Toxicity Criteria for Carcinogenic (Non-Threshold) Endpoints

Constituent	Inhalation Slope Factor $(mg/kg/day)^{-1}$	Discussion / Comments
Benzene	$2.1*10^{-2}$	Inhalation slope factor based on WHO (2000) 'Air Quality Guidelines for Europe, 2nd Edition' (chapter 5.2) unit risk of $6.0*10^{-6}$ $(\mu g/m^3)^{-1}$.
Benzo(a)pyrene	304	Inhalation slope factor based on WHO (2000) 'Air Quality Guidelines for Europe, 2nd Edition' (chapter 5.9) unit risk of $8.7*10^{-2}$ $(\mu g/m^3)^{-1}$.

Table 10.2: Toxicity Criteria for Non-Carcinogenic (Threshold) Endpoints

Constituent	Inhalation ADI, mg/kg/day	Discussion / Comments
Benzene	$2.9*10^{-3}$	Inhalation ADI based on ATSDR (August 2007) 'Toxicological Profile for Benzene' chronic duration inhalation exposure MRL of $10\mu g/m^3$. More conservative than US EPA IRIS Database (2003) value.

10.5 Exposure Assessment

Potentially exposed populations have been identified by the identification of the discrete receptors in **Table 7.1** and shown on **Figure 10**. This includes properties used for residential, recreational and commercial purposes.

Exposure parameters are required for each of the potentially exposed populations. These are summarised in **Tables 10.3** to **10.5**.

Table 10.3: Global Parameters –Residential Receptor (Adult & Child) – Nearby Residents

Exposure Parameter	Units	Factor	Reference
Exposure Frequency	days/year	154	As per excavation duration of the 'surface soils' area. Considered upper estimate
Exposure Duration	months	6	Minimum averaging of toxicological data
Exposure Time	hours	10	As per duration of excavation activities. Found to contribute highest levels of COPCs
Body Weight	kg kg kg	13.2 34.5 70	Child 0-5 years, enHealth (2004) Child 6-15 years, Langley & Sobardo (1996) as per NEPC (1999) mean body weight for 10 year old child Adult 16+ years, NEPC (1999)
Averaging Time - non Threshold	years	70	NEPC (1999)
Averaging Time - Threshold	months	12	Minimum duration of threshold toxicological data

Table 10.4: Global Parameters – Adult Commercial / Industrial Workers

Exposure Parameter	Units	Factor	Reference
Exposure Frequency	days/year	240	enHealth (2004)
Exposure Duration	months	12	Maximum duration of receipt and handling of soils from Macdonaldtown
Exposure Time	hours	8	enHealth (2004)
Body Weight	kg	70	NEPC (1999)
Averaging Time - non Threshold	years	70	NEPC (1999)
Averaging Time - Threshold	months	12	Minimum duration of threshold toxicological data

Table 10.5: Inhalation Parameters

Exposure Parameter	Units	Factor	Reference
Industrial / Commercial Worker (indoors)	m^3/hour	1.33	Langley & Sobardo (1996) as per NEPC (1999). Based on slow walking and average of males and females.
Adult Residential / Recreational Receptor	m^3/hour	1.20	enHealth(2004). Average inhalation rate for light activity for an adult male
Child Residential / Recreational Receptor (6-15 years)	m^3/hour	0.78	enHealth(2004). Average inhalation rate for light activity for 10 year old child.
Child Residential / Recreational Receptor (0-5 years)	m^3/hour	0.63	Langley & Sobardo (1996). Young children, light activity

Risk modelling has been undertaken as per the guidance in US EPA (1989) 'Risk Assessment Guidance for Superfund, Volume 1 Human Health Evaluation Manual, Part A'. Exposure parameters have been used to estimate adjusted intake concentrations by the use of the following relationship:

CDI = (C * IR * ET * EF * ED) / (365 * AT * BW)

Where: CDI – chronic daily intake (mg/kg/day);

C – chemical concentration in air (mg/m^3)

IR – inhalation rate (m^3/h)

ET – exposure time (h/d)

EF – exposure frequency (day/year)

ED – exposure duration (years)

AT – averaging time (70 years for non threshold, ED for threshold)

BW – body weight (kg)

The modelling has been undertaken by assuming a direct exposure to the worse case 24h concentration of each constituent as base on the mean concentrations, as predicted for each particular receptor, for the complete duration of the works, being twelve months.

This is essentially the assumption that each of the assessed receptors is present downwind of the works for the entire duration of the works.

10.6 Risk Characterisation

10.6.1 Risk Measurement

For carcinogens, risks are estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the potential carcinogen. The slope factor (SF) converts estimated daily intakes averaged over a lifetime of exposure directly to incremental risk of an individual of developing cancer. Because relatively low intakes (compared to those experienced by test animals) occur with exposures on most contaminated sites it can generally be assumed that the dose response relationship is linear in the low-dose portion of the multistage model dose-response curve. Under this assumption the slope factor is constant and risk is directly related to intake. Thus the following linear based carcinogenic risk equation is used:

Risk = CDI * SF

where: Risk – unitless probability of an individual developing cancer;

CDI – chronic daily intake averaged over 70 years (mg/kg-day); and

SF – slope factor expressed in $(mg/kg\text{-}day)^{-1}$.

The slope factor is often an upper 95% percentile confidence limit of the probability of response based on experimental animal data used in the multistage model. Consequently the carcinogenic risk estimate will often be an upper bound estimate (US EPA, 1989).

The measure used to describe the potential for non carcinogenic toxicity to occur in an individual is not expressed as the probability of an individual suffering an adverse effect. Instead the potential for non carcinogenic effects is evaluated by comparing an exposure level over a specific time period with a reference dose derived for a similar exposure period. The ratio of exposure to toxicity is called a hazard quotient and is calculated as:

Noncancer hazard quotient = E / RfD

where: E – exposure level (or intake); and

RfD – reference dose (E and RfD are expressed in the same units (US EPA, 1989).

At most sites the potential health effects of more than one chemical require to be assessed. Potential additive effects of exposure to multiple chemicals require to be considered in risk assessment. US EPA (1989) recommends that carcinogenic risks are added.

To assess the overall potential for non-carcinogenic effects posed by more than one chemical a hazard index approach is used. This is undertaken by summing of all hazard quotients to determine a hazard index.

10.6.2 Adopted Risk Criteria

Acceptable risk guidelines are available from a range of national and international environmental agencies. These include:

- US EPA (1991) states that "Where the cumulative site risk to an individual based on a reasonable maximum exposure for both current and future land use is less than 10^{-4},…. action is generally not warranted unless there are adverse environmental impacts". Where the level of risk exceeds 10^{-4} it is recommended that remediation goals are developed based on a 10^{-6} cancer risk;
- WHO (1996) 'Guidelines for Drinking Water Quality' are based on a risk of 1 in 100,000 (1×10^{-5}); and
- NHMRC/ARMCANZ (1996) 'Australian Drinking Water Guidelines' nominate a negligible level of risk of 1 in 1,000,000 (1×10^{-6}).

No formal policy exists for the acceptable level of cancer risk, however it has been the experience of JBS that NSW, ACT and Victorian Environmental Auditors generally consider risks in the range of 1 in 100,000 (1×10^{-5}) to be acceptable. This level of acceptable risk will be adopted for the Works.

For the purposes of this risk assessment an acceptable level of risk is defined as risk less than 1 x 10^{-5} incremental lifetime risk of cancer.

10.6.3 Risk Estimates

Incremental risks and hazard indexes have been summed for each of the discrete receptors and are summarised in **Table 10.6**. Risk calculations have been undertaken on the basis of the following constituent levels:

- Benzo(a)pyrene: 0.005 to 0.025 µg/m^3; and
- Benzene: 0.0007 to 0.0076 µg/m^3.

The concentrations selected were the highest 24 hour averaging time concentrations reported at any receptor location and are based on:

- The 'annual' level of total suspended particulate as predicted for the site with air quality controls applied; and
- Consideration of vapour emissions only from areas of the site outside of the enclosed area as per the reduced areas of soils potentially subject to volatilisation processes.

Additionally it was assumed that at any one time, the population at each receptor location will be exposed to emissions from only one source area on the site. This is based on:

- the spatial distribution of site activities to be undertaken external to the enclosure (i.e. retaining wall excavations at the north and surface soil excavations generally in the southern and eastern portion of the site); and
- Review of the windrose data for the site indicates that emissions from the northern and southeastern portions of the site are unlikely to reach the receptor locations at the same time.

Based on the dispersion modelling results summarised in **Table 7.9** the works undertaken as part of the Stage 1 remediation works are likely to generate the greatest concentration of particulate air emissions. To ensure a conservative assessment the health risk assessment assumed that the Stage 1 emissions occurred for the likely duration of active remediation works (i.e. 6 months). Additionally as the results of dispersions modelling in

Table 7.10 indicates that emissions from the water treatment system and groundwater will potentially contribute the highest concentrations of air toxins to receptors these sources have also been included. It is noted that when remediation works commence the dispersion modelling results indicate that emissions to air will decrease by at least one order of magnitude once the Stage 1 works are completed.

The selection of the highest concentration reported, across all receptor locations, from any one source area on the site was therefore considered to be appropriate. Hazard index and risk level calculations based on the highest reported receptor location concentration are provided in **Appendix I** and summarise in **Table 10.6**.

Table 10.6: Summary of Worst Case Risk and Hazard Estimates

Receptor ID	Receptor ID	Hazard Index	Risk[1]
1	1 Leamington St Erskineville	7.94×10^{-3}	6.2×10^{-7}
2	Railway Offices, within Stabling Shed	3.3×10^{-2}	9.77×10^{-6}
3	Railway Workshops, nearest to site	1.55×10^{-2}	3.4×10^{-6}
4	95 Railway Pde Erskineville	7.32×10^{-4}	5.14×10^{-7}
5	15 Burren St Erskineville	9.54×10^{-3}	2.02×10^{-6}
6	31 Burren St Erskineville	2.3×10^{-2}	5.77×10^{-6}
Notes 1: risk to child resident at receptor location			

Assuming the proposed controls (**Table 7.2**) are maintained each of the predicted levels of hazard and risk levels is well below the adopted criteria.

11 Conclusions and Recommendations

An assessment of the potential air quality impacts of remediation works at the former Macdonaldtown gasworks has been undertaken.

The objectives of this air quality assessment were to:

- Estimate potential air emissions including particulates, potential chemical constituents and odours from the proposed remediation works;
- Identify the requirement and type of air emission controls required;
- Undertake dispersion modelling of air emissions to determine potential impacts to nearby receptors and adjoining properties;
- Assess the effectiveness of proposed air emission controls;
- Undertake a health risk assessment to determine potential health impacts of speciated chemical constituents identified as occurring from the works to nearby receptors and adjoining properties;
- Based on results of air modelling, assess compliance with relevant OEH and NEPC published criteria; and
- Estimate the greenhouse contribution of the proposed works.

A range of activities that may be undertaken with the gasworks remediation has been considered in the air quality assessment including:

- Excavation, handling and stockpiling of low level contaminated soils;
- Excavation , handling and stockpiling of coal tar contaminated soils;
- Movement of site vehicles over non-paved site haulage roads;
- Treatment of coal tar contaminated soils on-site by stabilisation / immobilisation;
- Treatment of coal tar contaminated soils on-site by bioremediation;
- Dewatering of coal tar impacted groundwater from excavations and operation of a water treatment plant; and
- Potential pooling and evaporation of coal tar impacted groundwater within site excavations.

The assessment has been initially completed by undertaking air modelling to determine worst case impacts for a range of representative receptor locations in close proximity of the site. A number of conservative assumptions, including the complete absence of any air quality controls, has been assumed in the air modelling to allow the identification of all site activities that will require air quality controls. Modelling results have been compared to OEH published and endorsed air quality criteria.

A number of air quality controls have been designed to reduce the air emissions from the proposed works. These include:

- Excavation Works: Water will be applied to disturbed areas at least hourly within the remediation site. Areas of coal tar impacted soil excavation will require addition of an odour suppression agent to the water sprays. Notwithstanding this recommendation, any works involving the excavation or

handling of potential asbestos contaminated soils shall be undertaken subject to constant water application;

- Enclosure of Remediation Works: The excavation of soils impacted with high levels of coal tar anticipated in proximity of the northern gasholder and the former tar wells to the north of the gasholder shall require encapsulation within a ventilation controlled enclosure. Air discharges from the enclosure shall be through a controlled air filtering system designed to remove malodorous emissions and particulates;
- Soils Treatment on Site: Where treatment of coal tar impacted soils (as defined by the soil criteria summarised in **Table 11.1**) is proposed to occur on site this shall also be required to occur within a ventilation controlled enclosure. The enclosure shall be sufficiently sized to accommodate both the soil treatment works and the associated stockpiling;
- Odour Control: The presence of the coal tar impacted soils and groundwater on the site causes them to be highly malodorous on exposure during excavation and when stockpiled. A number of measures require implementation to minimise the impacts of odours including, in some sections of the site, enclosure of any excavation and soil handling works with treatment of air emissions to remove odours. In areas unsuited to the enclosure of soil handling activities, control measures shall include the minimisation of areas of exposed soils by works staging and covering of stockpiles, covering of tippers used to transport materials on the site, enclosure and controlled ventilation of any areas of splash filling the water treatment plant, installation and operation of an odour suppression system on the site boundary, application of odour suppression agents with dust control sprays during excavation and soil handling works and prevention of the exposure of contaminated groundwater saturated soils by control of water levels in open excavations. Materials with chemical concentrations exceeding those stipulated in **Table 11.1** shall not be stockpiled outside of enclosure without odour controls;
- Air Treatment System Monitoring: daily monitoring of volatile constituents will be required in emissions from the carbon filter forming part of the treatment system for the enclosure. When the measured concentrations exceed the nominated screening level the filter requires replacement and work within the enclosure shall be halted until a new filter has been installed;
- Site Monitoring: Site monitoring will be required, including assessment for particles less than 10 micron in diameter (PM_{10}), malodorous emissions, levels of volatile organic compounds, respirable fibres and dust deposition. Where site monitoring identifies potential exceedances of acceptable levels of dust or odour, site practices shall be reviewed, or the particular dust / odour generating activity ceased until more favourable meteorological conditions occur or revised mitigation practices are adopted;
- Deep Excavations: Infiltrating coal tar impacted groundwater is to be prevented from accumulating within excavations by removing any ponded groundwater generated during the remediation works; and
- Monitoring: An atmospheric monitoring program requires to be implemented at the site boundary and adjoining residential areas to continually assess levels of airborne pollutants and offensive odours being generated by the works.

Monitoring shall include dust and particulate, odour, asbestos and volatile constituents.

Table 11.1: Summary of Maximum Allowable Levels of Malodorous Constituents

Constituent	Criteria (mg/kg)	Comments
Benzene	2.5	-
Ethylbenzene	5	-
Toluene	10	-
Xylene (total)	10	-
Cresols	_	Non volatile, no limits requiring covering from odour potential
Acenaphthene	35	-
Naphthalene	25	-
Phenol	40	-

Notwithstanding the implementation of these air quality controls, it is considered likely that localised detections of coal tar odours will occur in close proximity of the site for the duration of the works. However the level of impact is not considered to be offensive, and is unavoidable in achieving the environmental rehabilitation of the site. The program of odour controls proposed are considered to be best practice, and while they may not be capable of completely eliminating offensive odours, they will be sufficient to reduce the duration of odour releases and provide a framework for monitoring and refining the odour management during remediation. The Human Health Risk Assessment has also shown that the proposed works will not pose an unacceptable risk to the health of nearby receptors.

An Air Quality Management Plan (AQMP) detailing the requirements for the aforementioned controls and monitoring requirements has been prepared for the remediation program. The proposed controls are considered to be best practice for the proposed remediation works. The recommended controls above are identified as having a 'High' relative effectiveness (USEPA, 1991). Enclosures of soil handling works, with collection and treatment of air emissions, has been demonstrated as effective in protecting the surrounding community on other sites heavily impacted with tar (USEPA 1992).

Greenhouse gas emissions associated with the proposed works were assessed. While the proposed remediation strategy will generate some greenhouse gases from standard fuel based emissions, the controls proposed in the Air Quality Management Plan for the project will reduce the magnitude of these emissions and minimise the associated fugitive emissions. The provision to enable contaminated soil to be treated will reduce the volume of material being sent to landfill. These inclusions are consistent with the objectives and commitments of the NSW Greenhouse Plan and *Action for Air: The NSW Government's 25 year Air Quality Management Plan,* that are relevant to waste minimisation.

12 References

ASTM (2002) '*Standard Guide for Risk Based Corrective Action Applied at Petroleum Release Sites*'

Australian Oil Industry Environmental Guidelines Working Group (April 1999) '*Guidelines for the Management of Petroleum Hydrocarbon Impacted Land*'

Australian Railway Historical Society (June 2003) '*A Brief History of NSW Railway Gasworks*'

Banksia Heritage & Archaeology '*Macdonaldtown Station Works – Archaeological Assessment*'

CH2M Hill (June 2000) *'Phase I & II Environmental Site Assessments'*

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13 Limitations

This report has been prepared for use by the client who commissioned the works in accordance with the project brief only and has been based in part on information obtained from other parties. The advice herein relates only to this project and all results conclusions and recommendations made should be reviewed by a competent person with experience in environmental investigations, before being used for any other purpose.

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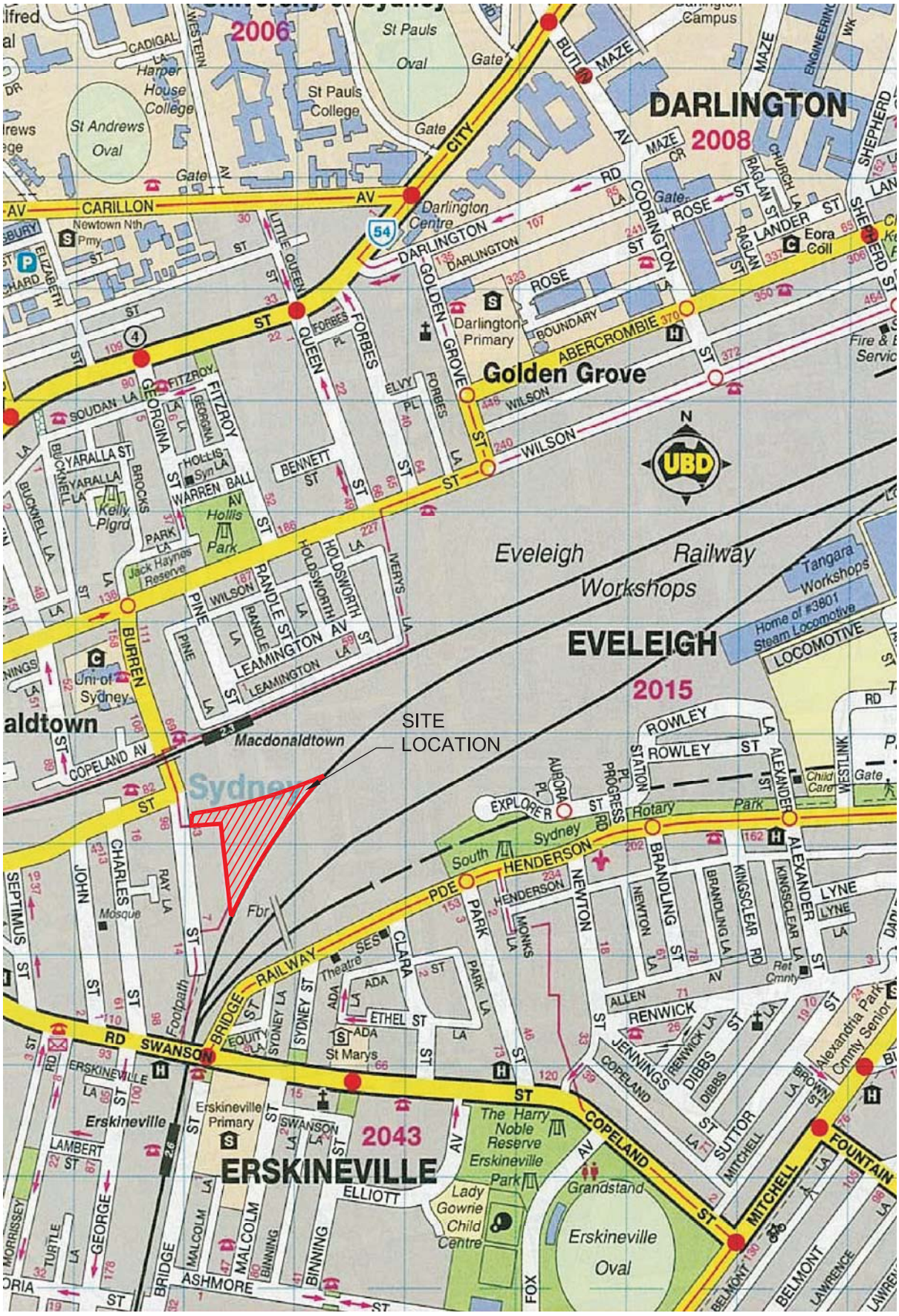
This report does not provide a complete assessment of the potential hazards associated with the site, and it is limited to the scope defined herein. Should information become available regarding conditions at the site including previously unknown sources of potential hazards, JBS Environmental Pty Ltd reserves the right to review the report in the context of the additional information.

Figures



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0 500m

Approximate scale

Figure 1 **Site Location (Macdonaldtown)**

CH2M Hill (2007)
Note- All locations shown are approximate only

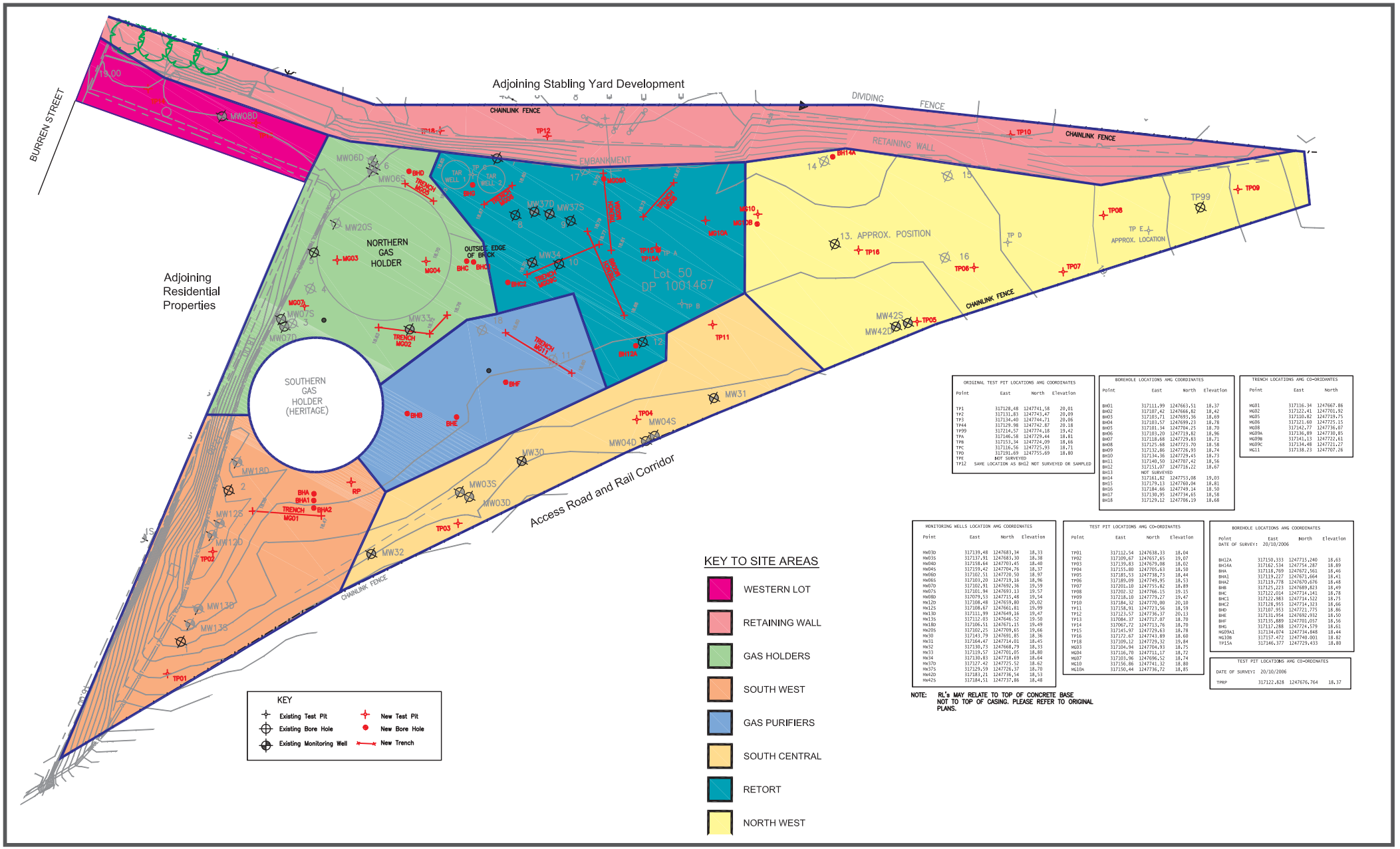
JBS ENVIRONMENTAL

0 100m

Approximate scale

Figure 2 **Current Macdonaldtown Site Plan**

CH2M Hill (2007)
Note- All locations shown are approximate only



ORIGINAL TEST PIT LOCATIONS AMG COORDINATES

Point	East	North	Elevation
TP1	317128.48	1247741.58	20.01
TP2	317131.83	1247743.47	20.09
TP3	317134.40	1247744.71	20.06
TP44	317129.98	1247742.87	20.18
TP99	317214.57	1247774.16	19.42
TP4	317146.58	1247729.44	18.81
TP8	317153.34	1247724.09	18.66
TPC	317116.56	1247725.93	18.71
TPD	317191.69	1247755.69	18.80
TPE	NOT SURVEYED		
TP12	SAME LOCATION AS BH12 NOT SURVEYED OR SAMPLED		

BOREHOLE LOCATIONS AMG COORDINATES

Point	East	North	Elevation
BH01	317111.99	1247663.51	18.37
BH02	317107.42	1247666.82	18.42
BH03	317103.71	1247693.36	18.69
BH04	317103.57	1247699.23	18.78
BH05	317101.34	1247704.25	18.70
BH06	317103.20	1247719.82	18.96
BH07	317118.68	1247729.83	18.71
BH08	317125.68	1247723.70	18.58
BH09	317132.86	1247726.93	18.74
BH10	317134.36	1247729.45	18.73
BH11	317140.50	1247707.42	18.56
BH12	317151.07	1247716.22	18.67
BH13	NOT SURVEYED		
BH14	317161.82	1247753.08	19.03
BH15	317179.13	1247760.04	18.81
BH16	317184.66	1247749.14	18.50
BH17	317130.95	1247734.65	18.58
BH18	317129.12	1247706.19	18.68

TRENCH LOCATIONS AMG CO-ORDINATES

Point	East	North
MG01	317116.34	1247667.86
MG02	317122.41	1247701.92
MG05	317110.82	1247719.75
MG06	317121.60	1247725.15
MG08	317142.77	1247736.07
MG09A	317136.89	1247730.85
MG09B	317141.13	1247722.61
MG09C	317134.48	1247721.27
MG11	317138.23	1247707.26

MONITORING WELLS LOCATION AMG COORDINATES

Point	East	North	Elevation
MW03D	317139.48	1247683.34	18.33
MW03S	317137.91	1247683.30	18.38
MW04D	317158.64	1247703.45	18.40
MW04S	317159.42	1247704.76	18.37
MW06D	317102.51	1247720.50	18.97
MW06S	317103.20	1247719.16	18.96
MW07D	317102.91	1247692.36	19.59
MW07S	317101.94	1247693.13	19.57
MW08D	317079.53	1247715.48	19.54
MW12D	317108.48	1247659.80	20.02
MW12S	317108.67	1247661.81	19.99
MW13D	317111.99	1247649.16	19.67
MW13S	317112.03	1247646.52	19.50
MW18D	317106.51	1247671.15	19.49
MW20S	317102.25	1247709.65	19.66
MW30	317143.79	1247691.85	18.36
MW31	317164.47	1247714.01	18.45
MW32	317130.73	1247668.79	18.33
MW33	317119.57	1247701.05	18.80
MW34	317130.83	1247718.69	18.64
MW37D	317127.42	1247725.52	18.62
MW37S	317129.59	1247726.37	18.70
MW42D	317183.21	1247736.54	18.53
MW42S	317184.51	1247737.86	18.48

TEST PIT LOCATIONS AMG CO-ORDINATES

Point	East	North	Elevation
TP01	317112.54	1247638.33	18.04
TP02	317109.67	1247657.65	19.07
TP03	317139.83	1247679.08	18.02
TP04	317155.80	1247705.63	18.50
TP05	317185.53	1247738.73	18.44
TP06	317189.09	1247749.95	18.53
TP07	317201.10	1247755.82	18.89
TP08	317202.32	1247766.15	19.15
TP09	317218.10	1247779.27	19.47
TP10	317184.32	1247770.00	20.10
TP11	317158.91	1247723.56	18.59
TP12	317123.57	1247736.37	20.13
TP13	317084.37	1247717.07	18.70
TP14	317067.72	1247713.76	18.70
TP15	317145.97	1247729.63	18.78
TP16	317172.67	1247743.89	18.60
TP18	317109.12	1247729.32	19.84
MG03	317104.94	1247704.93	18.75
MG04	317116.70	1247711.17	18.72
MG07	317103.96	1247696.52	18.74
MG10	317156.86	1247741.32	18.80
MG10A	317150.44	1247736.72	18.85

BOREHOLE LOCATIONS AMG COORDINATES

Point	East	North	Elevation
DATE OF SURVEY: 20/10/2006			
BH12A	317150.333	1247715.240	18.63
BH14A	317162.534	1247754.287	18.89
BHA	317118.769	1247672.161	18.46
BHA1	317119.227	1247671.664	18.41
BHA2	317119.778	1247670.676	18.48
BHB	317125.223	1247689.823	18.49
BHC	317122.014	1247714.141	18.78
BHC1	317122.983	1247714.522	18.75
BHC2	317128.955	1247714.323	18.66
BHD	317107.953	1247721.775	18.86
BHE	317131.954	1247692.932	18.50
BHF	317135.689	1247701.057	18.56
BHG	317117.288	1247724.579	18.61
MG09A1	317134.074	1247734.848	18.44
MG10B	317157.472	1247740.001	18.82
TP15A	317146.377	1247729.433	18.80

TEST PIT LOCATIONS AMG CO-ORDINATES

Point	East	North	Elevation
DATE OF SURVEY: 20/10/2006			
TPRP	317122.828	1247676.764	18.37

NOTE: RL's MAY RELATE TO TOP OF CONCRETE BASE NOT TO TOP OF CASING. PLEASE REFER TO ORIGINAL PLANS.

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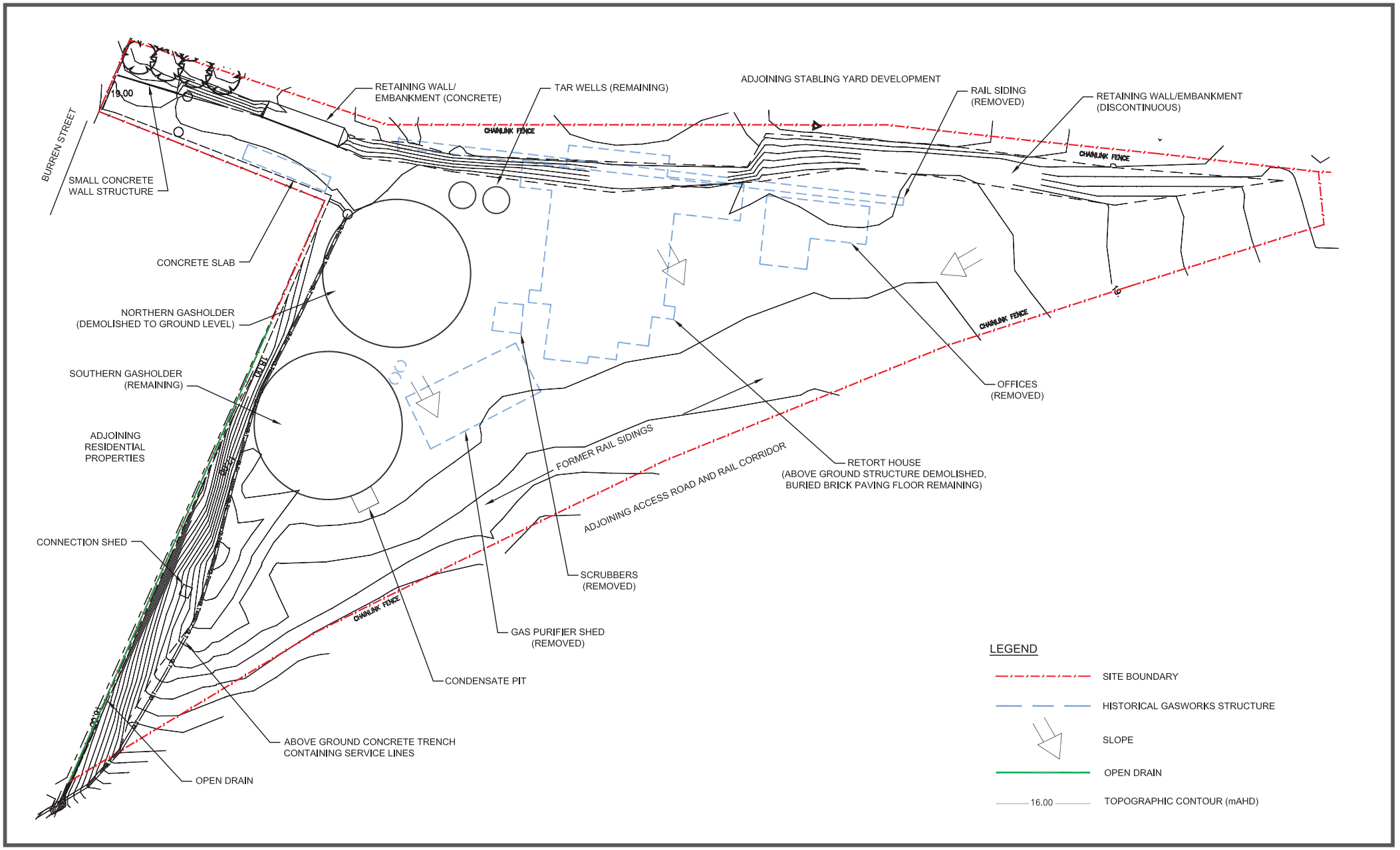
0 50m

Approximate scale

Figure 3 **Site Areas**

CH2M Hill (2007)
Note- All locations shown are approximate only



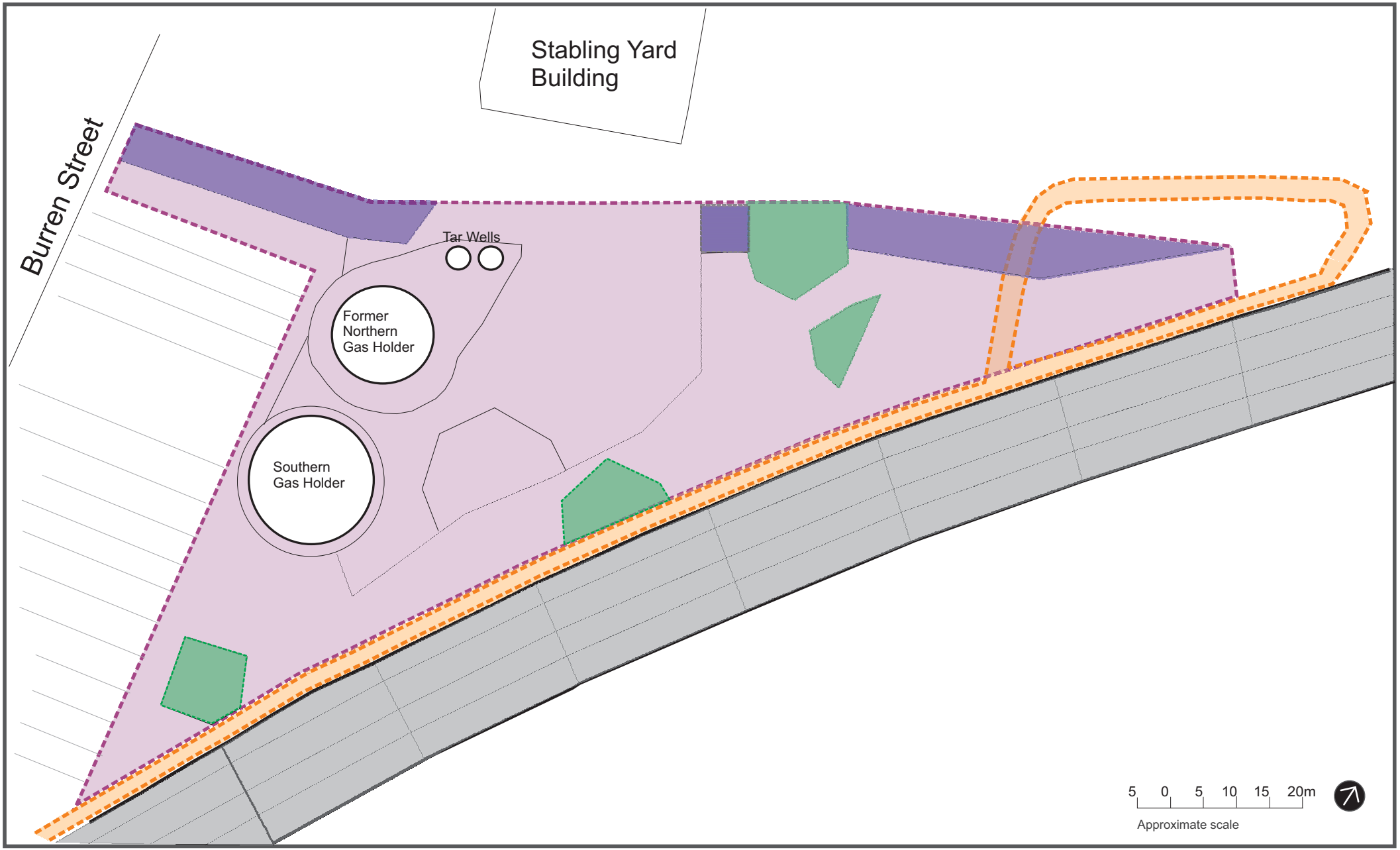
JBS ENVIRONMENTAL

0 50m

Approximate scale

Figure 4 **Location of Historical Gasworks Infrastructure**

CH2M Hill (2007)
Note- All locations shown are approximate only



Site Boundary

Task 1A - assessment of blue area for suitability to remain on site

Task 1B - installation of access road turning circle

Task 1C - strip off top 0.5 of fill (for remediation by cement stabilisation)

Task 1D - Excavate and validate hotspots (for remediation by cement stabilisation)

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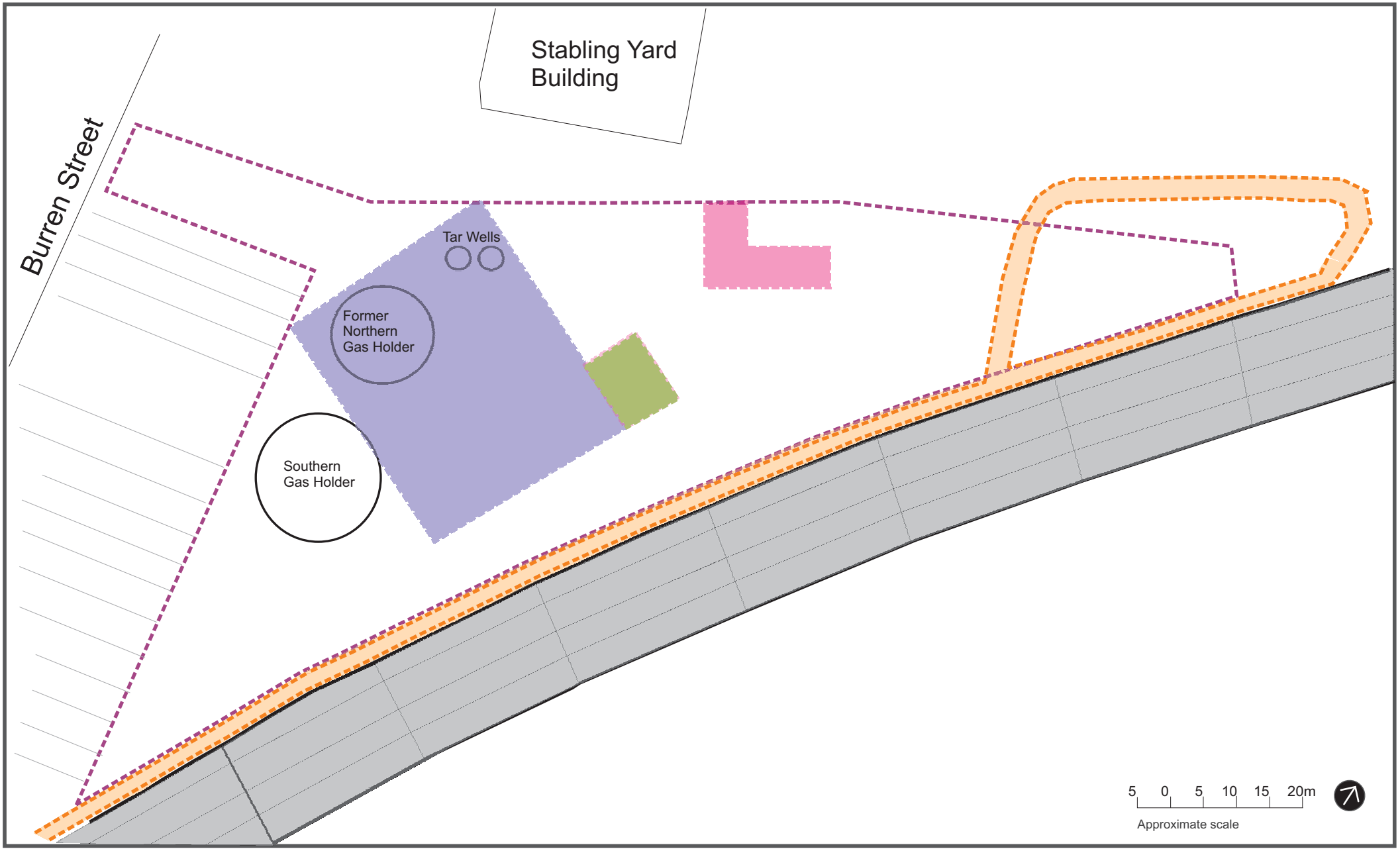
Figure 5 **Former Macdonaldtown Gasworks - Remediation Stage One Works**

As adapted from Figure 4 CH2M Hill 2007



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- Site Boundary
- Temporary Enclosure
- Air Emissions Treatment System
- Water Treatment System
- Site Access Road
- Water Treatment System

Figure 6 **Macdonaldtown Remediation Proposed Site Setup**

As adapted from Figure 4 CH2M Hill 2007

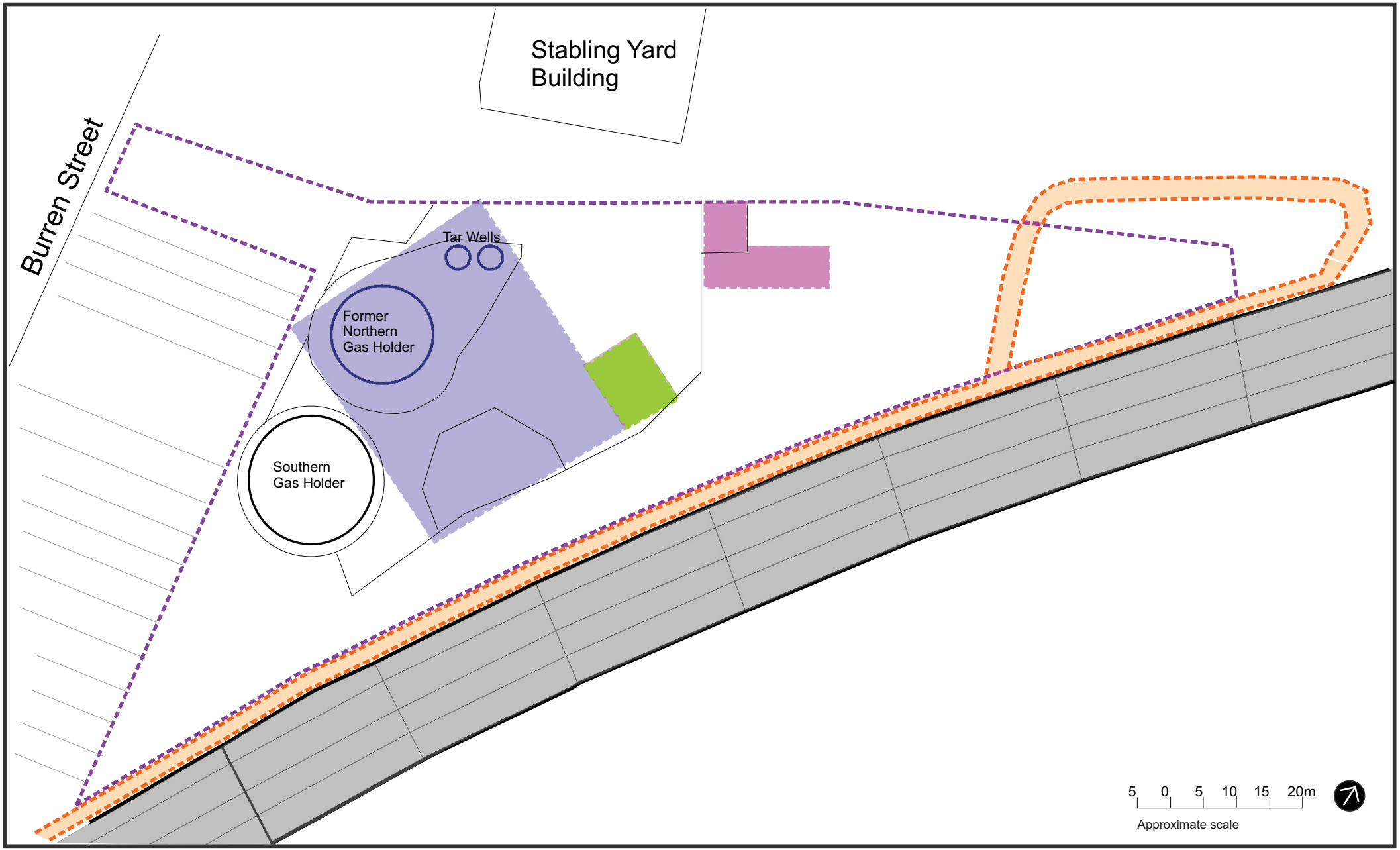
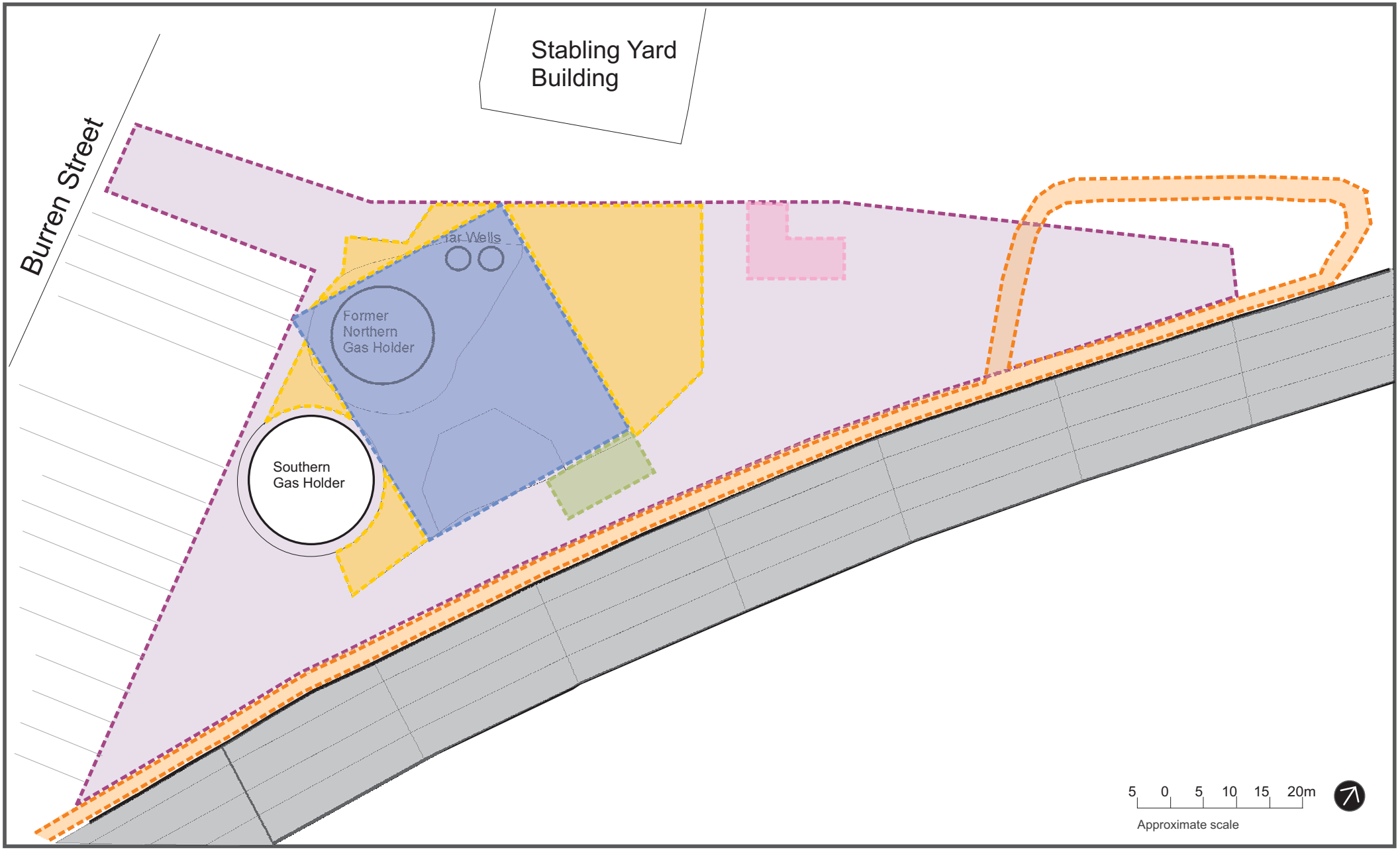


Figure 7 **Former Macdonaldtown Gasworks - Remediation Stage 2**

As adapted from Figure 4 CH2M Hill 2007



Site Boundary

Task 3A - excavate areas of impact and assess potential for bioremediation

Potential Stockpiling areas

Figure 8 **Former Macdonaldtown Gasworks - Remediation Stage Three Works**

As adapted from Figure 4 CH2M Hill 2007

LEGEND

Zone suitable for placement of uncovered stockpiles provided criteria below are satisfied

Contaminant	Odour Based Criteria for Uncovered Stockpiling (mg/kg)
Benzene	2.5
Ethylbenzene	5
Toluene	10
Xylene (total)	10
Cresols	_
Acenaphthene	35
Naphthalene	25
Phenol	40

Zone unsuitable for placement of uncovered stockpiles

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0 100m

Approximate scale

Figure 9 **Stockpiling Zones**

CH2M Hill (2007)
Note- All locations shown are approximate only