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LIDCOMBE 2 PTY LTD

REMEDIATION ACTION PLAN

18-24 RAILWAY STREET, LIDCOMBE NSW

Report E23006 AB_Rev 0

29 September 2016

REPORT DISTRIBUTION

Remediation Action Plan
18 - 24 Railway St, Lidcombe, NSW

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Copies	Recipient
1 Soft Copy (PDF – Secured, issued by email)	Mr Adrian Giardina Lidcombe 2 Pty Ltd Suite 802, Level 8, 117 York Street, Sydney NSW 2000 Email: agiardina@pyetyhp.com.au
Original (Saved to Digital Archives)	EI Australia Suite 6.01, 55 Miller Street, PYRMONT NSW 2009

Author	Technical Reviewer
	
Mariana Torres Environmental Engineer	**Greg Brickle** Principal Environmental Scientist

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EXECUTIVE SUMMARY

Background

This Remediation Action Plan (RAP) outlines the methods and procedures that will be used to remediate the site identified as 18 - 24 Railway St, Lidcombe, NSW ('the site') to a condition suitable for residential land use with minimal access to soils, without the need for ongoing environmental monitoring.

At the time of report preparation 18 Railway Street was occupied by Kitchen and Joinery fabricators comprising a one storey warehouse covering the footprint of the site, 20 Railway Street was occupied by Emons Furniture distributors comprising a two storey warehouse, 22 Railway Street was occupied by a yard covering the majority of the footprint of the site and a small rendered one storey brick and timber office structure and 24 Railway Street comprised a petrol station/mechanical workshop.

Site History

Historical uses of the site have been primarily commercial since the 1930's, with occupation by distributors of memorial supplies (head stones), a welding and metal fabrication workshop, an auto repair shop, distributors of carpets and furniture, and fabricators of kitchens and joinery. Land titles information indicates that the service station has occupied Lot 1 (24 Railway Street) since 1957.

SafeWork NSW records indicated the presence of four underground tanks used to store petroleum fuels at 24 Railway Street. Correspondence indicated three underground tanks were decommissioned at 18 Railway Street in 1994.

Sub-surface Conditions and Impacted Areas

Previous investigations have identified:

- Fill soils of gravelly sands and sandy clay soils in an upper-most horizon and ranging in depth from 0.4 m to around 1.1 m below ground level (BGL) across the whole of the site. Fill was underlain by residual sandy clay to a depth range of 1m to 2.4m BGL and then shale to a depth of 4.7m+ BGL.
- Groundwater occurred at an average standing water level of 3.78 m to 5.83 m BGL. The main aquifer lies within fractured Ashfield Shale.
- Statistical analysis of the available data set, which included previous investigation results (EI, 2016), indicated that elevated lead at BH1M (1900 mg/kg) and BH11 (1400 mg/kg) did not represent hotspots and will therefore be managed with surrounding residual fill for offsite disposal to licensed landfill, under the appropriate waste classifications.
- Asbestos in (cement sheeting fragment/fibre bundle) was reported at location BH9 and was identified as a hot spot.
- The following groundwater quality impacts were also identified:
  - Metals zinc, nickel and copper were reported in excess of the adopted groundwater investigation levels (GILs), however, only two wells BH1M (EI, 2016) and BH12M (ASSET, 2016) of the five available wells made sufficient water for characterisation and sampling; and
  - Groundwater VOCs were reported below the PQL with the exception of 2-nitroproprane (130 ug/L) at BH12M. No other VOCs were reported in groundwater.

Data Gaps

The following data gaps were found to require closure by supplementary investigation and contamination delineation works:

- Soil characteristics within the footprint of the warehouse on 20 Railway Street;
- The condition of underground petroleum storage systems (UPSS) (USTs and associated infrastructure) at the service station (24 Railway Street);
- Groundwater characteristics particularly in the vicinity of UPSS; and
- Potential presence of hazardous materials present within the existing structures.

Remediation Strategy

The preferred remedial option for the site is for offsite disposal to licensed waste facilities of all impacted fill soils, followed by site reinstatement with validated, imported excavated natural materials for the proposed deep soils area (172 m^2) on the south eastern side of the site. , Validation assessment was required to confirm that remaining site soils are suitable for the proposed residential land use, without the need for ongoing environmental management or monitoring. The required work stages are outlined as follows:

- Stage 1 – Site Preparation
- Stage 2 – Data gap closure investigations (Soils and groundwater)
- Stage 3 – UPSS Removal and Validation
- Stage 4 – Contaminated soil hotspot removal
- Stage 5 – Removal of remaining fill
- Stage 6 – Site Validation
- Stage 7 – Validation Report Preparation

Should unexpected finds be discovered during the course of the site remediation, the procedures described under the Unexpected Finds Protocol and the Site Validation Plan will be implemented, until the site remediation goals have been achieved and the site is deemed suitable for the intended land use.

Following completion of site remedial and validation assessment works, a Site Validation Report will be prepared in accordance with the OEH (2011) *Guidelines for Consultants Reporting on Contaminated Sites.*

1 INTRODUCTION

1.1 BACKGROUND

Mr Adrian Giardina of Lidcombe 2 Pty Ltd (the client) engaged EI Australia Pty Ltd (EI) to prepare a Remediation Action Plan (RAP) for the property located at 18 - 24 Railway St, Lidcombe, NSW ('the site').

The remediation approach detailed in this RAP follows on from a Detailed Site Investigation conducted by EI during June 2016, as documented in a report titled *18-24 Railway Street, Lidcombe, NSW* (Ref. EI Report No. E23006 AA_Rev0, dated 23 June 2016).

The site is approximately 2,323 m^2 in area and located 17 km west of the Sydney central business district, within the Local Government Area of Cumberland Council.

The site is located within a mixed commercial and residential area and is currently occupied by Kitchen and Joinery fabricators, furniture distributors and a petrol station/mechanical workshop.

The purpose of this RAP is to guide remediation works required to make the site suitable for the proposed residential land uses, with minimal access to soil.

1.2 PROPOSED DEVELOPMENT

The proposed development comprises a nine storey mixed use commercial and residential building with associated two level basement car parking facilities. A 495 m^2 retail area is situated at the ground floor level off Railway Street. A courtyard is situated on the ground level at the south eastern side of the site. The footprint of the building and basement occupies almost the entire site area except for 172 m^2 deep planting area on the south eastern boundary of the courtyard.

1.3 OBJECTIVES

The main objective of this RAP is to inform and guide the site remediation and validation assessment process by:

- Providing detailed procedures on how to carry out remediation works in a safe and environmentally friendly manner, while minimising impacts to human health (including site workers and the general public) and the environment;
- Providing a sampling and analytical quality plan to be used for site validation, and
- Complying with the DA Conditions for the development.

1.4 REGULATORY FRAMEWORK

The following regulatory framework and guidelines were considered during the preparation of this RAP:

Legislation

- *Contaminated Land Management Act 1997* (CLM Act 1997);
- *Protection of the Environment Operations Act 1997* (PoEO Act 1997) and associated Regulations including *UPSS Regulation 2014* and *Waste Regulation 2014*;
- *State Environment Protection Policy 55 – Remediation of Land (SEPP 55)* under the *Environmental Planning and Assessment Act 1997* (EP&A Act 1997);
- City of Sydney *Contaminated Land Development Control Plan 2004*; and
- *Work Health and Safety Act 2011* (WHS Act 2011) and associated Regulations and Codes of Practice.

Guidelines

- ANZECC & ARMCANZ (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*;
- DEC (2007) *Guidelines for the Assessment and Management of Groundwater Contamination*;
- DEC (2006) *Guidelines for the NSW Site Auditor Scheme* (2nd Edition);
- DECCW (2009) *Guidelines for Implementing the Protection of the Environment Operations (Underground Petroleum Storage Systems) Regulation 2008*
- EPA (1995) *Sampling Design Guidelines*;
- NEPM (2013) Schedule B(1) *Guideline on Investigation Levels for Soil and Groundwater*;
- NEPM (2013) Schedule B(2) *Guideline on Site Characterisation*;
- NSW EPA (2012) *Guidelines for the Assessment and Management of Sites Impacted by Hazardous Ground Gases*
- OEH (2011) *Guidelines for Consultants Reporting on Contaminated Sites*; and
- WorkCover (2014) *Managing Asbestos In or On Soil.*

1.5 SCOPE OF WORK

With the aim of achieving the above objectives while generally complying with the OEH (2011) Guidelines for Consultants Reporting on Contaminated Sites, the scope of work included:

- Review and assessment of the available data relevant to the remediation of the site and provided by the previous investigation reports for the site;
- Definition of remediation goals and acceptance criteria;
- Review and assessment of the latest technical literature on remediation technologies relevant to the site and relevant case studies;
- Technical assessment of alternative remediation technologies;
- Evaluation of available remediation options and selection of the most appropriate remedial strategy (or combination of strategies) for the site;
- Provision of information so that remedial works may be carried out in accordance with relevant laws and regulations;

- Provision of guidance on approvals and licences required for the remedial works, under current legislation (e.g. SEPP 55);
- Provision of information to assist the contractor in their preparation of a Work Health and Safety Plan and other site management/planning documents;
- Development of a sampling, analysis and quality strategy for hotspot delineation and post-remedial validation.

The RAP also outlines measures for the excavation, stockpiling, management and disposal of spoil, water and sediment controls, as well as a contingency plan to handle any additional contamination that may be identified during the additional investigations and/or site remedial works. The measures provided in this RAP are brief, and are designed to accompany site specific management plans. These measures do not replace any other requirements for the site as a whole. A complete set of site specific management plans should be developed and adhered to. An outline of management measures to be addressed is provided in **Section 7.3**.

1.6 DEVIATIONS FROM THIS RAP

While it may be possible to vary the sequence and/or details of the actual site remediation and validation works to meet site constraints, a qualified Environmental Scientist performing the roles of Environmental Management Coordinator and Remediation Supervisor will be appointed to the project to ensure that:

- Critical stages of the site remediation/validation process (including, but not limited to, proper site induction of site personnel in relation to contamination hazards and environmental management issues, marking of remediation areas, inspection of environmental monitoring systems, implementation of specified control measures and required data gap closure and validation sampling), are appropriately supervised, implemented and documented, with the relevant data collected for environmental reporting purposes; and
- Any deviations from the works specified in this RAP are properly documented and approved, as required under the OEH (2011) *Guidelines for Consultants Reporting on Contaminated Sites*.

Performing remedial works without the presence of a qualified environmental engineer/scientist when necessary may lead to project delays and extra costs due to additional environmental investigation requirements imposed by a Qualified Independent Consultant or the appointed Site Auditor, to confirm the environmental status of the site.

In worst case scenarios, waste materials removed from the site without proper characterisation and/or waste classification assessment, may lead to regulatory action and potential penalties, as described under the *Waste Regulation 2014*, the *Protection of the Environment Operations Act 1997* and the *Contaminated Land Management Act 1997*.

2 SITE DESCRIPTION

2.1 PROPERTY IDENTIFICATION, LOCATION AND PHYSICAL SETTING

The site identification details and associated information are presented in **Table 2-1**.

Table 2-1 Site Identification, Location and Zoning

Attribute	Description
Street Address	18 - 24 Railway St, Lidcombe, NSW
Location Description	Approximately 17 km west of the Sydney CBD. Bound by Railway Street then a rail corridor north, commercial buildings east, Mark Street then commercial buildings west and commercial and residential structures south. North western corner of site under GDA94-MGA56 coordinates: Easting: 319274.819, Northing: 6251142.953 (Source: http://maps.six.nsw.gov.au).
Site Area	Approximately 2,323 m^2
Site Owner	Lidcombe 2 Pty Ltd
Lot and Deposited Plan (DP)	Lots 1, 2, 3 and 4 Section 2 in DP 846
State Survey Marks	Three State Survey Marks are situated in close proximity to the site: • SS63353D located at the north western corner of the site on Railway Street; • SS118708 located 30 m south west across Mark Street; and • SS63352 located 81m east of the site on Railway Street. (Source: http://maps.six.nsw.gov.au)
Local Government Authority	Cumberland Council
Parish	Liberty Plains
County	Cumberland
Current Zoning	B4 – Mixed Use (Auburn Local Environment Plan, 2010)
Recent Land Uses	18 Railway Street - Kitchen and Joinery fabricators comprising a one storey warehouse covering the footprint of the site. 20 Railway Street - Emons Furniture distributors comprising a two storey warehouse. 22 Railway Street - yard covering the majority of the footprint of the site and a small rendered one storey brick and timber office structure on the south eastern side of the site. 24 Railway Street - petrol station/mechanical workshop.

2.2 SURROUNDING LAND USE

The site is situated within an area of mixed land uses and current land use on surrounding properties are described in **Table 2-2**.

Table 2-2 Surrounding Land Uses

Direction	Land Use Description	Sensitive Receptors (& distance from site)
North	Railway Street then a rail corridor and Auburn Train Station followed by commercial and residential dwellings.	Residential properties north of the rail corridor, Saint Joseph's Child Care Centre to the north east.
South	Unnamed street lane then residential and commercial structures.	Lidcombe Remembrance Park, followed by residential properties.
East	Commercial structures followed by Friends Park and Rookwood Cemetery.	Friend Park in proximity to the south eastern corner of the site. Choice Child Care on East Street.
West	Mark Street then commercial structures	Cornwall Cottage child care centre south west of the site.

Overall, land uses up-gradient of the site are mainly commercial and residential in nature.

2.3 REGIONAL SETTING

Regional topography, geology, soil landscape and hydrogeology are summarised in **Table 2-3**.

Table 2-3 Regional Setting Information

Attribute	Description
Topography	Gently undulating rises with local relief between 10-30m. Slopes are generally <5% but occasionally up to 10%. Crests and ridges are broad (200-600m) and rounder with convex upper slopes grading into concave lower slopes and broad drainage depressions and valley flats.
Site Drainage	Based on observations on-site, stormwater is anticipated to be diverted by pit and pipe drainage to the municipal stormwater system or as subsurface infiltration or overland flow to Haslams Creek.
Regional Geology	Information on regional sub-surface conditions, referenced from the Department of Mineral Resources Geological Map Sydney 1:100,000 Geological Series Sheet 9130 (DMR 1991), indicated that the site overlies Ashfield Shale (Rwa) of the Wianamatta Group. Ashfield Shale is characterised by black to dark grey shale and laminite.
Soil Landscapes	The site lies on the boundary of the Birrong and Blacktown landscapes, characterised by moderately reactive, highly plastic subsoils, low fertility, poor drainage, high erosion hazards, saline subsoils, localised flooding and seasonal waterlogging.

Attribute	Description
Acid Sulfate Soil Risk	The Auburn Council LEP 2012 (Acid Sulfate Soils Map Sheet ASS_007) shows the site to be within areas mapped as Class 5 Acid Sulfate Soils (ASS). Acid sulfate soils are not typically found in Class 5 areas. Areas classified as Class 5 are located within 500 metres on adjacent class 1, 2, 3 or 4 land. Works in a class 5 area that are likely to lower the water table below 1 metre AHD on adjacent class 1, 2, 3 or 4 land will trigger the requirement for assessment and may require management.
Site Filling	Based on observations during previous investigations the maximum depth of surficial fill across the site is anticipated to range between 0.8 and 1.1 m bgl. The fill was observed to comprise gravelly sand and sandy clay.
Typical Soil Profile	**Fill** – Gravelly SAND, fine to medium grained, brown, gravel is angular sub-angular (varying thickness 1.0-1.1). sandy CLAY, low to medium plasticity, brown / orange mottled grey, mottled orange (varying thickness 0.2-0.8 m); **Residual** – Sandy CLAY; low plasticity, orange / grey / dark grey (varying thickness from 1.0 – 2.4 m); **Bedrock** – Shale, inferred extremely weathered / grey / brown / dark brown. Based on DSI (EI, 2016).
Depth to Groundwater	Groundwater was previously encountered between 3.78 m and 5.83 m BGL during EI's DSI conducted in June 2016.
Nearest Surface Water Feature	Haslams Creek situated 820 m west of the site draining into Homebush Bay situated 4 km north east of the site.
Groundwater Flow Direction	North towards Homebush Bay, which joins Parramatta River draining to Sydney Harbour.

2.4 GROUNDWATER USE

An online search of registered groundwater bores was conducted by EI on 27 May 2016 through NSW Office of Water online database (Ref: http://allwaterdata.water.nsw.gov.au/water.stm). There was one registered bore within 1 km of the site of the site. The identified bore and its direction and distance from the site are listed in **Table 2-4**.

Table 2-4 Registered Groundwater Bores within 500 m of the Site

Bore No.	Registered Use	Bore Depth (m BGL)	SWL	Approximate Location (in relation to site)
GW111940	Monitoring Bore	6.10	-	277m – south-east

Notes: - Data not recorded; SWL: Standing water level (presumably) measured in m BGL.

The registered bore was located up hydraulic gradient relative to the site. The drilled bore depth was registered at 6.10 m BGL, water table information was not available at the time of reporting. Given the available reticulated water supply in the region, the likelihood of groundwater being used for drinking purposes in the local area was considered to be low (EI, 2016).

3 SITE CHARACTERISATION

3.1 PREVIOUS INVESTIGATION REPORTS

A previous environmental investigation was conducted by EI for 18 - 24 Railway Street, Lidcombe as follows:

- *Detailed Site Investigation, 18 - 24 Railway Street, Lidcombe, New South Wales,* for Lidcombe 2 Pty Ltd, Report No. E23006 AA, dated 23 June 2016 (EI, 2016); and
- *Report on Geotechnical Investigation Proposed Mixed Use Development 18-24 Railway Street,* Lidcombe NSW, Report No. 3688 – R1 dated 3 June 2016.

3.2 SUMMARY OF PREVIOUS INVESTIGATION FINDINGS

The findings of the previous investigations showed that:

- Historical operations have been primarily commercial since the 1930's and included distributors of memorial supplies (head stones), welding/metal fabricators, auto repair shop, carpet and furniture distributors and kitchen and joinery fabricators. Land titles information indicates that a service station/mechanical workshop has occupied Lot 1 (24 Railway St) since 1957.
- The site is covered by a layer of fill of gravelly SAND and sandy CLAY to a depth ranging from 0.4 mBGL to 1.1 mBGL, overlying residual sandy CLAY to a depth ranging from 1.0 mBGL to 2.4 mBGL and shale at depth to a depth ranging from 4.7-6.9 mBGL.
- Groundwater was measured at standing water levels of 3.78m to 5.83m BGL (generally screening 2.8 – 8.5 m BGL); and

Laboratory analytical results for soil and groundwater were reported and summarised as **Tables T1 to T4** in the **Tables Appendix** (EI, 2016). Soil and groundwater results are summarised statistically in **Tables 3-1** and **3-2**. A more detailed statistical analysis of the data for Lead in soils, assessing the 95% UCL average concentrations and whether soil contamination hotspots are present onsite, is provided in **Section 3.4.1**.

Table 3-1 Summary of Soil Analytical Results

No. of primary samples *	Analyte	Min. Conc. (mg/kg)	Max. Conc. (mg/kg)	Sample locations > ILs (All exceedences were in Fill)
Heavy Metals				
21	Arsenic	<3	260	None
21	Cadmium	<0.3	0.8	None
21	Chromium (Total)	1.8	21	None (Compared to chromium VI criteria)
21	Copper	11	58	None
21	Lead	7	1900	Samples exceeding HIL B: BH1M_0.5-0.6 (1900 mg/kg), BH11_0.2-0.3 (1400 mg/kg)
21	Mercury	<0.01	0.48	None

No. of primary samples *	Analyte	Min. Conc. (mg/kg)	Max. Conc. (mg/kg)	Sample locations > ILs (All exceedences were in Fill)
21	Nickel	1.4	28	None
21	Zinc	13	480	None
Total Recoverable Hydrocarbons (TRH) and BTEX				
21	F1	<25	<25	None
21	F2	<25	66	None
21	F3	<90	<90	None
21	F4	<120	<120	None
21	Benzene	<0.1	<0.1	None
21	Toluene	<0.1	<0.1	None
21	Ethyl benzene	<0.1	<0.1	None
21	Total xylenes	<0.3	<0.3	None
Polycyclic Aromatic Hydrocarbons (PAHs)				
21	Naphthalene	<0.1	<0.1	None
21	Benzo(a)pyrene	<0.1	0.2	None
21	Carcinogenic PAHs*	<0.2	0.4	None
21	Total PAH	<0.8	3.3	None
Organochlorine (OCPs)				
10	Chlordane	<0.1	0.2	None
10	Other OCPs	ND	ND	None
Organophosphate Pesticides (OPPs)				
10	Total OPPs	ND	ND	None
PCBs				
10	Total PCBs	ND	ND	None
Asbestos				
11	>2mm to <8mm fibre bundles in 20*15*4 mm cement sheeting	<0.01	>0.01	BH9_0.2-0.3

Notes:

* Number of primary samples includes all EI soil samples and soil samples tested under SMEC, 2012.
** Carcinogenic PAHs as Benzo(a)pyrene TEQ (Ref. NEPM 2013, Schedule B1, Table 1A(1))
F1 = TPH (C6 - C10) minus the concentration of BTEX (Note: SMEC 2012 data applied: TPH C6-C9)
F2 = TPH (>C10 - C16) minus the concentration of Naphthalene (Note: SMEC 2012 data applied: TPH C10-C15)
F3 = TPH (>C16 - C34)
F4 = TPH (>C34 - C40)

Table 3-2 Groundwater Results Summary (SMEC 2012 & EI 2014, 2016)

No. of Primary Samples	Parameter	Lowest Detected Concentration (µg/L)	Maximum Concentration (µg/L)	Sample locations > GILs
Heavy Metals (dissolved)				
2	Arsenic	14	16	None
2	Cadmium	<0.1	<0.1	None
2	Chromium (total)	<1	<1	None
2	Copper	2	8	Sample exceeding GILs: BH1M (2 ug/L) BH12M (8 ug/L)
2	Lead	<1	<1	None
2	Mercury	<0.1	<0.1	None
2	Nickel	3	11	Samples exceeding GILs: BH1M (3 ug/L), BH12M (11 ug/L)
2	Zinc	56	250	Samples exceeding GILs: BH1M (56 ug/L), BH12M (250 ug/L)
TPHs				
2	F1	<50	<50	None
2	F2	<60	<60	None
2	F3	<500	<500	None
2	F4	<500	<500	None
BTEX				
2	Benzene	<0.5	<0.5	None
2	Toluene	<0.5	<0.5	None
2	Ethyl Benzene	<0.5	<0.5	None
2	Total Xylenes	<1.5	<1.5	None
Total VOCs				
2	Total VOCS	ND	ND	None
Chlorinated VOCs				
2	2- Nitropropane	<100	<130	Samples exceeding adopted criteria (US EPA Region 9 SSLs of 21ug/L): BH12M (130 ug/L)

Notes:

For <PQL values, 1 x PQL used when calculating average concentration.
NR = No recommended (published) criterion. NA = Not analysed. ND = Concentration of tested sample is under practical quantitation limit.
NEPM (2013) NEPM GIL = NEPM 2013 Groundwater Investigation Levels for the protection of Marine Waters based on ANZECC/ARMCANZ (2000) Marine water trigger values at 95% protection level, unless otherwise indicated.
1 = NEPM (2013) Groundwater Investigation Levels for drinking water quality, based on Australian Drinking Water Guidelines (NHMRC 2011).
2 = ANZECC/ARMCANZ (2000) Marine water trigger values at 99% protection level are applicable for the bio-accumulative metals cadmium and mercury.
3 = NEPM (2013) Table 1A(4) Groundwater HSLs for vapour intrusion.
4 = ANZECC/ARMCANZ (2000) Low-reliability Marine Water Trigger Values for chlorinated alkenes, Ref. Table 8.3.13, Paper No. 4, Vol. 2, Chapter 8 Aquatic Ecosystems – Rationale and Background Information.

In summary, previous assessments of the site showed:

- Bonded Asbestos Containing Material (ACM) in the form of fibre bundles (>2mm to <8mm) within cement sheeting (dimensions 20 x 15 x 4 mm) at location BH9.
- Localised fill soil contamination in relation to lead as follows:
  - An elevated concentration of the heavy metal lead at BH1M (1900 mg/kg) and BH11 (1400 mg/kg), which exceeded the NEPM 2013 HIL-B criterion in shallow fill at 0.5 and 0.2 m bgl respectively.

Although lead was detected in fill soils at two locations, on review of the development plans these locations are within the proposed basement construction area and will be excavated and removed for offsite disposal to licensed landfill facilities. Therefore, EI (2016) concluded this concentration was not considered to pose any threat to human receptors, provided appropriate waste management measures are implemented during the basement excavation process.

- Groundwater quality impacts were identified as follows:
  - Groundwater zinc, nickel and copper concentrations have been detected at BH1M and BH12M.
  - 2-nitroproprane (130 ug/L) was detected at BH12M. No other VOCs were reported in groundwater.

EI noted that at the time of the GME on 2 June 2016 (three days after wells installation on 30 June 2016) that there was a very low level of groundwater encountered at BH4M, BH6M and BH7M. Therefore the water quality at these locations was not assessed during the DSI, and, EI recommended a further groundwater monitoring event of the five available monitoring wells.

3.3 Conceptual Site Model (CSM)

In accordance with NEPM (2013) *Schedule B2 – Guideline on Site Characterisation* and to aid in the assessment of data collection for the site, EI developed a preliminary conceptual site model (CSM) assessing plausible pollutant linkages between potential contamination sources, migration pathways and receptors. The CSM provides a framework for the review of the reliability and useability of the data collected and to identify data gaps in the existing site characterisation.

The CSM takes into account the change in land use from commercial to residential, involving the construction of a nine storey mixed use commercial and residential building with associated two level basement car parking facilities, as illustrated in the proposed development plans shown in **Appendix B**.

3.3.1 Subsurface Conditions

The general site geology encountered during the previous investigations (EI 2016) is described as a layer of anthropogenic filling overlying sandy clay material then shale at depth, as summarised in **Table 3-3**.

Table 3-3 Generalised Subsurface Profile

Material	Depth (m BGL)+	General Description
Concrete	0.0 to 0.1	Concrete
Fill	0 to max 1.1 (average thickness 0.7m)	Gravelly SAND, fine to medium grained, brown, gravel is angular, sub-angular, moist. Sandy CLAY, low to medium plasticity, brown / orange mottled grey / light grey mottled orange / moist, no odour\.
Residual	0.4 to 2.4	Sandy CLAY; low plasticity, orange/ grey / dark grey.
Shale	1.0 to 6.9	Extremely weathered grey / brown / dark brown dry no odour.

Notes: + Approximate depth shown as m BGL. Refer to borehole logs in **Appendix C** for specific information at individual test bore locations.

3.3.2 Contamination Sources

Site history search findings and previous intrusive investigations identified the following potential contamination sources:

- Imported fill soils of unknown origin distributed across the site for relevelling purposes;
- Impacts from previous commercial / industrial operations, including chemical leakage and spills from dangerous goods depots;
- Impacts from long-term oil / gasoline leaks from parked vehicles, auto repair shop;
- Potential leakage from underground petroleum storage systems (UPSS) including USTs, underground fuel lines, fill points, etc. from service station;
- Weathering of building structures (i.e. painted surfaces, metallic structures, etc.);
- Hazardous building materials including, potential asbestos-containing materials resulting from uncontrolled demolition of former building structures on-site;
- Hazardous building products present in existing structures (leaded paint, fluorescent light capacitors, and asbestos-containing materials).

3.3.3 Chemicals of Concern

Based on the findings reported in EI's Detailed Site Investigation (EI, 2016), the chemicals of concern for site remediation, validation and data gap closure are as follows:

- **Soil** – heavy metals (HMs), total recoverable hydrocarbons (TRH), polycyclic aromatic hydrocarbons (PAH), benzene, toluene, ethylbenzene and xylenes (BTEX), organochlorine and

organophosphorus pesticides (OCP/OPP), polychlorinated biphenyls (PCB), total phenols, volatile organic compounds (VOC), and asbestos; and

- **Groundwater** – heavy metals (HMs), TRHs, PAHs, BTEX, VOCs.

3.3.4 Potential Sources, Exposure Pathways & Receptors

Potential contamination sources, exposure pathways, human and environmental receptors that were considered relevant for this assessment are summarised along with a qualitative assessment of the potential risks posed by complete exposure pathways in **Table 3-4**.

Table 3-4 Presentation of the Conceptual Site Model

Contamination Source	Transport Mechanism	Exposure Pathway	Potential Receptor	Likelihood of Exposure
Impacted soils	Dermal contact, dust inhalation or ingestion	Ingestion and dermal contact, inhalation of asbestos fibres during site redevelopment and/or future public use	Construction phase workers and end users of the residences	Unlikely – for end users, if remedial action results in the complete removal of fill from the site. (i.e. offsite removal to licensed landfill; and Low – for site workers, since: • Previously identified Asbestos was bonded ACM at one location (BH9) in fill; and • If appropriate WH&S measures (e.g. wearing of PPE, wetting of exposed soils, mist used to control dust) are implemented during site remediation works.
	Atmospheric dispersion from soil containing Asbestos	Inhalation of asbestos fibres from impacted soil disturbed during site remediation works / site maintenance works	Workers and/or end users of the residences, as well as general public and neighbouring residents	Unlikely – for end users, if remedial action results in the complete removal of fill from the site. (i.e. offsite removal to licensed landfill; and Low – for site workers, since: • Previously identified Asbestos (EI, 2016) was in bonded ACM form; and • If appropriate WH&S measures (e.g. wearing of PPE, wetting of exposed soils, mist used to control dust) are implemented during site remediation works.
	Volatilisation & diffusion from soil / soil vapour to indoor air spaces	Inhalation of vapours from CVOC.	Workers and/or end users of the residences	Unlikely – Given no concentrations were reported in soil.
Impacted Groundwater	Contact with impacted groundwater	Dermal contact, ingestion and inhalation of vapours	Offsite groundwater users	Low likelihood – Given the available reticulated water supply in the region.
		Potential seepage into deep basements	Offsite users of constructed basements that are not water tight	Low likelihood – groundwater seepage is not likely due to: • groundwater CVOC concentrations are very low to non-detectable (GME, June 2016), as reported in EI, 2016.
	Migration of dissolved phase impacts in groundwater	Ingestion and dermal contact	Aquatic organisms and recreational water users	Low likelihood - as attenuation processes (dilution, dispersion and adsorption) would be expected to diminish groundwater concentrations along the flow path to Homebush Bay situated 4 km north east of the site.

Contamination Source	Transport Mechanism	Exposure Pathway	Potential Receptor	Likelihood of Exposure
		Contact with groundwater if extracted for recreational use	Offsite groundwater users	Contact with groundwater is unlikely as there are no offsite registered, down-gradient bores being used for groundwater supply purposes.
	Volatilisation from groundwater to indoor or outdoor air spaces	Inhalation of vapours from impacted groundwater	Residential users of the site	Unlikely as groundwater is not significantly impacted with CVOCs (concentrations are very low to non-detectable). This will be reviewed subject to additional groundwater quality assessment findings, which will be conducted as part of Groundwater Data Gap Closure investigations (see Section 6.2.8).

3.4 EXISTING SITE CONTAMINATION

3.4.1 Contamination Hotspots and Residual Impacts

EI conducted a statistical analysis of lead exceedances as part of this RAP. Statistical results did not indicate the distribution of lead to represent a contamination hotspot. Results of the analysis are summarised in **Table 3 5**.

Table 3-5 Statistical Analysis Summary

Test Qty *	Analyte	Max. Depth (m) **	Max. Conc. (mg/kg)	SD	95% UCL mean	IL	Sample(s) with max. conc.	Max. Depth (m bgl)	Max. > 250% of IL	SD > 50% of IL
21	Lead	0.6	1900	491.2	223.2	1200	BH1M_0.5-0.6	0.6	No	No

Notes:
IL = Investigation Level, Tier 1 screening criteria (NEPM 2013 HIL-B criteria).

3.5 EXTENT OF REMEDIATION REQUIRED

3.5.1 Remediation Areas

Based on all existing site characterisation data the areas of the site requiring remediation are illustrated in **Figure 2** and outlined as follows:

- **UPSS** – the four known, underground storage tanks (10kL to 55kL) located at 24 Railway Street, Lidcombe , require appropriate offsite removal and destruction in accordance with SafeWork NSW regulations, with supply of disposal documentation.
- **Asbestos Soil Hotspot** – fill soils previously identified with asbestos impacts at BH9 require excavation to an estimated depth of around 0.8 m BGL and offsite disposal after waste classification, followed by validation assessment of excavation surfaces.

3.5.2 Approximate Soil Volumes

The excavation and offsite disposal remedial option should ensure no sources of soil contamination remain that would trigger the requirement for ongoing environmental management and monitoring.

As shown in **Table 3-6**, it is estimated that a total approximate in-situ volume of 1,309 m^3 of fill/soil is to be excavated for the remedial works. However the degree of excavation and quantity of fill/soil requiring disposal from UPSS remediation is unknown, as there is limited information available regarding alignment of the USTs.

Further in-situ characterisation of fill material is required to adequately classify the soils to be removed as waste, and may assist by informing the segregation of further potentially asbestos-impacted materials.

Table 3-6 Approximate Excavation Volumes

Area	Approximate In-situ Volume	Excavation Area- Approximate Dimensions	
	(m^3)	Area (m^2)	Depth (m)
Soil Asbestos Area (hotspot BH9)	17.5 (5 m x 5 m x 0.7)	25 (5 m x 5 m)	0.7
UPSS	300 (10m x 10m x 3m (less tank void)	100	3
Fill (after hotspot removal)	1,309	2,198	0.7
Total Estimated Volume of fill	**1,626**	2,323	

Notes: * Residual fill volume was calculated as Total fill volume minus total contaminated hotspot/plume volume. Residual fill may contain asbestos which will require appropriate management and waste classification, in accordance with the procedures described in this RAP.

4 REMEDIATION GOALS & CRITERIA

4.1 REMEDIATION GOALS

The remediation goals for this RAP, are consistent with NSW EPA, SEPP 55 guidelines and Council's contaminated land policy, and include:

- Meeting the conditions of the planning consent and to render the site suitable for the proposed land use(s);
- Demonstrating that the proposed remediation strategy for the site is environmentally justifiable, practical and technically feasible;
- Adopting clean-up criteria appropriate for the future use of the site to mitigate possible impacts to human health and the environment;
- Mitigating possible off-site migration of contaminants (including migration in existing utilities such as the sewer, stormwater and other subsurface pipes or service trenches);
- Consideration of the principles of ecologically sustainable development in line with Section 9 of the Contaminated Land Management Act 1997;
- Minimising waste generation under the Waste Avoidance and Resource Recovery Act 2001;
- To remediate all contamination at the site so there are no unacceptable risks to off-site receptors;
- To remediate the site to a condition where any residual contamination does not require long-term management using an EMP; and
- Demonstrating that the plans for site management of remediation work consider work health and safety, environmental management, community relations and site contingencies.

4.2 DATA GAP CLOSURE INVESTIGATIONS

A number of data gaps remain for the site, which need to be closed to enable the appropriate level of remedial action for the proposed site redevelopment. The following data gap closure investigations will therefore be carried out prior to the commencement of site remediation:

- Soil characteristics within the footprint of the warehouse on 20 Railway St.
- Groundwater characteristics particularly in the vicinity of UPSS. Wells BH4M, BH6M and BH7M did not make sufficient water and so could not be tested at the time of reporting; and
- Potential presence of hazardous materials present within the existing structures.

4.3 REMEDIATION CRITERIA

4.3.1 Soil Remediation (Validation) Criteria

As the proposed site development will comprise a residential use with minimal access to soils, the following soil remediation criteria, which are based on NEPM (2013) *Schedule B1 Guideline on Investigation Levels for Soil and Groundwater*, will be adopted as clean up levels for the applicable areas of the site:

Residential with minimal access to soil areas

- NEPM 2013 *Residential B Health-based Investigation Levels* (HIL B) for residential settings with minimal opportunities for soil access;
- NEPM 2013 *Recreational C Health-based Investigation Levels* (HIL C) for soils in the proposed deep soil area to be used for recreational/open space ;
- NEPM 2013 *Soil Health Screening Levels* for vapour intrusion (HSL D) threshold for commercial / industrial sites for vapour intrusion within areas of the proposed building area located above the basement carpark.
- NEPM 2013 Ecological Investigation Levels (EIL) and Ecological Screening Levels (ESL) for the protection of terrestrial ecosystems in urban residential settings.

The contaminant threshold values relating to the adopted soil remediation criteria are tabulated in **Appendix D, Table E-1**. Conformance with the soil remediation criteria will be deemed to have been attained when soil validation samples from similar lithology and depth show contaminant concentrations that are below the specified criteria, or, as a minimum, the 95% upper confidence limit (UCL) mean concentration values of each contaminant in the soil remediated area (i.e. across the excavated surface), are below the respective remediation criteria.

4.4 Waste Criteria

Prior to being removed from the site, excavated soils must be classified in accordance with the DECCW (2014) Waste Classification Guidelines (the 'Waste Guidelines'). Under these guidelines, fill/soils may be classified into the following groups: *General Solid Waste*, *Restricted Solid Waste* or *Hazardous Waste*, subject to chemical assessment using NATA-registered laboratory methods for total and leachable contaminant levels.

The total contaminant threshold concentrations and leachate thresholds tested using the TCLP methodology for each relevant contaminant parameter will then be interpreted against the respective DECCW (2009) thresholds, which are presented in **Appendix D, Tables E-2** and **E-3**, in order to classify the waste soils. Any soils containing asbestos would also be classified as *Special Waste - Asbestos Waste*. In accordance with the *NSW Waste Regulation 2014*, waste soils must only be disposed to a waste facility that is appropriately licenced to receive the incoming waste. It is therefore recommended that confirmation of acceptance is obtained from the waste facility prior the materials being removed from the site.

Should the analytical results exceed the SCC2 and/or TCLP2 thresholds, then the materials will be classified as *Hazardous Waste*. In such cases, material stabilisation treatment with EPA approval may be required prior to offsite disposal. Unexpected material may need to be segregated depending on the source of the waste, prior to conducting waste classification assessment. This approach is discussed in more detail under *Contingency Management* in **Section 7.4**.

4.5 Groundwater Criteria

Although groundwater remediation has not been confirmed as being required at this stage, the following groundwater assessment criteria will apply for any data gap closure investigations in relation to groundwater, given the proximity to Haslams Creek (nearest surface water receptor), which discharges to Homebush Bay:

- NEPM (2013) *Groundwater Investigation Levels* (GILs) for the protection of Marine Waters (based on ANZECC 2000); and
- NEPM (2013) GILs for the protection of Fresh Waters (for parameters not addressed by the Marine Water GILs).

5 REMEDIATION TECHNOLOGY

5.1 REGULATORY OVERVIEW

In order to attain an environmental outcome, the NEPM 2013 guidelines (Volume 1 Section 16) provides a preferred hierarchy of site remediation options and/or management as follows:

- On-site treatment of the contamination so that it is destroyed or the associated risk is reduced to an acceptable level; and
- Off-site treatment of excavated soil, so that the contamination is destroyed or the associated risk is reduced to an acceptable level, after which soil is returned to the site; or, if the above are not practicable:
- Consolidation and isolation of the soil on site by containment with a properly designed barrier; and
- Removal of contaminated material to an approved site or facility, followed, where necessary, by replacement with appropriate material; or,
- Where the assessment indicates remediation would have no net environmental benefit or would have a net adverse environmental effect, implementation of an appropriate management strategy.

When deciding which option to choose, the sustainability (environmental, economic and social) of each option should be considered, in terms of achieving an appropriate balance between the benefits and effects of undertaking the option.

Other considerations outlined by NSW EPA (2007) to mitigate groundwater contamination (if present) may include, but are not limited to:

- Notifying of the affected property (under the CLM Act, 1997) and the downgradient receptors;
- Containment of the contamination plume;
- Active or passive clean-up of contaminated groundwater (this may include the concept of Clean-up to the extent practicable or CUTEP) which may include ongoing monitoring of groundwater, and/or contingency plans and management plans to mitigate risks; and
- Legislative control through restricting groundwater use in and down-gradient of the contaminant plume.

For the subject site, a number of remediation options were reviewed to examine the suitability of each management method, the surrounding properties, geological and hydrogeological limitations and the following considerations:

- Development requirements (residential, with minimal access to soils);
- Prioritisation of works in areas of most concern;
- Ability of remedial method to treat contamination with respect to material and infrastructure limitations;
- Remedial timetable;
- Defensible method to ensure the site is remediated to appropriate levels / validation criteria; and
- Regulatory compliance.

5.2 REMEDIAL TECHNOLOGIES REVIEW

A number of soil and groundwater remediation options were reviewed to examine the suitability of each method, with due regard for the surrounding land uses, as well as the geological and hydrogeological limitations.

Brief discussion on the various remediation technology options is provided in **Appendix E**. Each of the available remediation technologies, except approaches that are not commonly used in Australia (e.g. in-situ thermal or steam injection), are summarised in terms of suitability for treatment of soils and groundwater in **Table 5-1**.

5.3 PREFERRED REMEDIATION OPTION

Based on the assessment remedial technologies, the proposed site development (residential with limited access to soils), the potential risks to human health and the environment, and the relative cost effectiveness of feasible remedial techniques, the preferred remedial option for the site is for complete and offsite disposal to licensed waste facilities of all impacted fill soils, followed by site reinstatement with validated, imported excavated natural materials for the proposed deep soils area (172 m^2) on the south eastern side of the site.

5.4 SITE PREPARATION, LICENCES & APPROVALS

5.4.1 Consent Requirements

In accordance with SEPP 55 (1998) – *Remediation of Land* the category of the remediation works defines whether consent is required prior to the commencement of the works. Under SEPP 55, works where there is the potential for significant environmental impact are classed as Category 1 works and require development consent. Category 2 works pose a low potential for environmental impact and do not therefore require prior consent. The determination for the subject site is outlined in **Table 5-2**.

Table 5-1 Remedial Technology Review - Soils

Remediation methodology	Description	Advantages	Disadvantages	Suitability
No Action	'No Action' can be considered if: • There is no measurable contamination; • Contaminant concentrations are below assessment guidelines; • Contaminants are not mobile; or • Exposure to contaminated soils is unlikely.	No remediation costs Creates minimal disturbance to the site Retains material on-site	Not applicable to the kind of contamination encountered at the site. Asbestos contamination would remain in situ. Would pose limitations on land use options. Requires an Environmental Management Plan and ongoing monitoring.	Not Suitable – as the key objective of the remedial strategy is to make the site suitable for residential use without the need for ongoing monitoring.
On-site bioremediation	Excavated soils are thoroughly broken down and aerated, mixed with microorganisms and nutrients, stockpiled and aerated in above ground enclosures.	Cost effective if soils are utilised on-site. Lower disposal costs. Limited requirement to import fill material to site. Retains material on-site. Suitable for petroleum hydrocarbon contamination	Significant area of site required to land farm material. Undefined remediation timeframe. Potential for odour problems. Uncertainty of successful results. Not suitable for asbestos or metal contamination.	Not suitable – Asbestos contamination hotspot not addressed by this remediation approach.
In-situ treatment	In-situ treatment of impacted soils within the smear zone and saturated zone using in-situ treatment methods such as SVE, steam stripping, ISCO or injection of oxygen releasing compounds.	Creates minimal disturbance to the site (no excavation). Cost effective for large scale site remediation projects of light to mid-weight petroleum hydrocarbons. Potential to simultaneously remediate dissolved phase hydrocarbons in site groundwater.	Not applicable to the kind of contamination encountered at the site. Expensive establishment costs. Potential for odour problems. Requires detailed design, pilot trials and management.	Not suitable – this method is designed for widespread hydrocarbon impacted soils. Since the present dataset does not provide evidence of widespread contamination, this is not considered to be an economically viable option.

Remediation methodology	Description	Advantages	Disadvantages	Suitability
Consolidation and/or capping	Risk minimisation approach where impacted soils are managed on-site by capping the ground surface with a clean, impermeable layer of fill material.	Effectively removes risk to human health by eliminating exposure pathways.	Importance of capping materials. Contamination would remain in situ allowing potential off-site migration of contamination and impacts on groundwater. Would pose limitations on land use options. Requires an Environmental Management Plan and ongoing monitoring.	Not Suitable – Given the majority of the site fill soils will be removed offsite for basement construction. Furthermore an environmental management plan (EMP) with ongoing monitoring would be required, due to the retention of contaminated materials on the site, and the key objective of the remedial strategy is to make the site suitable for residential use without the need for ongoing monitoring.
Excavation and off-site disposal	Excavate impacted materials. Transport directly to a licensed landfill facility. Re-instate site with imported clean fill material for the deep soil area.	Fast – impacted material removed immediately. No storage or treatment problems. Minimal design and management costs.	Transfer of waste to another location (licensed waste facility). High costs associated with the disposal of waste soils and importation of clean backfill. Requires waste classification prior to disposal, keeping of thorough waste records, waste tracking and reporting. Sustainability issues related with disposal to landfill.	Suitable – for meeting the key project objective to make the site suitable for residential use without the need for ongoing monitoring. The proposed development requires construction of a basement across the majority of the site. Excess soil requires excavation and disposal. This remediation option aligns with the construction requirements the proposed development.
Natural attenuation	Allowing the contaminants to biodegrade naturally following removal of the contamination source.	No remedial excavation of site. Retains materials on site. Sustainable, cost effective remediation method.	Slow process. Potential for contamination to further impact on the groundwater aquifer and nearby environmental receptors. Would require Environmental Management Plan and ongoing monitoring.	Not Suitable – this approach is primarily suited to addressing groundwater contamination, which is not identified as being significant. In addition, the approach would not address asbestos soil impacts.

Table 5-2 Remediation Works Category Determination

Significant Environment Impact	Yes/No	Category
Designated Development or State Significant Development	No	2
Critical or threatened species habitat	No	2
Have significant impact on threatened species, populations, ecological communities or their habitats	No	2
In area identified, environmental significance such as scenic areas, wetlands (see list*)	No	2
Comply with a policy made under the contaminated land planning guidelines by the council.	Yes	2
Is work ancillary to designated development	Yes	2

Notes: * Environmental significance list -coastal protection, conservation or heritage conservation, habitat area, habitat protection area, habitat or wildlife corridor, environment protection, escarpment, escarpment protection or escarpment preservation, floodway, littoral rainforest, nature reserve, scenic area or scenic protection, or wetland.

Based on the above assessment the remediation works for the site are considered as Category 2 remediation works and will not require development consent. Category 2 works do however require notification to the consent authority; therefore, Council should be notified 30 days before commencement of the works. The 30-day limit does not prevent Council intervention after that time for a breach of the EPA Act 1997 or non-compliance with SEPP 55. The notification also serves as the basis for updating Council records on properties in the local government area and must:

- Be in writing;
- Provide contact details for the notice;
- Briefly describe the remediation work;
- Show why the work is considered category 2 remediation work;
- Specify the property description and street address on which the remediation work is to be carried out;
- Provide a location map; and
- Provide estimates for commencement and completion dates of the work.
- Provision of this RAP, as well as an indication of commencement and completion dates of the works in writing, is usually sufficient to meet the requirements of this notification.

5.4.2 Development Consent & Control Plans

All works should be in accordance with the Cumberland Council DCPs and any development consent issued by Council for the development.

5.4.3 Other Licence Requirements

The appointed site contractor should prepare an appropriate Construction Environmental Management Plan (CEMP), health and safety plans and other plans required by the Council DA and

DCPs. Where asbestos removal is required, the contractor must be appropriately licensed to perform such works.

6 REMEDIATION WORKS

6.1 REMEDIATION STRATEGY

Following approvals and site establishment, the main site remediation works would include, but not be limited to the following. Identified areas requiring remediation are shown on **Figure 2**.

- Stage 1 – Site Preparation
- Stage 2 – Data Gap Closure Investigations (Soils and groundwater)
- Stage 3 – UPSS Removal and validation
- Stage 4 – Contaminated Soil Hotspot removal
- Stage 5 – Removal of remaining fill
- Stage 6 – Site Validation
- Stage 7 – Validation Report Preparation

Contingent Action

Should unexpected finds be discovered during the course of the site remediation program, or should any phase of validation assessment identify residual high level contamination requiring additional remediation, then the procedures described under the Unexpected Finds Protocol (**Section 7.7**) and/or the Validation Plan (**Section 8.1**) will be implemented, until the site remediation goals have been achieved and the site is deemed suitable for the intended land use.

6.2 REMEDIATION METHODOLOGY

6.2.1 Stage 1 – Site Preparation

Notice should be given to Council at least 30 days prior to the commencement of remediation works. A list of all required work permits will be obtained from Council and arrangements are to be made to obtain the necessary approvals from the relevant regulatory authorities.

The site itself will be prepared in accordance with the requirements of the Site Management Plan outlined in **Section 7**. The plan includes the requirement for a thorough walkover inspection of the site to assess for visible evidence of fibre cement sheeting, which may include asbestos-containing materials (ACM).

Establishment of environmental controls, site access, security, fencing, warning signage and preparation of a Health Safety and Environment Plan is required prior to works commencement. A project plan should also be developed to outline engineering design for excavation support (if required), water treatment requirements and design, staging of excavation works, stockpiling, waste stabilisation, waste material loading, traffic management and waste tracking.

As part of the site preparation phase and preliminary tasks a remediation workshop should be conducted with the appointed contractor(s) to further develop any remedial measures, excavation plans and environmental management requirements.

Also prior to commencing work the site contractor is to prepare a staging or project plan that outlines the basic stages of the remediation works. The staging plan should include, but not be limited to:

- Staging of areas to be excavated;

- Areas designated for waste segregation, screening and storage (stockpiling), amenities, soil and groundwater treatment (if required);
- Truck movement to allow loading to mitigate impacts to surrounding land users and council infrastructure; and
- Proposed environmental mitigation measures.

6.2.2 Stage 2 – Data Gap Closure Investigations (Soils and Groundwater)

Data Gap Closure Investigations Soils

The Client should ensure an appropriately qualified and experienced environmental professional completes the data gap closure investigations. In regards to site soils, this will require the following activities to be carried out:

- Additional soil sampling of previously inaccessible areas should be undertaken once the concrete slab is removed. Sufficient additional locations should be sampled to enable in situ waste classification of Fill and natural soil for disposal and management. This should also include analysis for appropriate contaminants of concern including lead following TCLP.

All soil samples should be collected with headspace duplicates, which will be field-screened for volatiles using a portable photo-ionisation detector (PID) and maximum PID readings for each sample are to be recorded as part of the soil logging procedure.

Duplicate soil samples should be collected at a rate of 1 in 10, with triplicate samples to be collected at a rate of 1 in 20, for field QAQC testing by the primary and secondary laboratories, respectively. Analysis of QAQC samples should mimic analysis of the primary sample.

Soil samples should be placed within a chilled esky immediately after collection, and sent to NATA accredited laboratories as soon as practicable, using strict chain of custody procedures.

Should PID readings greater than 20 parts per million be identified, or hydrocarbon odours be detected in any of the additional sampling locations, further locations should be advanced 3 m lineally away from the impacted sampling location. Further sampling locations should be advanced at increasing distances, until no olfactory evidence of hydrocarbon impacts are identified.

Data Gap Closure Investigations Groundwater

Data gap closure investigations in relation to groundwater will involve:

- One groundwater monitoring event to be conducted at BH1M, BH4M, BH6M, BH7M and previously installed well BH12M, with laboratory analysis of the collected groundwater sample for TRH, BTEX, PAHs, heavy metals, VOCs and phenols; and
- A survey of all existing monitoring wells for standing water level to enable confirmation of groundwater flow direction.

Should groundwater contamination be identified during the data gap closure investigations, an addendum to the RAP will be required to describe how the identified contamination will be managed. As groundwater impacts have not yet been confirmed, groundwater remediation is not proposed at this stage.

6.2.3 Stage 3 – UPSS Removal & Validation

- SafeWork NSW indicated the presence of at least 4 USTs at 24 Railway Street, Lidcombe.
- Appropriate decommissioning and removal the UPSS and any associated filling points, fuel feed lines and vent pipes (firstly draining where necessary) in accordance with:
  - AS4976 – 2008, Australian Standard for the removal and disposal of underground petroleum storage tanks;
  - POEO (Underground Petroleum Storage System) Regulations (2014); and
  - SafeWork NSW and other requirements under the Work Health and Safety Act and associated regulations.
- Detailed inspections of the UPSS areas will be conducted immediately following removal of tanks to determine whether further groundwater investigation is required in the vicinity of, or down hydraulic gradient in relation to the former underground tank locations.
- Field screening of soil samples collected from the base and side walls of the final excavations in accordance with EPA (2014) *Technical Note: Investigation of Service Station Sites*, during which, a portable photo-ionisation detector (PID fitted with a 10.6eV lamp) will be used as a field screening tool to provide indicative (semi-quantitative) data in relation to VOC concentrations in soil headspace samples, together with visual and olfactory observations.
- Should detectable odours, stained soils and/or PID headspace measurements indicate the presence of petroleum impacts to UPSS area soils, the former tank area(s) should be excavated to chase out impacted soils until PID readings from the walls and base of the excavation are less than 20 ppm. Should the site boundary be encountered prior to the target PID readings being recorded, then excavation will cease, and samples at the site boundary will be collected, for characterisation purposes.
- Validation samples will be collected from final excavation surfaces (walls and bases) and laboratory analysed for TRH, BTEX, PAHs, heavy metals and VOC. Sampling frequency will be in accordance with EPA (2014) *Technical Note: Investigation of Service Station Sites.*

Petroleum hydrocarbon impacted soils are to be stockpiled separately from all other site fill/soils, and sampled ex-situ at a rate of 1 sample per 25 m^3 of excavated soil for waste classification assessment. Water that may collect within remedial excavations will require water sampling and testing to enable appropriate disposal and /or recycling, to be managed by the environmental consultant.

6.2.4 Stage 4 – Contaminated Soil Hotspot Removal

Asbestos Management Controls

Contaminated fill/soil hotspot removal must be carried out under the supervision of a qualified environmental scientist and in compliance with a site-specific AMP. Fill disturbance for the remediation works must not be commenced therefore, until the relevant control measures are in place, including friable asbestos management controls and associated asbestos fibre monitoring, as specified in the AMP.

Hotspot Remediation (BH9)

After waste classification of hotspot soils (as described in **Section 6.2.2**), the hotspot area will be excavated independently of the remaining fill material, and under no circumstances should impacted

soils with different waste classifications be mixed. Remedial excavations should be conducted under the supervision of a suitably qualified environmental professional. Asbestos soil contamination hotspot will be remediated using the following procedure:

1. Mark out the hotspot area, based on previously recorded sampling locations and findings of the Detailed Site Investigation works (EI, 2016). A potential outline is provided on **Figure 2**. The extent of the impacts should be marked in a way to withstand external conditions and should be readily identifiable during the entire remedial works program, to enable contaminated soil chase-out excavations and revalidation, if necessary.
2. Plant, machinery and / or other equipment used for the excavation works should be dedicated to the individual excavation, and should be clean and free of all solid materials prior to the start of remedial excavation works.
3. Hotspot fill/soils, which have been classified under the same waste category (e.g. *General Solid Waste*) will then be excavated and directly loaded onto the same transport vehicle.
4. Under the NSW Waste Regulations 2014 different waste streams must be kept separate. **Hotspot soils with different waste classifications cannot be loaded onto the same waste transport vehicle, for landfill disposal purposes.**
5. Should the temporary stockpiling of excavated, contamination hotspot soils be necessary, soils from different areas must be stockpiled separately and isolated from all other excavated materials, on an impermeable surface (such as a plastic liner). Stockpiles should also be protected from wind to avoid airborne dispersion of asbestos, which was previously detected in fill at the site.
6. Any soils with heavy staining and/or exhibiting odours are to be isolated from other excavated materials, for additional waste classification sampling and testing.
7. Validation samples will be collected from excavation surfaces (walls and bases) for laboratory analysis for the contaminant of which the respective area is being remediated.
8. Should the wall or base validation sample from the hotspot remedial excavation be found to contain contaminant concentrations that exceed the adopted soil validation criteria, additional chase-out excavations will be conducted to remove more fill from the area of residual impacts, followed by resampling for revalidation testing.
9. When all wall and base validation samples show results that are below the adopted validation criteria, the hotspot areas will be deemed to have been effectively remediated.

Dust control measures (such as spraying and fine misting) will therefore be employed as required during the remediation works to prevent asbestos fibres from becoming airborne. In addition, air monitoring for asbestos fibres will be undertaken during ground disturbance and fill screening activities, which typically generate dust.

All asbestos fibre air monitoring must be conducted in accordance with the Guidance Note on the Membrane Filter Method for Estimating Airborne Asbestos Fibres [NOHSC: 3003 (2005)] and analysed by a NATA-accredited laboratory. The criteria and actions that will apply to this project are summarised in **Table 6-1**.

Table 6-1 Soil Asbestos Control Measures

Control Level (fibres/mL)	Control / Action
< 0.01	• No Action. Continue with existing control measures

Control Level (fibres/mL)	Control / Action
≥0.01	• Asbestos Consultant to notify Site Controller and provide results as soon as practicable. • Site Controller to notify Licensed Asbestos Removal Contractor. • Asbestos Consultant & Site Controller to review current control measures and improve, where applicable. This may include improved work practices, use of further control measures (e.g. plastic screening or wet wiping techniques) or changing the work methodology.
≥0.02	• Asbestos Consultant to notify Site Controller and provide results as soon as practicable. • Asbestos Consultant to advise Licensed Asbestos Removal Contractor to stop work immediately. • Asbestos Consultant to conduct investigations to establish cause of problem. • Asbestos Consultant to advise Licensed Asbestos Removal Contractor on necessary works to rectify problem. • Asbestos air monitoring to be continued by Asbestos Consultant. • Contractors will be allowed to return to works area after results are <0.01 fibres/mL.

6.2.5 Stage 5 – Removal of Remaining Fill Soils

Asbestos Management Controls

Removal of residual fill/soils must also be carried out under the supervision of a qualified environmental scientist and in compliance with the AMP. The control measures established prior to the removal of the contamination hotspot (described in **Section 6.2.4**) must therefore remain in place for the duration of the residual fill removal works.

Removal of Residual Fill Soils

- After removal of UPSS and associated material (Section **6.2.3**), bulk excavation of the remaining Fill and soils not impacted with petroleum hydrocarbons may be commenced as necessary to allow for the construction of the basement levels.
- In situ waste classification of Fill and underlying natural soil as outlined in **Section 6.2.2**.
- A waste classification certificate will be prepared for bulk excavated material by the environmental consultant; however, the construction contractor must establish a material tracking system as part of a site-specific waste soil management plan, to ensure appropriate documentation of material disposal and final reporting.
- Pre-classified Fill and natural soil should be excavated and directly loaded onto waste transport vehicles.
- Any material excavated which exhibits "unexpected finds" (i.e. observation of odours, sheen, fragments of potential asbestos-containing material, or unusual colours) is to be stockpiled separately and prevented from mixing with 'clean' excavated material and examined by the environmental consultant who will determine if additional characterisation prior to off-site disposal is required.
- Once stockpiled material is classified for waste disposal purposes, it should be quarantined and not mixed with other materials (otherwise re-sampling and re-classification should be undertaken)

Residual (natural) soils may be classified as Excavated Natural Material (ENM) or virgin excavated natural materials (VENM) depending on sampling for potential contaminants. Both ENM and VENM can be reused or recycled, however, the environmental consultant must be involved with this process to ensure appropriate documentation and reporting in accordance with NSW EPA waste compliance regulations.

6.2.6 Stage 6 – Site Validation

After the complete removal of all fill from the site:

1. A detailed site walkover inspection will be conducted by a team led by the Environmental Management Coordinator / Remediation Supervisor to confirm that all fill has been removed.
2. Eleven surface validation samples will be collected using a hand trowel from 100 – 200 mm below the base of the final excavation surface arranged in a systematic, triangular grid pattern across the site. (Note: Eleven is the minimum number recommended in the NSW EPA (1995) Sampling Design Guidelines for the area of the site)
3. One intra-laboratory duplicate sample and one rinsate blank will also be collected for QC testing;
4. Analysis of soil samples for eight heavy metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc), TRHs, BTEX and Asbestos identification; and
5. Sampling from the natural clay surface shall be accompanied by ambient VOC monitoring with the use of a PID, along with visual and olfactory observations, with all measurements and observations documented for validation reporting purposes.
6. Any results showing that elevated concentrations (above background) are present at the top of the natural soil surface, this will trigger deeper excavations and appropriate chase-out excavations to remediate the impacted natural materials.
7. Should the deeper excavation of impacted natural soils extend to more than 1.5 m in depth, then localised shoring will be employed to prevent excavation wall collapse. The shoring system will require technical approval by a qualified and experienced structural engineer.
8. Additional spoil resulting from further chase out excavations, will be stockpiled and assessed to produce additional waste classification for the respective materials, followed by appropriate offsite disposal using the same methodology described in **Section 6.2.5**. This will be followed by revalidation of the new excavation.
9. Steps 5, 6 and 7 will be repeated until all validation results for excavation surfaces (walls and base) indicate analyte concentrations that are below the relevant Validation Criteria, as detailed in **Section 4.2.1**.

More details in relation to validation sample collection and handling are provided in **Section 8.1**.

6.2.7 Stage 7 Works – Validation Report Preparation

A site validation report will be prepared in accordance with the NSW EPA (2011) Guidelines for Consultants Reporting on Contaminated Sites and NSW DEC (2006) Guidelines for the NSW Site Auditor Scheme, as described in **Section 8.2**.

6.3 REMEDIATION SCHEDULE

An estimated schedule for the remedial works is detailed below in **Table 6-2**. The proposed schedule is based on the remedial works being completed as outlined in this RAP and is dependent on Council approval of any DA and conditions of consent.

Table 6-2 Indicative Site Remediation Schedule

Timeframe	Action
Start	Auditor Approval of Remediation Plan
Week 1/2	Stage 1 – Site Preparation
Week 3	Stage 2 – Data Gap Closure Investigations (Soils and Groundwater)
Week 4/5	Stage 3 – UPSS Removal and validation
Week 6	Stage 4 – Contaminated soil hotspot removal
Week 7/8	Stage 5 – Removal of remaining fill soils
Week 9/10/11	Stage 6 – Site Validation
Week 12/13/14	Stage 7 – Validation Report Preparation

Note: * If human health &/or environmental risk assessment is needed, an additional 2 weeks may apply.

6.4 REMEDIAL CONTINGENCIES

At this stage it is anticipated that the proposed remedial technologies should be effective in dealing with the contamination present, however remedial contingencies may be required should the scenarios detailed in **Table 6-3** arise.

Table 6-3 Remedial Contingencies

Scenario	Remedial Contingencies/Actions Required
Highly contaminated soils not identified during previous investigation are encountered, particularly at site boundaries	Follow the unexpected finds protocol as detailed in **Section 7.7** of this RAP. Work to be suspended until the Environmental Project Manager can further assess impacted soils/ materials and associated risks.
Underground tanks are encountered at locations other than the former service station	Systems to be removed and the excavations appropriately validated and backfilled by experienced contractor. Tank removal works reported by appropriate environmental consultant in accordance with NSW EPA (2014) Technical Note: Investigation of Service Station Sites and Australian Standard AS4976 (2008). Follow the unexpected finds protocol as detailed in **Section 7.7** of this RAP.
Highly impacted sludge's are uncovered	The leachability of heavy metals and hydrocarbons will need to be assessed before disposal options are considered. Follow the unexpected finds protocol as detailed in **Section 7.7** of this RAP.
Significant asbestos wastes are encountered	Work to be suspended and asbestos work removed by a suitably qualified contactor, in accordance with WorkCover regulations. Follow the unexpected finds protocol as detailed in **Section 7.7** of this RAP.
Residual soil impacts remain on-site between site boundary and basement excavation	Review/assess potential vapour hazard If there is a vapour risk additional remedial measures may be required including

Scenario	Remedial Contingencies/Actions Required
	installation of a vapour barrier or passive or active vapour extraction system.
Contaminated groundwater (including LNAPL or DNAPL) encountered	Review of groundwater conditions on site, may require further groundwater investigations / remediation and longer-term management plan. Any dewatering may require approval under the Water Management Act (2000) Remedial measures may include, source removal, natural attenuation, bioremediation, PSH recovery using active pumping (including hydraulic control), installation of a groundwater permeability barrier or similar or in-situ oxidation or stabilisation.
Groundwater contaminant plume is identified and is migrating off-site or there are increases in concentration due to increased infiltration (following demolition)	Review contaminant increase and analytes. Review active remediation alternatives (if necessary). Ensure down-gradient monitoring is undertaken. Carry out fate and transport modelling (if required) and assess the need for further action.
Changes in proposed basement excavation depth	Review of the remediation works completed for the site.
Changes in proposed future land uses at the site	Review of the remediation works completed for the site.

7 SITE MANAGEMENT

7.1 RESPONSIBILITIES AND CONTACTS

The responsibilities for the various parties involved with the remediation programme are outlined in **Table 7-1.**

Table 7-1 Site Management Responsibilities

Responsible Party	Details/Contacts	Responsible for:
Principal Project Manager (PPM)	EI Australia	Overall management of the site remedial activities
Property Owner	Lidcombe 2 Pty Ltd	Management of the site and associated remedial activities, particularly with respect to policy and operational procedures
Environmental Management Coordinator (EMC)/ Remediation Supervisor	EI Australia	1. Ensuring that the site remediation works are carried out in an environmentally responsible manner; 2. Liaising between the appointed Environmental Consultant and Council providing regular updates and informing of any problems encountered; 3. Ensuring that all environmental protection measures are in place and are functioning correctly during site remediation works; and 4. Reporting any environmental issues to owner.
Demolition, Earthworks or Remediation Contractor	TBA	5. Ensuring that all operations are carried out as identified in the RAP (demolition and remediation), as directed by the PPM and EMC; 6. Inducting all employees, subcontractors and authorised visitors on procedures with respect to site works, WHS and environmental management procedures; 7. Reporting any environmental issues to EMC; 8. Maintaining site induction, site visitor and complaint registers; 9. Ensuring that fugitive emissions and dust potentially leaving the confines of the site are suitably controlled and minimised; 10. Ensuring that water containing any suspended matter or contaminants must not leave the site must be minimised and suitably controlled, so as not to pollute the environment; 11. Ensuring that vehicles are cleaned and secured so that no mud, soil or water are deposited on any public roadways or adjacent areas;

Responsible Party	Details/Contacts	Responsible for:
Demolition, Earthworks or Remediation Contractor (cont.)	As above	12. Ensure that noise and vibration levels at the site boundaries comply with the legislative requirements.
Environmental Consultant	EI Australia	13. Ensure that all operations are carried out as identified in the RAP (demolition and remediation); and 14. Advise the Site Auditor (if appointed) should a scenario arise requiring deviation from the procedures and requirements detailed in this RAP.
Qualified Independent Consultant	Auditor (if appointed)	15. Reviewing proposed remediation strategies and ensuring remediation is technically feasible, environmentally justifiable and consistent with relevant legislation and guidelines; 16. Review of actions taken demolition, earthworks or remediation contractor; 17. Ensure all works have complied with the RAP and remedial procedures.

7.2 MATERIALS HANDLING AND MANAGEMENT

Table 7-2 summarises the measures that should be implemented in respect of materials handling during excavation and remediation works at the site.

Table 7-2 Materials Handling and Management Requirements

Item	Description/ Requirements
Earthworks contractors	Excavation of fill materials should be completed by a suitably qualified contractor to ensure: • All site staff are aware of the environmental and health and safety requirements to be adhered to; • There is no discernible release of dust into the atmosphere as a consequence of the works; • There is no discernible release of contaminated soil into any waterway as a consequence of the works; and • There are no pollution incidents, health impacts or complaints.
Stockpiling of materials	All stockpiles will be maintained as follows: • Stockpiles must be located on sealed surfaces such as sealed concrete, asphalt, or high density polyethylene; • Should stockpiles be placed on bare soils, these soils should be placed on yet to be remediated areas. Contaminated materials should only be stockpiled in locations that do not pose any environmental risk (e.g. hardstand areas); • Excavated soils should be stored in an orderly and safe condition (≤2m height); • Stockpiles should be battered with sloped angles to prevent collapse;

Item	Description/ Requirements
Stockpiling of materials (cont.)	• Stockpiles should be covered after being lightly conditioned by sprinkler to prevent dust blow and control odours; • As outlined in **Section 6.2.5**, the CEMP should describe suitable options for the control of air emissions; for example, using a hydrocarbon mitigation agent such as BioSolve®, Pinkwater®, or Anotech (or equivalent product selected by the contractor) in combination with the fine mist spray in the impacted area during disturbance and stockpiling of petroleum hydrocarbon impacted –materials during works at the service station; • Should the stockpile remain in-situ for over 24 hours, silt fences or hay bales should be erected around each stockpile to prevent losses from surface erosion (runoff); and • Stockpiles will be strategically located to mitigate environmental impacts while facilitating material handling requirements.
Loading of material	Loading of stockpiles / materials will be as follows: • Transport of contaminated material off the site is to be via a clearly distinguished haul route. • Measures shall be implemented to ensure no contaminated material is spilled onto public roadways or tracked off-site on vehicle wheels. Such measures should include the use of a wheel washing/cleaning facility, placed before the egress point on the site, and should be able to handle all vehicles and plant operating on-site. • Residue from the cleaning facility should be collected, and either dewatered on site in a contained/bunded area or disposed as a slurry to an approved facility. Such residue will be deemed contaminated unless proven otherwise.
Transport of materials	Prior to being assigned to an appropriate waste disposal facility, all waste fill/soils should be classified in accordance with the NSW EPA (2014) Waste Classification Guidelines. If prior immobilisation treatment of the waste soils is required, disposal consent will be obtained from the NSW EPA prior to spoil transport. • All trucks transporting soils from the site are to be covered with tarpaulins (or equivalent). • All haulage routes for trucks transporting soil, materials, equipment and machinery shall comply with all road traffic rules, minimise noise, vibration and odour to adjacent premises, utilise state roads and minimise use of local road. • All deliveries of soil, materials equipment or machinery should be completed during the approved hours of remediation and exit the site in a forward direction. • Removal of waste materials from the site shall only be carried out by a recognised contractor holding the appropriate EPA NSW licenses, consents and approvals. • Waste must be transported less than 150 km from the source (POEO, Waste, 2014) and landfills are required to be licensed for the category of waste they are scheduled to receive.

Item	Description/ Requirements
Material tracking	Materials excavated from the site should be tracked from the time of their excavation until their disposal. Tracking of the excavated materials should be completed by recording the following: • Origin of material; • Material type; • Approximate volume; and • Truck registration number. Disposal locations will be determined by the remediation contractor. Disposal location, waste disposal documentation (weighbridge dockets) and the above listed information should be provided to the remediation consultant for reporting purposes.
Material visual inspection prior to validation sampling.	Following the completion of remedial works as specified within this RAP, the following applies: • A suitably qualified environmental scientist should undertake a visual inspection of the work area. If visual observations indicate contamination, the earthworks contractors should rectify any issues arising from the inspection (i.e. further excavation or 'chasing out' until soils show no evidence of contamination based on visual inspection and/or odours); and • Following satisfactory completion of the visual inspection, validation sampling of soils should be completed. Validation sampling is discussed in **Section 8**. Only following satisfactory validation, will remedial works be deemed as completed.

7.3 MANAGEMENT MEASURES

All work should be undertaken with due regard to the minimisation of environmental effects and to meet all statutory environmental and safety requirements (**Section 7.6**). A CEMP should be developed for the site works by the site contractor/builder, which takes into account relevant guidance including, but not limited to:

- DA Conditions of Consent;
- Auburn Development Control Plan 2010; and
- Managing Urban Stormwater, Soils and Construction, Volume 1: 4th edition (March 2004) – often referred to as the 'blue book'.

Overall site management requirements related to the remedial works are presented in **Table 7-3**.

Table 7-3 Site Management Measures

Category	Measure
Demolition (including Asbestos Management)	Appropriate measures shall be taken to ensure that demolition works are completed in accordance with SafeWork Standards and Codes of Practice. Any asbestos identified within building materials should be managed in accordance with SafeWork Codes of Practice and Australian Standards, and should be detailed within the EMP. **Note:** As demolition has already been completed at the site, a detailed 'emu bob' site walkover will be performed to visually screen the site and assess for visible evidence of fibre cement sheeting (FCS), which could potentially be asbestos-containing material (ACM). All detected fragments of FCS must therefore be collected and bagged for appropriate offsite disposal.

Category	Measure
Site Stormwater Management and Control	Appropriate measures shall be taken to ensure that potentially contaminated water does not leave the site. Such measures should include, but not be limited to: • Diversion and isolation of any stormwater from any contaminated areas; • Provision of sediment traps including geotextiles or hay bales; and • Discharge of any water to drains and water bodies must meet the appropriate effluent discharge consent condition under the *Protection of the Environmental Operations Act*.
Soil Management	Appropriate measures shall be taken to ensure soils are excavated using a methodology appropriate to reduce nuisance dust and odours from leaving the boundary, and are disposed of in accordance with the NSW Government *Protection of the Environment Operations (Waste) Regulation* (2014).
Dust and Odour	Control of dust and odour during the course of the remediation works shall be maintained by the contractor to ensure no nuisance dust or odours are received at the site boundary according to requirements of Auburn Council DCP (2010). A minimum of four monitoring points on the four site boundaries would be established and monitoring for asbestos fibres prior to the remedial excavations. Action levels and specific control measures would be described in the site construction phase environmental management plan (CEMP) and may include, but will not be limited to the following: • Site wide water spraying, as and when appropriate, to eliminate wind-blown dust; • Use of mist sprays, and/or sprinklers on stockpiles, fill screening areas and loaded fill to lightly condition the material; • Use of tarpaulin or tack-coat emulsion or sprays to prevent dust blow from stockpiles or from vehicle loads; • Covering of stockpiles or loads with polythene or geotextile membranes; • Restriction of stockpile heights to 2m above surrounding site level; • Ceasing works during periods of inclement weather such as high winds or heavy rain; • Use of vapour masks or respirators for works near asbestos areas; and • Regular checking of the fugitive dust and odour issues to ensure compliance with the CEMP requirements, undertaking immediate remedial measures to rectify any cases of excessive dust or odour (e.g. use of misting sprays or odour masking agent). Due to the presence of asbestos within fill material, it is advised that all site workers use adequate dust masks during fill excavation, and that machine operators remain within an enclosed, air conditioned cab.
Noise and Vibration	Noise and vibration will be restricted to reasonable levels. All plant and machinery used on site will be noise muffled to ensure that noise emissions do not breach statutory levels as defined within the Auburn Council DCP (2010).
Hours of Operation	Working hours will be restricted to those specified by Council, which are defined as being 7am to 7pm weekdays and 7am to 5pm Saturdays; no Sunday work permitted. These hours may differ from DA conditions, and DA conditions specified for the site must be adhered to.

Category	Measure
Community Engagement	Community engagement should be carried out in accordance with Schedule B (8) of NEPM (2013). Prior to the commencement of any remediation works at the site, every owner and occupier of any land located either wholly or partly within 100 m of the boundary of the premises (including local council and the RMS) should be notified at least 30 days in advance. The notice should include: • Advice of demolition & excavation work to be carried out on the premises; • State the time and date such work is to commence; • Indicate that the works are being conducted to minimise any risk of site contamination impacting on off-site receptors; • Provide appropriate site signage at an easily readable location on the site fencing, including site contact name and phone number to be contacted should any matter arise; provide the phone number of a person present on the premises whilst remediation works are being undertaken; and • Provide contact information and procedure for registering any complaints.
Incident Management and Community Relations	While various environmental management and occupational safety plans will be developed to protect human health and the environment, incidents may occur which pose a risk to the various stakeholders. To mitigate these risks and ensure that a suitable response is carried out quickly, a response plan to any incident that may occur on site should be prepared and various responsibilities assigned. The site health and safety plan and environmental management plan should document these procedures and responsibilities, and incident contact numbers should be maintained in an on-site register. All other relevant emergency contact numbers such as Police, Fire Brigade, and Hospital should be listed in the Health and Safety Plan and posted on-site for easy access.

7.4 CONTINGENCY MANAGEMENT

Contingency plans for anticipated problems that may arise on-site during the course of the site preparation works comprising demolition and remediation are presented below in **Table 7-4**

Table 7-4 Contingency Management

Anticipated Problems	Corrective Actions
Chemical/ fuel spill	Stop work, notify above site project manager. Use accessible soil or appropriate absorbent material on site to absorb the spill (if practicable). Stockpile the impacted material in a secure location, sample and determine the appropriate disposal/treatment option.
Excessive Dust	Use water sprays to suppress the dust or stop site activities generating the dust until it abates.
Excessive Noise	Identify the source, isolate the source if possible, modify the actions of the source or erect temporary noise barriers if required.

Anticipated Problems	**Corrective Actions**
Excessive Odours/Vapours	Stage works to minimise odours/vapours. If excessive organic odours/vapours are being generated, stop works and monitor ambient air across site for organic vapours with a PID and odours at site boundaries. Implement control measures including respirators for on-site workers, use of odour suppressants, wetting down of excavated material. EI notes that no nuisance odours shall be detected at any site boundary as part of the remedial works. Should odour emissions be detected at or beyond the site boundary, it is recommended, as part of the CEMP and community consultation procedure, that the Remediation Contractor and the Principal Project Manager: • Notify the owners and occupiers of premises adjoining and across the road from the site regarding potential odour issues. Notification should be in writing. This is also required by the Council Contaminated Land Policy; • In the notification, as well as on street signage, provide contact details of the site personnel for anyone who may be concerned by odour emission during the remediation; • Temporarily pause site works to allow for excess odour to subside to a level acceptable by off-site receptors, should it be necessary, after implementation of the above-listed control measures; and • Record logs for volatile emissions and odours. Such records should be kept on-site and made available for inspection on request.
Excessive Odours/Vapours (continued)	In regard to off-site impact from petroleum vapour, EI notes that odour is generally detected at concentrations much lower than what will constitute a health-based risk. Measures listed above for odour control (**Table 7-3**) may also be applied for vapour control.
Excessive rainfall	Ensure sediment and surface water controls are operating correctly. If possible divert surface water away from active work areas or excavations.
Water in excavations	Collect samples and assess against relevant NSW EPA *(2014) Waste Classification Guidelines* assessment criteria, to enable disposal options to be formulated.
Leaking machinery or equipment	Stop the identified leak (if possible). Clean up the spill with absorbent material. Stockpile the impacted material in a secure location, sample and determine the appropriate disposal/treatment option.
Failure of erosion or sedimentation control measures	Stop work, repair failed control measure.
Unearthing unexpected materials, fill or waste	Stop activities, contact the site project manager. Follow the unexpected finds protocol as detailed in **Section 7.6** of this RAP. Prepare a management plan if required, to address the issue.
Identification of cultural or building heritage items	Stop work and notify site project manager. Follow the unexpected finds protocol as detailed in **Section 7.6** of this RAP. Prepare action or conservation plan as required.
Equipment failures	Ensure that spare equipment is on hand at site, or that the failed equipment can be serviced by site personnel or a local contractor.

Anticipated Problems	Corrective Actions
Complaint Management	Notify Client, Project Managers and Environmental Consultant (if required) following complaint. Report complaint as per management procedures. Implement control measures to address reason of complaint (if possible). Notify complainant of results of remedial actions.

7.5 WORK HEALTH AND SAFETY PLAN

As required by the NSW Work Health and Safety Act 2011 and associated Regulations, a Work Health and Safety (WHS) Plan should be prepared by the Principal Contractor (see **Responsibilities and Contacts, Section 7.1**), to manage the health and safety of site workers and nearby residents, and address such issues as site security, exclusion zones, excavation safety, vibration, noise, odour and dust levels. The plan should address the risks during the remediation works and cover site specific requirements associated with the contaminants present within the site soils and groundwater.

The site officer responsible for implementing health and safety procedures should induct all site personnel so that they are aware of and comply with, the requirements of this document. It is the contractor's responsibility, with assistance from client/owner(s) of the site to ensure that all other permits, approvals, consents or licences are current. The following hazards and mitigation measures relevant to the remedial works are presented in **Section 4**, with a brief summary in **Table 7-5.**

Table 7-5 Remedial Hazards

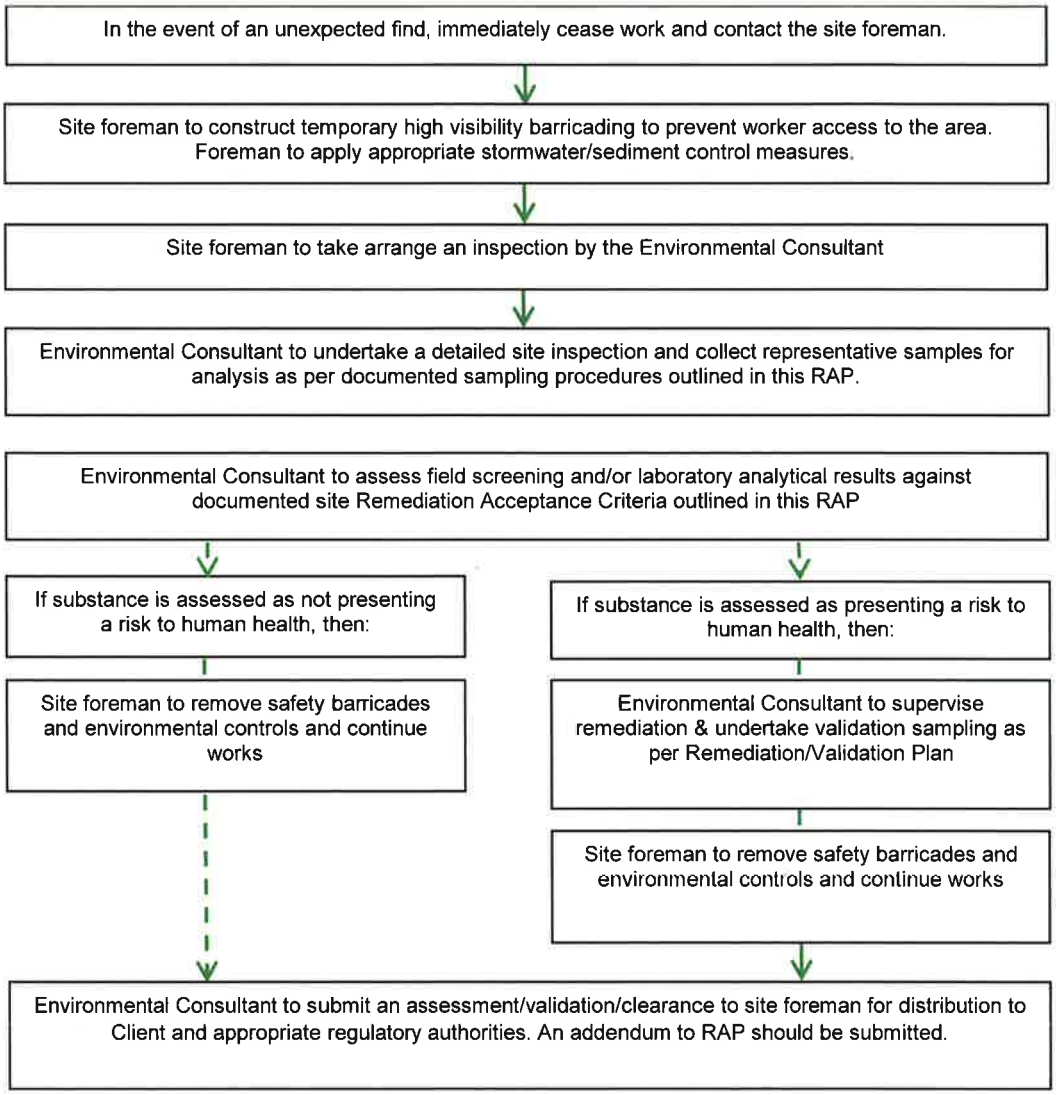
Anticipated Problems	Corrective Actions
Chemical Hazards	Contaminated sites have chemical compounds substances or materials that may present a risk to human health and the environment. Chemicals of concern and associated risks are as detailed within the Conceptual Site Model, within **Section 3.** The site specific WHS plan should set out controls to mitigate any potential risks.
Physical Hazards	The following hazards are associated with conditions that may be created during site works: • Heat exposure; • Buried services; • Noise, vibration and dust; • Electrical equipment; and • The operation of heavy plant equipment.
Personal Protective Equipment and Monitoring	Personnel should, wherever possible, avoid direct contact with potentially contaminated material. Workers are to ensure that surface waters or groundwater is not ingested or swallowed and that direct skin contact with soil and water is avoided. Standard PPE with the addition of disposable P2 dust masks as specified for the contractor will be sufficient for the prescribed remedial works.

7.6 UNEXPECTED FINDS PROTOCOL

Should unexpected finds be encountered, the approach in **Table 7-6** should be followed.

A unexpected find may include uncovering suspected asbestos containing material, additional underground storage tanks or lines, stained or odorous soil, ash or slag, or buried structures or materials.

Table 7-6 Unexpected Finds Protocol



8 VALIDATION SAMPLING AND ANALYSIS QUALITY PLAN

The remediation of the impacted soil areas will be deemed acceptable based on the achievement of the following two validation objectives:

1. ***Remedial Excavations*** – Validation of the remedial excavations will continue to the extent of the impacts as defined by delineation testing, and resulting contaminant concentrations are within the *Remediation (Validation) Criteria* (**Section 4.4**).

2. ***Backfill Materials*** – Should backfilling be required, validation of imported fill materials used for the backfilling of remediated areas would be required to verify their suitability for the proposed land use.

8.1 VALIDATION SOIL SAMPLING METHODOLOGY

Soil sampling and handling of the collected samples will be as described in **Table 8-1**.

Table 8-1 Validation Sample Collection and Handling Procedures

Action	Description
Sample Collection (soils)	Soil validation sampling will be directly from the exposed surface of excavation, or from the material brought to the surface by the backhoe/excavator bucket. Sampling data shall be recorded to comply with routine chain of custody requirements
Sampling Frequency	*Excavations from UPSS Removal (Validation Sampling) (NSW EPA 2014 Technical Note: Investigation of Service Station Sites)* Walls: 1 sample per 5 lineal metres Base: 1 sample per 25 m^2 Fuel line trenches *Remediated Hotspot Excavations (Validation Sampling):* 1 sample per 100 m^2, across the entire site, with one sample per 10 lineal metres along each wall (with a minimum of one sample per excavation wall). *Site-wide Fill Fill Excavations (Validation Sampling):* 1 sample per 50 m^2, across the remainder of the site. *Imported Backfill Materials (Validation Sampling):* 1 sample per 100 m^3 for VENM materials (lower sampling frequency may be accepted for uniform materials, subject to approval by EI Environmental Manager).
Sampling, handling, transport and tracking (for non-volatiles)	• The use of stainless steel sampling equipment; • All sampling equipment (including hand tools or excavator parts) to be washed in a 3% solution of phosphate free detergent (Decon 90), followed by a rinse with potable water prior to each sample being collected. • Direct transfer of the sample into new glass jars or plastic bags is preferred, with each plastic bag individually sealed to eliminate cross contamination during transportation to the laboratory; • Label sample containers with individual and unique identification including Project No., Sample No., Sampling depth, date and time of sampling; • Place sample containers into a chilled, enclosed and secure container for transport to the laboratory; and • Provide chain of custody documentation to ensure that sample tracking and custody can be cross-checked at any point in the transfer of samples from the field to the environmental laboratory.
Sample Containers & Holding Times	• Metals - 250g glass jar / refrigeration 4°C / 6 months (maximum holding period);

Action	Description
	• TRH/BTEX - 250g glass jar / refrigeration 4°C / 14 days (maximum holding period); • PAH - 250g glass jar / refrigeration 4°C / 14 days (maximum holding period); and • Asbestos – up to a 10 Litre resealable plastic (polyethylene) bag / no refrigeration / indefinite holding time.
Laboratory Analysis	• Each sample obtained for soil validation purposes will be analysed for the following: – Asbestos analysis using the bulk analysis methodology as described in NEPM (2013); and – Heavy metals, TPHs, BTEX, PAHs, OCPs, OPPs, PCBs. – The minimum suite specified for imported fill under the EPA (2014) guideline (e.g. heavy metals, TRHs, BTEX, PAHs, OCPs, OPPs, PCBs and asbestos), plus the physicochemical parameters pH and cation exchange capacity for areas of accessible soils intended for landscaping.
Field QA/QC	Quality assurance (QA) and quality control (QC) procedures will be adopted throughout the field sampling programme to ensure sampling precision and accuracy, which will be assessed through the analysis of 10% field duplicate/replicate samples. Appropriate sampling procedures will be undertaken to prevent cross contamination, in accordance with EI's Standard Operating Procedures Manual. This will ensure: • Standard operating procedures are followed; • Site safety plans are developed prior to works commencement; • Split duplicate field samples are collected and analysed; • Samples are stored under secure, temperature controlled conditions; • Chain of custody documentation is employed for the handling, transport and delivery of samples to the contracted environmental laboratory; and • Contaminated soil, fill or groundwater originating from the site area is disposed in accordance with relevant regulatory guidelines. In total, field QA/QC will include one in 10 samples to be tested as blind field duplicates, one in 20 samples to be tested as inter-laboratory duplicates (ILD), as well as one VOC trip blank (intra-lab) sample and one equipment wash blank sample per sample batch. No QAQC samples will be collected for asbestos sampling.
Laboratory Quality Assurance and Quality Control	The contract laboratory will conduct in-house QA/QC procedures involving the routine analysis of: • Reagent blanks; • Spike recoveries; • Laboratory duplicates; • Calibration standards and blanks; • QC statistical data; and • Control standards and recovery plots.
Achievement of Data Quality Objectives	Based on the analysis of quality control samples (i.e. duplicates/replicates and in-house laboratory QA/QC procedures), the following data quality objectives are required to be achieved: • conformance with specified holding times; • accuracy of spiked samples will be in the range of 70-130%; and • field and laboratory duplicates and replicates samples will have a precision average of +/- 30% relative percent difference (RPD).

Action	Description
	An assessment of the overall data quality should be presented in the final validation report, in accordance with the DEC (2006) *Guidelines for the NSW Site Auditor Scheme.*

8.2 VALIDATION REPORTING

All fieldwork, chemical analysis, discussions, conclusions and recommendations will be documented in a validation report for the site. The validation report will be prepared in general accordance with requirements of the NSW EPA (2011) *Guidelines for Consultants Reporting on Contaminated Sites* and NSW DEC (2006) *Guidelines for the NSW Site Auditor Scheme* and will confirm the site has been remediated to a suitable standard for the proposed development.

The Site Validation Report will be submitted for Council at the completion of the remediation works programme.

9 CONCLUSIONS

Based on the information available from previous investigations at the site, this RAP has been prepared to inform the remediation works at 18 - 24 Railway St, Lidcombe, NSW.

Remediation works will be implemented in stages, as follows:

- Stage 1 – Site Preparation
- Stage 2 – Data Gap Closure Investigations (Soils and Groundwater)
- Stage 3 – UPSS Removal and Validation
- Stage 4 – Contaminated Soil Hotspot removal
- Stage 5 – Site Validation
- Stage 6 – Validation Report Preparation

In summary, EI considers that the site can be made suitable for residential use with accessible soils, through the implementation of the works described in this RAP.

10 STATEMENT OF LIMITATIONS

This report has been prepared for the exclusive use of Lidcombe 2 Pty Ltd, who is the only intended beneficiary of our work. The scope of the investigations carried out for the purpose of this report is limited to those agreed with Lidcombe 2 Pty Ltd.

No other party should rely on the document without the prior written consent of EI, and EI undertakes no duty, or accepts any responsibility or liability, to any third party who purports to rely upon this document without EI's approval.

EI has used a degree of care and skill ordinarily exercised in similar investigations by reputable members of the environmental industry in Australia as at the date of this document. No other warranty, expressed or implied, is made or intended. Each section of this report must be read in conjunction with the whole of this report, including its appendices and attachments.

The conclusions presented in this report are based on a limited investigation of conditions, with specific sampling locations chosen to be as representative as possible under the given circumstances.

EI's professional opinions are reasonable and based on its professional judgment, experience, training and results from analytical data. EI may also have relied upon information provided by the Client and other third parties to prepare this document, some of which may not have been verified by EI.

EI's professional opinions contained in this document are subject to modification if additional information is obtained through further investigation, observations, or validation testing and analysis during remedial activities. In some cases, further testing and analysis may be required, which may result in a further report with different conclusions.

REFERENCES

ANZECC/ARMCANZ (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, October 2000.

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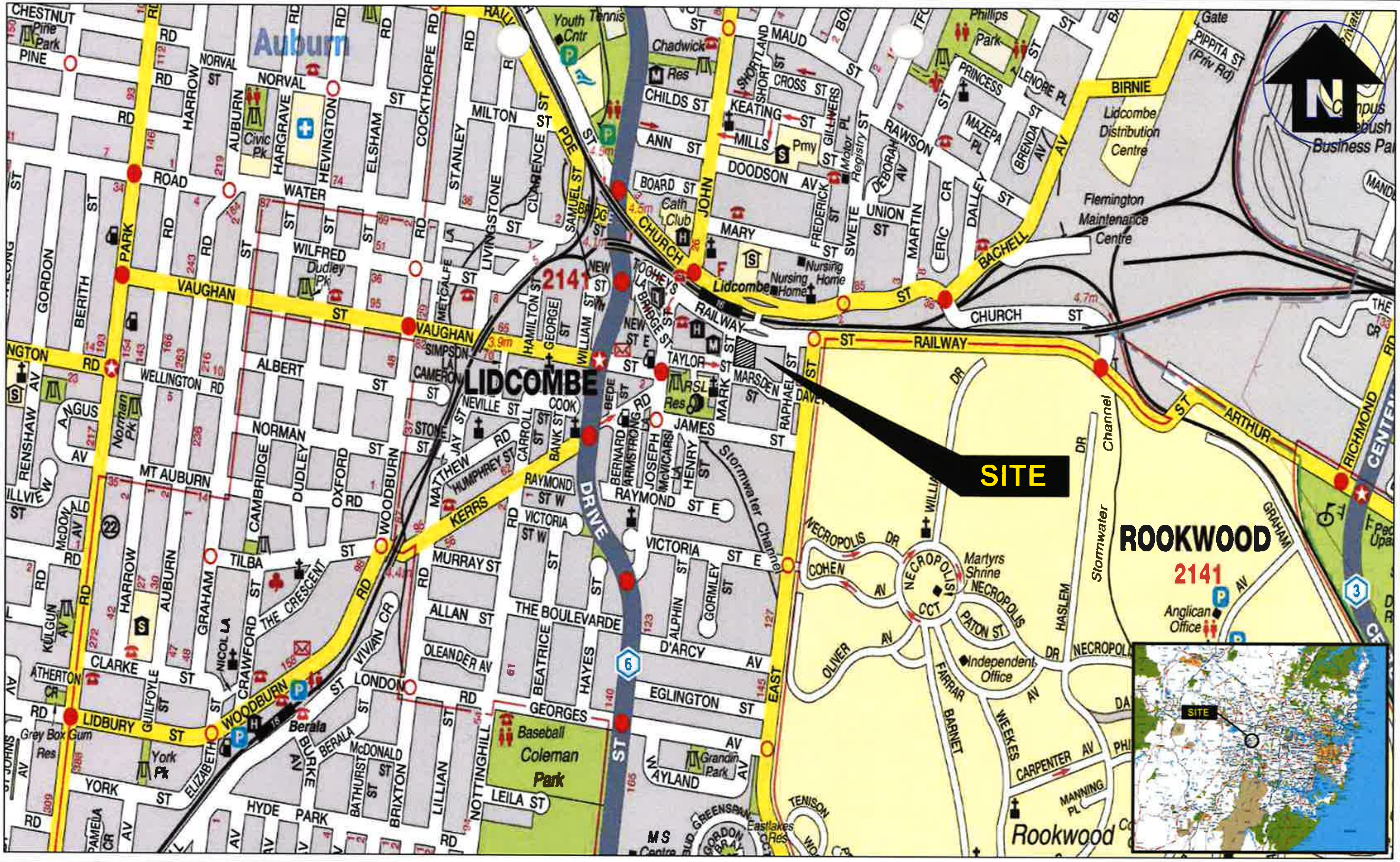
ABBREVIATIONS

AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
B(a)P	Benzo(a)Pyrene
bgl	Below Ground Level
BH	Borehole
BTEX	Benzene, Toluene, Ethyl benzene, Xylene
CSM	Conceptual Site Model
CT	Contaminant Thresholds
CVOCs	Chlorinated Volatile Organic Compounds
DECC	Department of Environment and Climate Change, NSW (formerly DEC)
DP	Deposited Plan
DQO	Data Quality Objectives
EPA	Environment Protection Authority
EMP	Environmental Management Plan
ENM	Excavated Natural Material
GIL	Groundwater Investigation Level
GME	Groundwater monitoring event
HIL	Health-based Investigation Level
HSL	Health-based Screening Level
m	Metres
m AHD	Metres relative to Australian Height Datum
m bgl	Metres below ground level
NSW	New South Wales
OEH	Office of Environment and Heritage, NSW (formerly DEC, DECC, DECCW)
PAHs	Polycyclic Aromatic Hydrocarbons
RAP	Remediation Action Plan
SIL	Soil Investigation Level
TPH	Total Petroleum Hydrocarbons
TRH	Total Recoverable Hydrocarbons
UCL	Upper Confidence Limit
UPSS	Underground Petroleum Storage System
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
VENM	Virgin Excavated Natural Material
VOC	Volatile Organic Compounds

FIGURES



eiaustralia
Contamination | Remediation | Geotechnical
Suite 6.01, 55 Miller Street, PYRMONT 2009
Ph (02) 9516 0722 Fax (02) 9518 5088

Drawn:	M.T.
Approved:	G.B.
Date:	29-09-16
Approx Scale:	N.T.S.

Lidcombe 2 Pty Ltd
Remediation Action Plan
18-24 Railway Street,
Lidcombe NSW
Site Locality Plan

Figure: 1

Project: E23006 AB

Sample location	Sample Matrix	Chemical in Concern	Concentration (mg/kg)
BH12M	GW	Copper	8
		Nickel	11
		Zinc	250
		Nitropropane	130

Sample location	Sample Matrix	Chemical in Concern	Concentration (mg/kg)
BH1M_0.5-0.6	Soil	Lead	1900
BH1M	GW	Copper	2
		Zinc	56

Sample location	Sample Matrix	Chemical in Concern	Concentration (mg/kg)
BH11M_0.2-0.3	Soil	Lead	1400

Sample location	Sample Matrix	Chemical in Concern	Concentration (mg/kg)
BH9_0.2-0.3	Soil	Asbestos	>0.01%

LEGEND

- Approximate site boundary
- Sampling locations (EI, 2016)
- Groundwater monitoring well locations (EI, 2016)
- Previously installed monitoring well (Asset, 2016)
- Approximate location of USTs
- Concentration exceeding adopted groundwater investigation criteria
- Concentration exceeding adopted health based soil criteria
- Approximate remediation area for asbestos

eiaustralia
Contamination | Remediation | Geotechnics
Suite 6.01, 55 Miller Street, PYRMONT 2009
Ph (02) 9516 0722 Fax (02) 9516 5088

Drawn:	M.T.
Approved:	N.F
Date:	-09-16

Lidcombe 2 Pty Ltd
Remediation Action Plan
18-24 Railway Street, Lidcombe NSW

Sampling Location Plan

Figure: 2

Project: E23006 AB_Rev0

APPENDIX A
SUMMARY OF LABORATORY RESULTS (EI 2016)

Table T1 – Summary of Soil Investigation Results for Heavy Metals

Sample ID	Sampling Date	Arsenic	Cadmium	Chromium (VI)	Copper	Lead	Mercury	Nickel	Zinc
BH1M_0.5-0.6	30/05/2016	93	0.6	17	31	1900	0.06	13	290
BH2_0.1-0.2	30/05/2016	8	<0.3	7.7	19	270	0.1	5.1	88
BH4M_0.2-0.3	30/05/2016	6	<0.3	14	15	71	0.04	6.3	30
BH4M_1.9-2.0	30/05/2016	6	<0.3	1.8	58	18	0.02	2.9	21
BH4M_2.9-3.0	30/05/2016	<3	0.4	9.7	29	15	0.04	21	92
BH4M_3.9-4.0	30/05/2016	5	<0.3	4.7	44	19	0.06	17	85
BH4M_4.9-5.0	30/05/2016	5	<0.3	7.1	27	17	0.05	16	74
BH5_0.4-0.5	30/05/2016	6	<0.3	6.6	11	160	0.02	4.4	97
BH6M_0.8-0.9	30/05/2016	6	<0.3	7.6	25	11	0.02	4.1	35
BH6M_0.1-0.2	30/05/2016	17	<0.3	8.7	15	20	0.01	10	30
BH6M_1.9-2.0	30/05/2016	11	<0.3	7.8	30	17	0.03	28	150
BH6M_3.4-3.5	30/05/2016	4	0.4	7.2	26	16	0.05	22	95
BH7M_0.2-0.3	30/05/2016	6	0.3	9.7	20	370	0.1	5.2	71
BH8_0.3-0.4	30/05/2016	260	0.3	17	23	230	0.07	8.1	120
BH8_2.4-2.5	30/05/2016	57	<0.3	4.8	34	33	0.13	31	100
BH10_0.1-0.2	30/05/2016	47	<0.3	4.1	7.9	18	0.01	2	20
BH10_1.1-1.2	30/05/2016	<3	<0.3	7.6	30	14	0.03	6.8	52
BH11_0.2-0.3	30/05/2016	6	0.8	14	46	1400	0.48	6.4	480
BH11_1.0-1.1	30/05/2016	7	<0.3	14	29	15	<0.01	5.3	52
Deep Planting Soils Location									
BH9_0.2-0.3	30/05/2016	20	0.4	21	17	66	0.16	7	67
BH9_1.8-1.9	30/05/2016	<3	<0.3	1.8	16	7	0.03	1.4	13
				SILs					
HIL A[1]	*Residential with accessible soils*	100	20	100	6000	300	40	400	7400
HIL B[1]	*Residential with minimal access to soil*	500[2]	150	500	30,000	1,200[3]	120[4]	1,200	60,000
HIL C[1]	*Public Open Space*	300	90	300	17,000	600	80	1,200	30,000
HIL D[1]	*Commercial / Industrial*	3,000	900	3,600	240,000	1,500	730	6,000	400,000
EILs[5]	*Urban Residential and public open space*	100	NR	205[6]	160[7]	1,260	NR	35[8]	195[9]

indicates concentration exceeds HSL

indicates concentration exceeds ESL

Notes:	All results are reported in mg/kg unless stated otherwise
SIL	Soil investigation Levels.
HIL	Health-based investigation levels (mg/kg) as per NEPM 1999 Schedule B1 2013 Amendment.
EIL	Ecological Investigation Levels (mg/kg) as per NEPM. As physiochemical properties were not analysed, the most conservative value applicable to the site was apr
N.R.	No Recommended soil assessment criteria are currently available for the indicated parameter(s).
N.A.	Not analysed.
1	Health-based investigation levels (mg/kg) as per NEPM 1999 Schedule B1 2013 Amendment.
2	Arsenic - HIL assumes 70% oral bioavailability. Site-specific bioavailability may be important and should be considered where appropriate (refer to NEPM 1999 Sc
3	Lead - HIL is based on blood lead models (IEUBK for HILs A, B and C and adult lead model for HIL D where 50% oral bioavailability has been considered. Site-sp bioavailability may be important and should be considered where appropriate.
4	Value shown is representative of inorganic mercury as provided in Table 1A(1) (refer to NEPM 1999 Schedule B1 2013 Amendment).
5	EIL values are for urban residential and public open space. Assumes an old NSW high traffic suburb. EILs only applicable to BH9 sampling location.
6	Assumes clay content >10%
7	Assumesassumes pH 5.5
8	Aassumes CEC 5
9	Assumes pH5.5 & CEC 5

Table T2 – Summary of Soil Investigation Results for TRH, BTEX, PAH, Naphthalene, VOC, OCPs, OPPs and PCBs

Sample ID	Sampling Date	PID Reading (PPM)	Total Recoverable Hydrocarbons (mg/kg)				Benzene (mg/kg)	Toluene (mg/kg)	Ethyl benzene (mg/kg)	Total Xylenes (mg/kg)	Naphthalene* (mg/kg)	VOC's	Carcinogenic PAHs (as BaP TEQ)**	Total PAHs	Benzo(a)pyrene	Chlordane	Other OCPs	OPPs	PCBs	Total Phenols
			F1[1]	F2[2]	F3[3]	F4[4]														
BH1M_0.5-0.6	30/05/2016	0.9	<25	<25	<90	<120	<0.1	<0.1	<0.1	<0.3	<0.1	ND	0.3	2.1	0.2	<0.1	ND	ND	ND	NA
BH2_0.1-0.2	30/05/2016	1.4	<25	<25	<90	<120	<0.1	<0.1	<0.1	<0.3	<0.1	ND	0.3	2.3	0.2	<0.1	ND	ND	ND	NA
BH4M_0.2-0.3	30/05/2016	0.1	<25	<25	<90	<120	<0.1	<0.1	<0.1	<0.3	<0.1	ND	<0.2	<0.8	<0.1	<0.1	ND	ND	ND	NA
BH4M_1.9-2.0	30/05/2016	1.9	<25	<25	<90	<120	<0.1	<0.1	<0.1	<0.3	<0.1	ND	<0.2	<0.8	<0.1	NA	NA	NA	NA	<0.1
BH4M_2.9-3.0	30/05/2016	0.7	<25	<25	<90	<120	<0.1	<0.1	<0.1	<0.3	<0.1	ND	<0.2	<0.8	<0.1	NA	NA	NA	NA	<0.1
BH4M_3.9-4.0	30/05/2016	0.6	<25	<25	<90	<120	<0.1	<0.1	<0.1	<0.3	<0.1	ND	<0.2	<0.8	<0.1	NA	NA	NA	NA	0.2
BH4M_4.9-5.0	30/05/2016	1.3	<25	66	<90	<120	<0.1	<0.1	<0.1	<0.3	<0.1	ND	0.3	0.8	0.2	NA	NA	NA	NA	<0.1
BH5_0.4-0.5	30/05/2016	2.3	<25	<25	<90	<120	<0.1	<0.1	<0.1	<0.3	<0.1	ND	<0.2	<0.8	<0.1	<0.1	ND	ND	ND	NA
BH6M_0.1-0.2	30/05/2016	0.1	<25	<25	<90	<120	<0.1	<0.1	<0.1	<0.3	<0.1	ND	<0.2	<0.8	<0.1	<0.1	ND	ND	ND	NA
BH6M_0.8-0.9	30/05/2016	2.2	<25	<25	<90	<120	<0.1	<0.1	<0.1	<0.3	<0.1	ND	<0.2	<0.8	<0.1	NA	NA	NA	NA	<0.1
BH6M_1.9-2.0	30/05/2016	1.4	<25	<25	<90	<120	<0.1	<0.1	<0.1	<0.3	<0.1	ND	<0.2	<0.8	<0.1	NA	NA	NA	NA	<0.1
BH6M_3.4-3.5	30/05/2016	2.4	<25	<25	<90	<120	<0.1	<0.1	<0.1	<0.3	<0.1	ND	<0.2	<0.8	<0.1	NA	NA	NA	NA	<0.1
BH7M_0.2-0.3	30/05/2016	1.3	<25	<25	<90	<120	<0.1	<0.1	<0.1	<0.3	<0.1	ND	<0.2	<0.8	<0.1	<0.1	ND	ND	ND	NA
BH8_0.3-0.4	30/05/2016	2.8	<25	<25	<90	<120	<0.1	<0.1	<0.1	<0.3	<0.1	ND	<0.2	<0.8	<0.1	<0.1	ND	ND	ND	NA
BH8_2.4-2.5	30/05/2016	1.8	<25	<25	<90	<120	<0.1	<0.1	<0.1	<0.3	<0.1	ND	<0.2	<0.8	<0.1	NA	NA	NA	NA	<0.1
BH10_0.1-0.2	30/05/2016	6.5	<25	<25	<90	<120	<0.1	<0.1	<0.1	<0.3	<0.1	ND	<0.2	<0.8	<0.1	<0.1	ND	ND	ND	NA
BH10_1.1-1.2	30/05/2016	6.6	<25	<25	<90	<120	<0.1	<0.1	<0.1	<0.3	<0.1	ND	<0.2	<0.8	<0.1	NA	NA	NA	NA	<0.1
BH11_0.2-0.3	30/05/2016	4.4	<25	<25	<90	<120	<0.1	<0.1	<0.1	<0.3	<0.1	ND	0.4	3.3	0.2	<0.1	ND	ND	ND	NA
BH11_1.0-1.1	30/05/2016	4.9	<25	<25	<90	<120	<0.1	<0.1	<0.1	<0.3	<0.1	ND	<0.2	<0.8	<0.1	NA	NA	NA	NA	<0.1
Deep Planting Soils Location																				
BH9_0.2-0.3	30/05/2016	4.5	<25	<25	<90	<120	<0.1	<0.1	<0.1	<0.3	<0.1	ND	0.4	3.1	0.2	0.2	ND	ND	ND	NA
BH9_1.8-1.9	30/05/2016	2.8	<25	<25	<90	<120	<0.1	<0.1	<0.1	<0.3	<0.1	ND	<0.2	<0.8	<0.1	NA	NA	NA	NA	<0.1
SILs																				

Sample ID	Sampling Date	PID Reading (PPM)	Total Recoverable Hydrocarbons (mg/kg)				Benzene (mg/kg)	Toluene (mg/kg)	Ethyl benzene (mg/kg)	Total Xylenes (mg/kg)	Naphthalene* (mg/kg)	VOC's	Carcinogenic PAHs (as BaP TEQ)**	Total PAHs	Benzo(a)pyrene	Chlordane	Other OCPs	OPPs	PCBs	Total Phenols
			F1[1]	F2[2]	F3[3]	F4[4]														
HSL A & B (Clay)	0 m to <1 m		50	280	NL	NL	0.7	480	NL	110	5	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.
	1 m to < 2 m		90	NL	NL	NL	1	NL	NL	310	NL	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.
	2 m to <4 m		150	NL	NL	NL	2	NL	NL	NL	NL	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.
	4 m +		290	NL	NL	NL	3	NL	NL	NL	NL	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.
HSL D (Clay)	0 m to <1 m		310	NL	NL	NL	4	NL	NL	NL	NL	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.
	1 m to < 2 m		480	NL	NL	NL	6	NL	NL	NL	NL	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.
	2 m to <4 m		NL	NL	NL	NL	9	NL	NL	NL	NL	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.
	4 m +		NL	NL	NL	NL	20	NL	NL	NL	NL	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.
HIL A	Residential with accessible soils		N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	3	300	N.R.	50	N.R.	N.R.	1	3000
HIL B	Residential with minimal access to soil		N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	4	400	N.R.	90	N.R.	N.R.	1	45000
HIL C	Public Open Space		N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	3	300	N.R.	70	N.R.	N.R.	1	40000
HIL D	Commercial / Industrial		N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	40	400	N.R.	530	N.R.	N.R.	7	240000
ESLs[5]	Fine grained		180*	120*	1,300	5,600	65	105	125	45	N.R.	N.R.	N.R.	N.R.	0.7	N.R.	N.R.	N.R.	N.R.	N.R.
EIL	Generic EIL Urban Residential and public open space										170									

Notes:

All results are reported in mg/kg unless stated otherwise

All soil assessment criteria are sourced from National Environment Protection (Assessment of Site Contamination) Measure 1999 – Amendment 2013, Schedule (B1) - Guideline on Investigation Levels for Soil and Groundwater (NEPM 2013).

SIL Soil investigation Level.

HSL Health screening levels (w/w) based on Low-high density residential (clay).

ESL Ecological screening level for urban residential / public open sapce sites, as per Table 1B(6) of NEPM 2013 Schedule B1

N.R. No Recommended soil assessment criteria are currently available for the indicated parameter(s).

NL Not Limiting" i.e. the derived soil HSL exceeds the maximim the soil saturation concentration.

N.A. Not analysed.

N.D. Not detected

* Results reported are volatile Naphthalene.

** Carcinogenic PAHs (as BaP TEQ)-assume results <LOR=LOR

1 F1 = TRH C6-C10 less BTEX

2 F2 = TRH > C10 - C16 less Naphthalene

3 F3 = TRH > C16 - C34

4 F4 = TRH > C34 - C40

5 ESLs are of low reliability except where indicated by * which indicates that the ESL is of moderate reliability. (Ref: Table 1B(6) NEPM 2013)

6 Region 9 SSL are screening levels for resident soils set by USEPA

Table T3 – Summary of Soil Investigation Results for Asbestos

Sample ID	Asbestos	Asbestos (% w/w)
BH1M_0.1-0.2	No	<0.01
BH2_0.1-0.2	No	<0.01
BH3_0.1-0.2	No	<0.01
BH4M_0.2-0.3	No	<0.01
BH5_0.2-0.3	No	<0.01
BH6M_0.2-0.3	No	<0.01
BH7M_0.2-0.3	No	<0.01
BH8_0.3-0.4	No	<0.01
BH9_0.2-0.3	Yes	**>0.01**
BH10_0.12-0.2	No	<0.01
BH11_0.2-0.3	No	<0.01
HSL		
Residential A	Residential with accessible soils	0.01%
Residential B	Residential with minimal access to soil	0.04%

Notes:

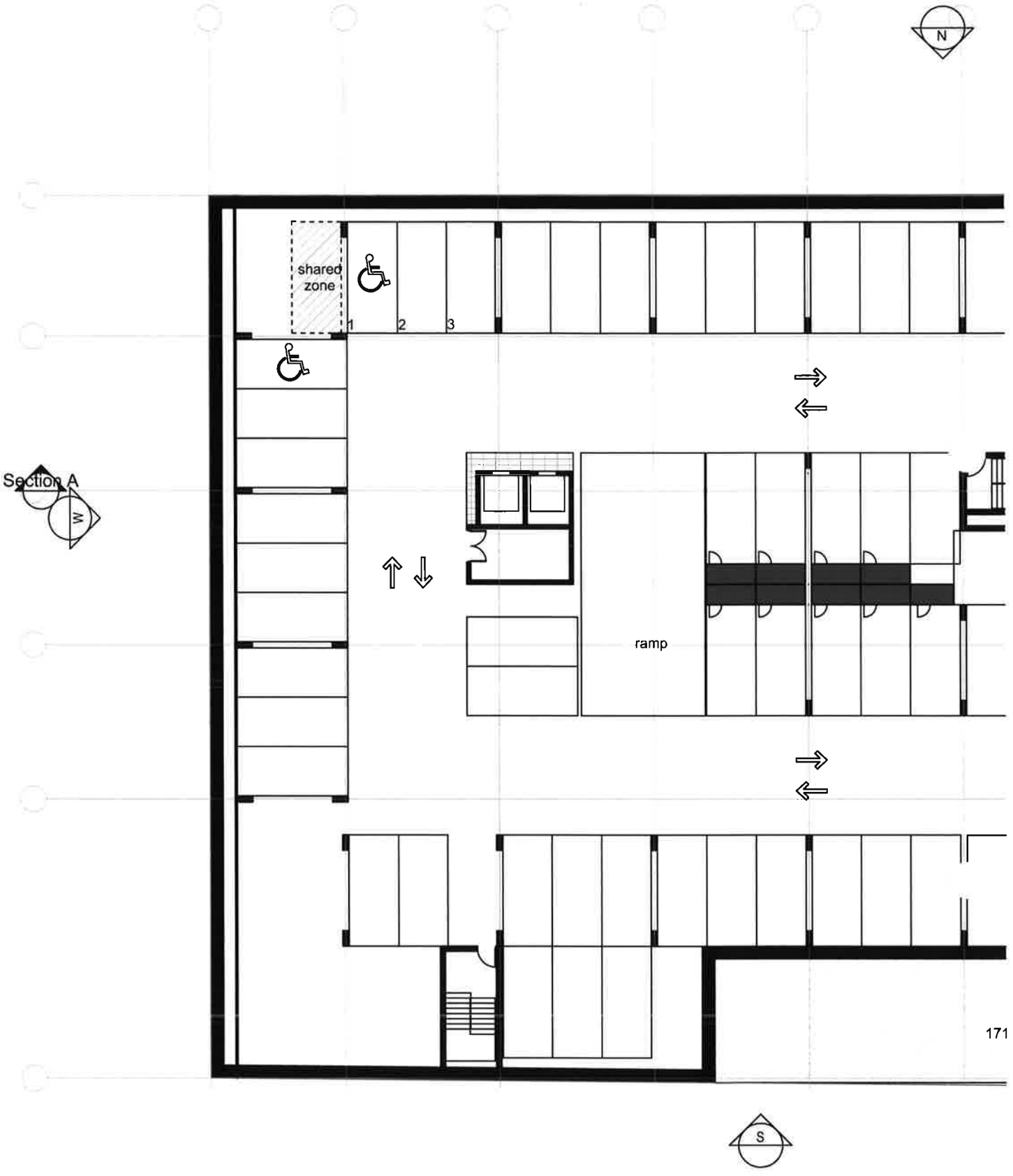
All soil assessment criteria are sourced from National Environment Protection (Assessment of Site Contamination) Measure 1999 – Amendment 2013, Schedule (B1) - Guideline on Investigation Levels for Soil and Groundwater (NEPM 2013).

HSL Health screening levels (w/w)

Sample ID		Heavy Metals								BTEXN					TRH				PAHs			VOC's
		Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc	Benzene	Toluene	Ethylbenzene	Total Xylene	Naphthalene	F1*	F2**	F3***	F4****	Total PAHs	Benzo(a)pyrene	Naphthalene	2-nitropropane
BH1M		14	<0.1	<1	2	<1	<0.1	3	56	<0.5	<0.5	<0.5	<1.5	<0.5	<50	<60	<500	<500	<1	<0.1	<0.1	<100
BH12M [6]		16	<0.1	<1	8	<1	<0.1	11	250	<0.5	<0.5	<0.5	<1.5	<0.5	<50	<60	<500	<500	<1	<0.1	<0.1	130
GIL																						
GIL (Marine Waters)		NR	0.7[2]	27 (Cr III) 4.4 (Cr VI)	1.3	4.4	0.1[2]	7[2]	15[3]	500[3]	180[4]	5[4]	75[4]	50	50[1]	60[1]	500[1]	500[1]	NR	NR	NR	NR
HSL A & B (Clay)	2 m to < 4 m	NR								5,000	NL	NL	NL	NL	NL	NL	NR					
	4 m to < 8 m									5,000	NL	NL	NL	NL	NL	NL						
Region 9 SSL [5]																						0.021

Notes:	All results and criteria are in µg/L, unless otherwise noted.
	Highlighted values indicate concentrations exceed the adopted GIL.
GIL (Marine Waters)	NEPM 2013 Schedule B1 . Groundwater investigation level for marine waters ecosystem
HSL A & B	Health screening level for residential sites, as per Table 1A(4) of NEPM 2013 Schedule B1. As soils encountered during field investigation comprised primarily clayey materials, HSL for clay was adopted. HSL are applied based on the estimated source depth of groundwater at each monitoring well.
NL	Not Limited (Ref. NEPM 2013, Schedule B1, Table 1(A)4)
NR	No recommended assessment criteria are currently available for the indicated parameter(s).
PQL	(Laboratory's) Practical Quantitation Limit
NT	Not tested.
*	F1 = TRH C6-C10 less BTEX
**	F2 = TRH > C10-C16 less Naphthalene
***	F3 = TRH > C16-C34
****	F4 = TRH > C34 - C40
1	ANZECC (2000) provides 7 µg/L as an assessment guideline for total petroleum hydrocarbons. Since the laboratory practical quantitation limits (PQL) is higher than the ANZECC guideline, the PQL has been adopted as the interim
2	The 99% Trigger Values were adopted for this assessment. Ref. ANZECC & ARMCANZ (2000).
3	Indicated threshold value may not protect key species from chronic toxicity. Ref. ANZECC & ARMCANZ (2000).
4	Low reliability 95% trigger values were adopted. Ref. Section 8.3.7, ANZECC & ARMCANZ (2000).
5	Region 9 SSL are screening levels for tap water set by USEPA drinking-water standards that set the maximum permissible level of contaminationin water that is deliveredto any user of a public water system (U.S.EPA, 2006)
6	Previously installed well BH1 (GI, ASSET 2016) herein referred as BH12M.

APPENDIX B
PROPOSED DEVELOPMENT PLANS


N
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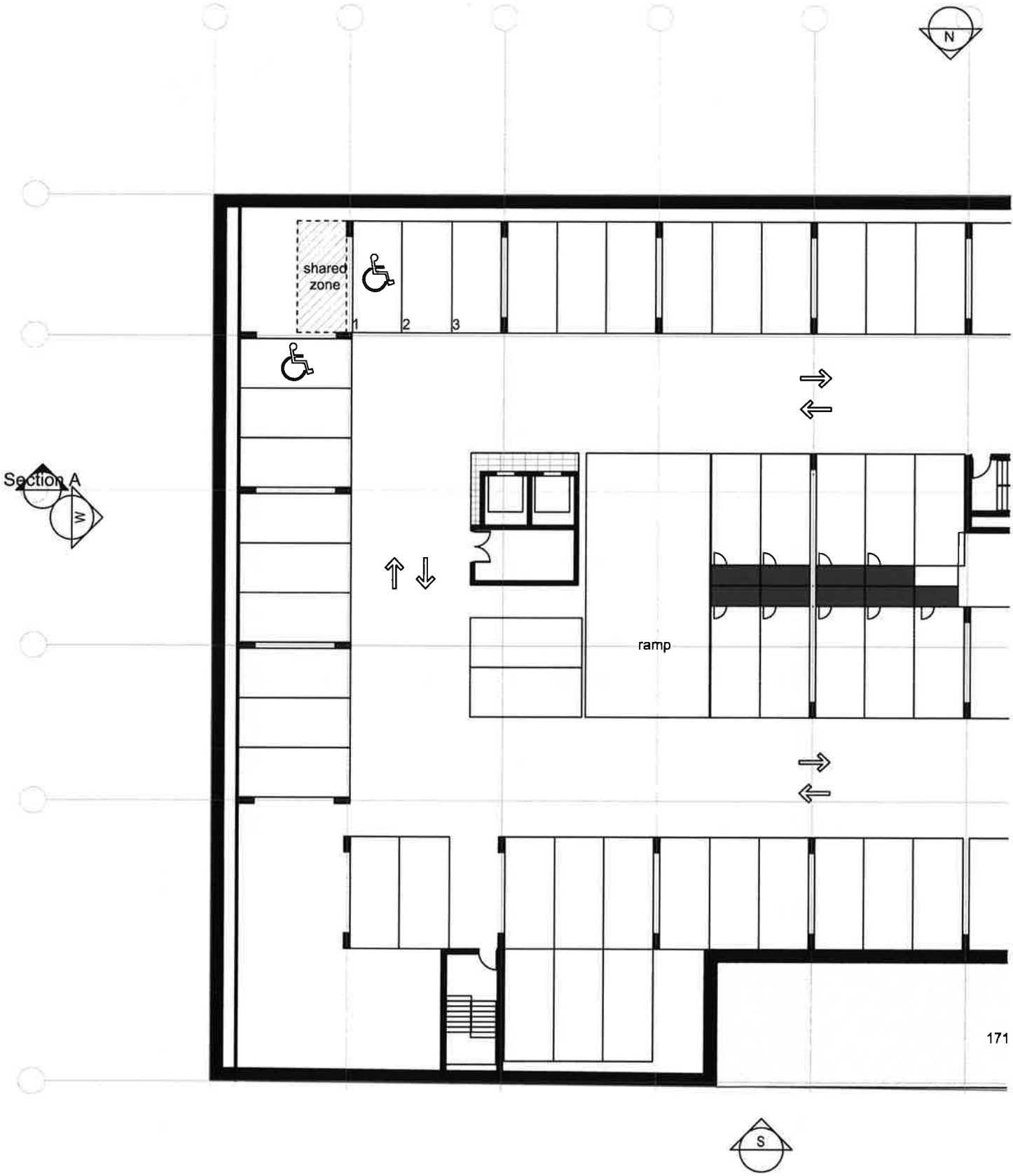
1
2
3
Section A
W
ramp
171
S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shared zone
1
2
3
Section A
W
ramp
S

Section A

Section A

LEGEND

Revision ID	Description	Date
A	PRELIMINARY	17.05.16

CLIENT

BillOne PROPERTY

ARCHITECT

FUSE ARCHITECTURE

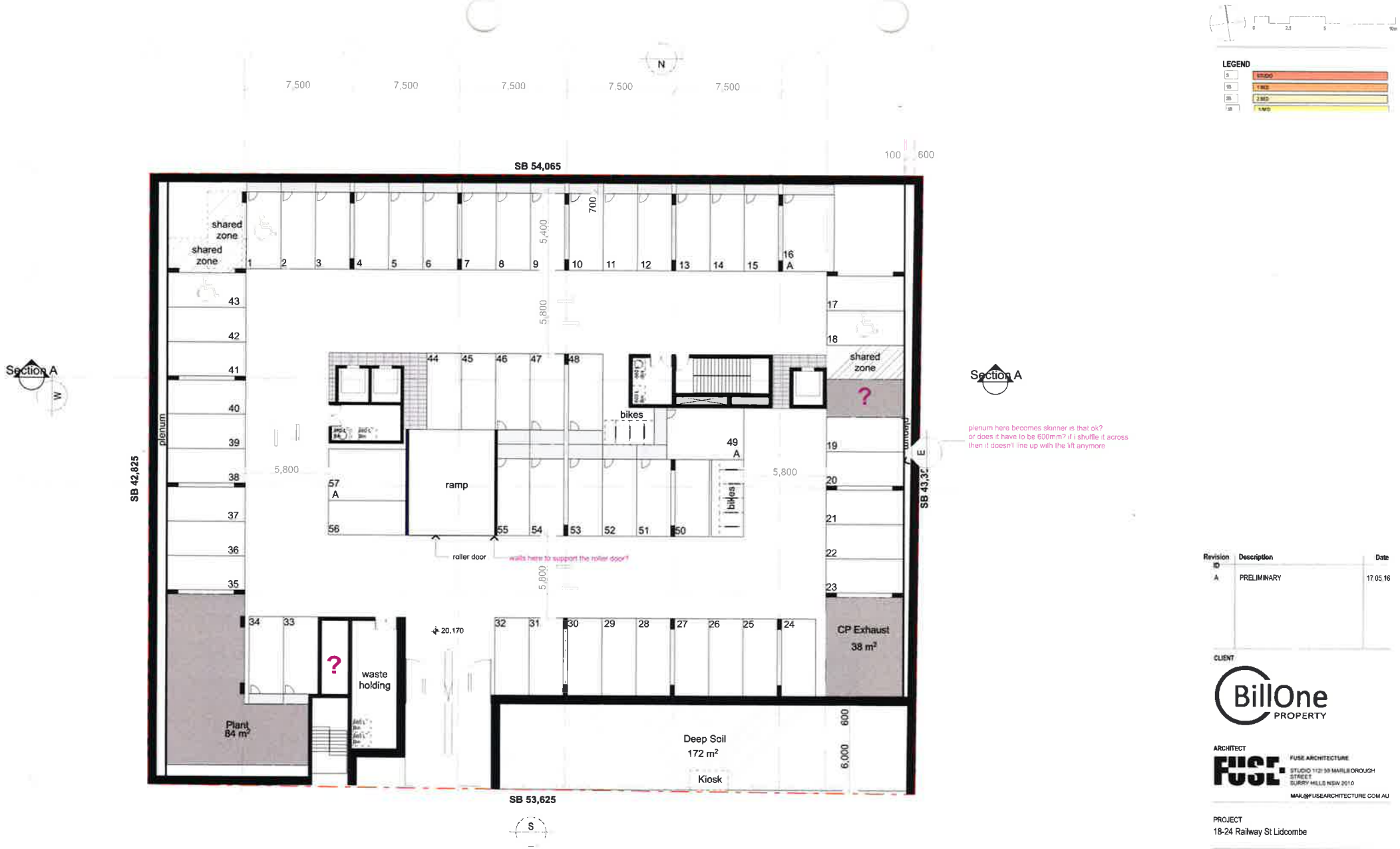
FUSE ARCHITECTURE
STUDIO 112/ 59 MARLBOROUGH STREET
SURRY HILLS NSW 2010
MAIL@FUSEARCHITECTURE.COM.AU

PROJECT
18-24 Railway St Lidcombe

TITLE
Plans
Plan - Basement 2

SCALE	@A3	PROJECT CODE
DATE	11.05.2016	1604
SHEET NO.		REVISION
DA03		

SKETCH PLAN



Revision ID	Description	Date
A	PRELIMINARY	17.05.16

CLIENT

BillOne PROPERTY

ARCHITECT

FUSE ARCHITECTURE

STUDIO 112/ 59 MARRICKVILLE ROAD
STREET
SURRY HILLS NSW 2010

MAIL@FUSEARCHITECTURE.COM.AU

PROJECT

18-24 Railway St Lidcombe

TITLE

Plans

Plan - Basement 1

SCALE	@A3	PROJECT CODE	1604
DATE	11.05.2016	REVISION	
SHEET NO.	DA04		

SKETCH PLAN

RAILWAY

N

MARK ST

Section A

W

SB 54,065

Retail
495 m²

LOBBY
23,820

LB

22 m²

3B
102 m²

SB 42,825

3B
108 m²

E+C

30 m²

LOBBY
23,820

Section A

3B
111 m²

34 m²

SB 43,35

E

1B
50 m²

20 m²

COURTYARD

38 m²

3B
112 m²

M

2B
77 m²

10 m²

SB 53,625

S

LANE

LEGEND

0	STUDIO
15	1 BED
25	2 BED
30	3 BED

Revision ID	Description	Date
A	PRELIMINARY	17.05.16

CLIENT

BillOne PROPERTY

ARCHITECT

FUSE.

FUSE ARCHITECTURE
STUDIO 112/ 59 MARLBOROUGH STREET
SURRY HILLS NSW 2010
MAIL@FUSEARCHITECTURE.COM.AU

PROJECT
18-24 Railway St Lidcombe

TITLE
Plans
Plan - Ground Floor Plan

SCALE	@A3	PROJECT CODE
DATE	11.05.2016	1604
SHEET NO.		REVISION
DA05		01 - WIP

SKETCH PLAN

APPENDIX C
BOREHOLE LOGS

eiaustralia

BOREHOLE: BH1M

eiaustralia
Contamination | Remediation | Geotechnical

Project	Detailed Site Investigation			Sheet	1 OF 1
Location	18-24 Railway Street, Lidcombe NSW			Date Started	30/6/16
Position	Refer to Figure 2			Date Completed	30/6/16
Job No.	E23006	Contractor	HartGeo Pty Ltd	Logged	MT Date:
Client	Lidcombe 2 Pty Ltd	Drill Rig	Ute-mounted Rig	Checked	Date:
		Inclination	-90°		

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID / Static Water Level
AD/T	-	-	0					-	FILL: Sandy CLAY; low plasticity, orange-brown, no odour.	M		BH1M: Gatic Cover
					BH1M_0.5-0.6 QD1 QT1							
			1	1.00	PID = 0.9 ppm			CL	Sandy CLAY; low plasticity, orange-grey, no odour.	M		Cuttings
				1.50	BH1M_1.0-1.1 PID=0.5 ppm			-	SHALE; light brown, extremely weathered no odour.	D		51 mm uPVC Casing
				1.90	BH1M_1.5-1.6 ES PID=0.4 ppm			CL	CLAY; high plasticity, orange mottled brown, no odour.	M		
			2	2.00	BH1M_1.9-2.0 ES PID=1.1 ppm			-	SHALE; light brown, extremely low strength to very low strength, extremely weathered.			
			3		BH1M_3.0-3.1 PID = 1.4 ppm							Bentonite
			4									
					BH1M_4.4-4.5 PID = 1.4 ppm					D		
			5									50 mm uPVC Screen Sand
			6		BH1M_5.9-6.0 PID = 1.6 ppm							
				6.90								
			7						Hole Terminated at 6.90 m Converted Into Monitoring Well.			
			8									
			9									
			10									

This borehole log should be read in conjunction with Environmental Investigations Australia's accompanying standard notes.

BOREHOLE: BH2

eiaustralia
Contamination | Remediation | Geotechnical

Project	Detailed Site Investigation			Sheet	1 OF 1
Location	18-24 Railway Street, Lidcombe NSW			Date Started	30/6/16
Position	Refer to Figure 2			Date Completed	30/6/16
Job No.	E23006	Contractor	HartGeo Pty Ltd	Logged MT	Date:
Client	Lidcombe 2 Pty Ltd	Drill Rig	Ute-mounted Rig	Checked	Date:
		Inclination	-90°		

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/T	-	GWNE	0		BH2_0.1-0.2			-	FILL: Gravelly SAND; fine to medium grained, brown, gravel is rounded subrounded, trace of brick, glass, no odour.	M		FILL
					PID = 1.4 ppm							
			1	1.00				CL	Sandy CLAY; low plasticity, grey / mottled orange, no odour.	M	-	RESIDUAL SOIL
					BH2_1.7-1.8 ES							
			2	2.20	PID = 0.5 ppm				Hole Terminated at 2.20 m			
			3									
			4									
			5									
			6									
			7									
			8									
			9									
			10									

This borehole log should be read in conjunction with Environmental Investigations Australia's accompanying standard notes.

BOREHOLE: BH3

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Contamination | Remediation | Geotechnical

Project	Detailed Site Investigation			Sheet	1 OF 1
Location	18-24 Railway Street, Lidcombe NSW			Date Started	30/6/16
Position	Refer to Figure 2			Date Completed	30/6/16
Job No.	E23006	Contractor	HartGeo Pty Ltd	Logged	MT Date:
Client	Lidcombe 2 Pty Ltd	Drill Rig	Ute-mounted Rig	Checked	Date:
		Inclination	-90°		

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/T	-	GWNE	0		BH3_0.3-0.4 PID = 0.5 ppm			-	FILL: Gravelly SAND; fine to medium grained, brown, gravel is rounded subrounded, with clay, trace of glass, no odour.	M		FILL
			1	1.10				CL	Sandy CLAY; low plasticity, orange mottled grey, no odour.	M		RESIDUAL SOIL
				1.80				CL	CLAY; medium to high plasticity, orange mottled grey, no odour.	M		
			2	2.00	BH3_1.9-2.0 PID =0.1 ppm			-		M		
				2.20				-	SHALE; light brown, extremely weathered, no odour.	D	-	WEATHERED ROCK
			3		BH3_2.2-2.3 PID = 0.5 ppm							
				3.50				-	From 3.5 m, light yellow.	D		
			4	4.00	BH3_3.5-3.6 PID = 0.6 ppm			-	From 4.0 m, dark grey.	D		
				4.70	BH3_4.4-4.5 PID = 0.9 ppm				Hole Terminated at 4.70 m			
			5									
			6									
			7									
			8									
			9									
			10									

This borehole log should be read in conjunction with Environmental Investigations Australia's accompanying standard notes.

BOREHOLE: BH4M

eiaustralia
Contamination | Remediation | Geotechnical

Project	Detailed Site Investigation			Sheet	1 OF 1
Location	18-24 Railway Street, Lidcombe NSW			Date Started	30/6/16
Position	Refer to Figure 2			Date Completed	30/6/16
Job No.	E23006	Contractor	HartGeo Pty Ltd	Logged MT	Date:
Client	Lidcombe 2 Pty Ltd	Drill Rig	Ute-mounted Rig	Checked	Date:
		Inclination	-90°		

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID Static Water Level BH4M
DT			0	0.10				-	CONCRETE; 100mm thick.	M		BH4M
					BH4M_0.2-0.3			-	FILL: Sandy CLAY; low plasticity, orange-brown, no odour.	M		
				0.50	PID = 0.1 ppm			CL	Sandy CLAY; low plasticity, orange mottled grey, no odour.	M		
			1	1.00				CL	From 1.0 m, grey mottled orange	M		
					BH4M_1.4-1.5							
				1.80	PID = 0.8 ppm			-	SHALE; dark brown, extremely weathered, no odour.	D		
			2		BH4M_1.9-2.0							
				2.20	PID = 1.9 ppm			-	From 2.2 m, light yellow.	D		
AD/T	-	-	3		BH4M_2.9-3.0							
				3.50	PID = 0.7 ppm			-	From 3.5 m, dark grey.	D		
			4		BH4M_3.9-4.0							
					PID = 0.6 ppm							
			5		BH4M_4.9-5.0							
					PID = 1.3 ppm							
			6	6.00	BH4M_5.9-6.0				Hole Terminated at 6.00 m			
					PID = 2.4 ppm							
			7									
			8									
			9									
			10									

PIEZOMETER DETAILS: Gatic Cover; Cuttings; Bentonite; 50 mm uPVC Screen; Sand

This borehole log should be read in conjunction with Environmental Investigations Australia's accompanying standard notes.

BOREHOLE: BH5

eiaustralia
Contamination | Remediation | Geotechnical

Project	Detailed Site Investigation			Sheet	1 OF 1
Location	18-24 Railway Street, Lidcombe NSW			Date Started	30/6/16
Position	Refer to Figure 2			Date Completed	30/6/16
Job No.	E23006	Contractor	HartGeo Pty Ltd	Logged	MT Date:
Client	Lidcombe 2 Pty Ltd	Drill Rig	Ute-mounted Rig	Checked	Date:
		Inclination	-90°		

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/T	-	GW/NE	0	0.10				-	CONCRETE; 100mm thick.	M		CONCRETE HARDSTAND
				0.50	BH5_0.4-0.5			-	FILL: Sandy CLAY; low to medium plasticity, dark brown / orange with gravel rounded, subrounded	M	-	FILL
					PID = 2.3 ppm							
			1						Hole Terminated at 0.50 m on refusal			
			2									
			3									
			4									
			5									
			6									
			7									
			8									
			9									
			10									

This borehole log should be read in conjunction with Environmental Investigations Australia's accompanying standard notes.

BOREHOLE: BH6M

eiaustralia
Contamination | Remediation | Geotechnical

Project	Detailed Site Investigation			Sheet	1 OF 1
Location	18-24 Railway Street, Lidcombe NSW			Date Started	30/6/16
Position	Refer to Figure 2			Date Completed	30/6/16
Job No.	E23006	Contractor	HartGeo Pty Ltd	Logged MT	Date:
Client	Lidcombe 2 Pty Ltd	Drill Rig	Ute-mounted Rig	Checked	Date:
		Inclination	-90°		

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY
DT			0	0.10	BH6M_0.1_0.2 ES 0.10-0.20 m 0.10 m PID = 3.8 ppm			-	CONCRETE; 100mm thick.	M	
				0.40	BH6M_0.5-0.6 ES 0.50-0.60 m 0.50 m PID = 1.9 ppm			-	FILL: Sandy CLAY; low to medium plasticity, orange mottled grey, moist, slight hydrocarbon odour, trace of tar.	M	
			1	1.00	BH6M_0.8-0.9 ES 0.80-0.90 m 0.80 m PID = 2.2 ppm			CL	Sandy CLAY; low plasticity, light grey mottled orange, no odour.		
								-	SHALE; extremely weathered, orange, no odour.	M D	
			2		BH6M_1.9-2.0 ES 1.90-2.00 m 1.90 m PID = 1.4 ppm			-	From 1.0, light brown		
AD/T			3								
					BH6M_3.4-3.5 ES 3.40-3.50 m 3.40 m PID = 2.4 ppm					D	
			4								
					BH6M_4.5-4.6 ES 4.50-4.60 m 4.50 m PID = 2.3 ppm						
			5								
				5.90							
			6						Hole Terminated at 5.90 m Converted Into Monitoring Well.		
			7								
			8								
			9								
			10								

PIEZOMETER DETAILS
ID Static Water Level
BH6M

BH6M

- Gatic Cover
- Cuttings
- 51 mm uPVC Casing
- Bentonite
- 50 mm uPVC Screen
- Sand

This borehole log should be read in conjunction with Environmental Investigations Australia's accompanying standard notes.

BOREHOLE: BH7M

eiaustralia
Contamination | Remediation | Geotechnical

Project	Detailed Site Investigation			Sheet	1 OF 1
Location	18-24 Railway Street, Lidcombe NSW			Date Started	30/6/16
Position	Refer to Figure 2			Date Completed	30/6/16
Job No.	E23006	Contractor	HartGeo Pty Ltd	Logged MT	Date:
Client	Lidcombe 2 Pty Ltd	Drill Rig	Ute-mounted Rig	Checked	Date:
		Inclination	-90°		

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID Static Water Level BH7M
AD/T	-	-	0	0.50	BH7M_0.2-0.3			-	FILL: Sandy CLAY; low to medium plasticity, brown with gravel rounded, subrounded	M		Gatic Cover
			1		PID = 1.3 ppm			CL	Sandy CLAY; low to medium plasticity, orange, moist, no odour.	M		Cuttings
				1.50								51 mm uPVC Casing
				1.70	BH7M_1.6-1.7			CL	From 1.5, grey mottled orange, no odour.	M		Bentonite
			2		PID = 1.5 ppm BH7M_2.0-2.1			-	SHALE; extremely weathered, brown, no odour.	D		
				2.50	PID = 1.6 ppm			-	From 2.5 m, dark grey.			
			3		BH7M_3.4-3.5							
			4		PID = 4.4 ppm					D		50 mm uPVC Screen Sand
					BH7M_4.5-4.6							
			5		PID = 1.6 ppm							
				5.80								
			6						Hole Terminated at 5.80 m Converted Into Monitoring Well.			
			7									
			8									
			9									
			10									

This borehole log should be read in conjunction with Environmental Investigations Australia's accompanying standard notes.

BOREHOLE: BH8

eiaustralia
Contamination | Remediation | Geotechnical

Project	Detailed Site Investigation			Sheet	1 OF 1
Location	18-24 Railway Street, Lidcombe NSW			Date Started	30/6/16
Position	Refer to Figure 2			Date Completed	30/6/16
Job No.	E23006	Contractor	HartGeo Pty Ltd	Logged MT	Date:
Client	Lidcombe 2 Pty Ltd	Drill Rig	Ute-mounted Rig	Checked	Date:
		Inclination	-90°		

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/T	-	GWNE	0		BH8_0.3-0.4 PID = 2.8 ppm			-	FILL: Sandy CLAY; low to medium plasticity, brown with gravel rounded, subrounded	M		FILL
				0.80				CL	Sandy CLAY; low to medium plasticity, orange mottled grey, moist, no odour.	M	-	RESIDUAL SOIL
			1		BH8_1.4-1.5 PID = 2.4 ppm							
			2									
				2.40	BH8_2.4-2.5			-	SHALE; extremely weathered, dark brown, no odour.	D		WEATHERED ROCK
				2.80	PID = 1.8 ppm				Hole Terminated at 2.80 m			
			3									
			4									
			5									
			6									
			7									
			8									
			9									
			10									

This borehole log should be read in conjunction with Environmental Investigations Australia's accompanying standard notes.

BOREHOLE: BH9

eiaustralia
Contamination | Remediation | Geotechnical

Project	Detailed Site Investigation			Sheet	1 OF 1
Location	18-24 Railway Street, Lidcombe NSW			Date Started	30/6/16
Position	Refer to Figure 2			Date Completed	30/6/16
Job No.	E23006	Contractor	HartGeo Pty Ltd	Logged MT	Date:
Client	Lidcombe 2 Pty Ltd	Drill Rig	Ute-mounted Rig	Checked	Date:
		Inclination	-90°		

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
DT			0	0.10				-	CONCRETE; 100mm thick.	M		CONCRETE HARDSTAND
AD/T	-	GWNE			BH9_0.2-0.3 PID = 4.5 ppm			-	FILL - Sandy CLAY; low to medium plasticity, dark brown, moist no odour, asbestos fragment	M		FILL
			1	0.80				CL	Sandy CLAY; low to medium plasticity, orange, no odour.	M	-	RESIDUAL SOIL
				1.50				CL	From 1.5 m, grey mottled orange	M		
			2	2.00	BH9_1.8-1.9 PID = 2.8 ppm				Hole Terminated at 2.00 m			
			3									
			4									
			5									
			6									
			7									
			8									
			9									
			10									

This borehole log should be read in conjunction with Environmental Investigations Australia's accompanying standard notes.

BOREHOLE: BH10

eiaustralia
Contamination | Remediation | Geotechnical

Project	Detailed Site Investigation			Sheet	1 OF 1
Location	18-24 Railway Street, Lidcombe NSW			Date Started	30/6/16
Position	Refer to Figure 2			Date Completed	30/6/16
Job No.	E23006	Contractor	HartGeo Pty Ltd	Logged MT	Date:
Client	Lidcombe 2 Pty Ltd	Drill Rig	Ute-mounted Rig	Checked	Date:
		Inclination	-90°		

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/T	-	GWNE	0	0.10				-	CONCRETE; 100mm thick.	M		CONCRETE HARDSTAND
				0.20	BH10_0.1-0.2 PID = 6.5 ppm			-	FILL: Sandy CLAY; low plasticity, light yellow, moist no odour.	M		FILL
								CL	Sandy CLAY; high plasticity, orange mottled grey, no odour.			RESIDUAL SOIL
					BH10_0.4-0.5 PID = 7 ppm					M	-	
			1	1.10								
				1.20	BH10_1.1-1.2 PID = 6.6 ppm			-	SHALE; extremely weathered, grey, no odour.	D		WEATHERED ROCK
									Hole Terminated at 1.20 m			
			2									
			3									
			4									
			5									
			6									
			7									
			8									
			9									
			10									

This borehole log should be read in conjunction with Environmental Investigations Australia's accompanying standard notes.

BOREHOLE: BH11

eiaustralia
Contamination | Remediation | Geotechnical

Project	Detailed Site Investigation			Sheet	1 OF 1
Location	18-24 Railway Street, Lidcombe NSW			Date Started	30/6/16
Position	Refer to Figure 2			Date Completed	30/6/16
Job No.	E23006	Contractor	HartGeo Pty Ltd	Logged MT	Date:
Client	Lidcombe 2 Pty Ltd	Drill Rig	Ute-mounted Rig	Checked	Date:
		Inclination	-90°		

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/T		GWNE	0		BH11_0.2-0.3			-	FILL: Sandy CLAY; low plasticity with gravel, brown, trace of glass, gravel is rounded subrounded	M		FILL
				0.50	PID = 4.4 ppm			CL	Sandy CLAY; low to medium plasticity, brown /orange no odour.			RESIDUAL SOIL
			1		BH11_1.0-1.1					M	-	
					PID = 4.9 ppm							
			2	2.10					Hole Terminated at 2.10 m			
			3									
			4									
			5									
			6									
			7									
			8									
			9									
			10									

This borehole log should be read in conjunction with Environmental Investigations Australia's accompanying standard notes.

APPENDIX D
REMEDIATION CRITERIA

Table E-1 Soil Remediation Criteria

Chemical	Unit	HIL B [1b]	HIL D	HSL A&B [11]	HSL D	EIL [2a]	ESL [2b]
Metals							
Arsenic – As	mg / kg	500 [3]	100	-	-	100	-
Cadmium - Cd	mg / kg	150	900	-	-	100	-
Chromium(VI) – Cr(VI)	mg / kg	500	3600	-	-	415	-
Copper – Cu	mg / kg	30,000	240000	-	-	125	-
Lead – Pb	mg / kg	1,200	1500	-	-	1260	-
Mercury – Hg (inorganic)	mg / kg	120	730	-	-	NA	-
Nickel – Ni	mg / kg	1,200	6000	-	-	135	-
Zinc – Zn	mg / kg	60,000	400000	-	-	350	-
Petroleum Hydrocarbons							
F1 [4]	mg / kg	-	-	50	310	-	180
F2 [5]	mg / kg	-	-	280	-	-	120
F3 [6]	mg / kg	-	-	-		-	300
F4 [7]	mg / kg	-	-	-		-	2800
Polycyclic Aromatic							
Naphthalene	mg / kg	-	-	3	-	170	-
Benzo(α)pyrene	mg / kg	-	-	-	-	-	0.7
Carcinogenic PAHs (as B(α)P	TEQ	4	40	-	-	-	-
Total PAHs [9]	mg / kg	400	400	-	-	-	-
Monocyclic Aromatic							
Benzene	mg / kg	-	-	0.7	4	-	50
Toluene	mg / kg	-	-	480	-	-	85
Ethylbenzene	mg / kg	-	-	-	-	-	70
Xylenes (total)	mg / kg	-	-	110	-	-	105
Asbestos		HSL B					
Asbestos (friable or fines)	w / w	0.001%					
Asbestos (bonded)	w / w	0.04%					

Notes:

1. Health-based investigation levels:
   a. HIL A - Residential with garden/accessible soil (home grown produce <10% fruit and vegetable intake (no poultry), also includes childcare centres, preschools and primary schools, Ref. NEPM 2013, Schedule B1, Table 1A(1).
   b. HIL B - Residential with minimal opportunities for soil access; includes dwellings with fully and permanently paved yard space such as high-rise buildings and apartments, Ref. NEPM 2013, Schedule B1, Table 1A(1).
2. Ecological investigation levels:
   a. EIL – Generic EIL for aged Arsenic and Naphthalene, Calculated EILs for other metals in urban residential and public open space settings with due regard for background concentrations, soil cation exchange capacity, texture and pH, Ref. NEPM 2013, Schedule B1, Tables 1B(1) to 1B(5).

b. ESL – Ecological Screening Level for F1, F2, F3, F4, BTEX and Benzo(a)pyrene in coarse texture soils in urban residential and public open space settings, Ref. NEPM 2013, Schedule B1, Table 1B(6).

3. Arsenic: HIL assumes 70% oral bioavailability. Site-specific bioavailability may be important and should be considered where appropriate (refer Schedule B7).
4. F1: concentration of TPH C_6-C_{10} fraction minus the sum of BTEX concentrations.
5. F2: concentration of TPH >C_{10}-C_{16} fraction minus the concentration of Naphthalene.
6. F3: concentration of TPH >C_{16}-C_{34}.
7. F4: concentration of TPH >C_{34}-C_{40}.
8. Carcinogenic PAHs: HIL is based on the 8 carcinogenic PAHs and their TEFs (potency relative to B(a)P) adopted by CCME 2008 (refer Schedule B7). The B(a)P TEQ is calculated by multiplying the concentration of each carcinogenic PAH in the sample by its B(a)P TEF, given below, and summing these products.
9. Total PAHs: HIL is based on the sum of the 16 PAHs most commonly reported for contaminated sites (WHO 1998). The application of the total PAH HIL should consider the presence of carcinogenic PAHs and naphthalene (the most volatile PAH). Carcinogenic PAHs reported in the total PAHs should meet the B(a)P TEQ HIL. Naphthalene reported in the total PAHs should meet the relevant HSL.
10. USEPA 2015 Region 9 Screening Levels (RSLs) for Resident Soils.
11. Soil HSLs for vapour intrusion assuming coarse texture (sand) soils and a contamination source at 0m to <1m depth.

Table E-2 Waste Classification without Leachate Testing

Contaminant	Maximum Values of Specific Contaminant Concentration for Classification without TCLP	
	General Solid Waste CT1 (mg/kg)	Restricted Solid Waste CT2 (mg/kg)
Arsenic	100	400
Asbestos	"Special Waste - Asbestos Waste" if ANY Asbestos is present	
Benzene	10	40
Benzo(a)pyrene	0.8	3.2
Cadmium	20	80
Chromium (VI)	100	400
Ethylbenzene	600	2,400
Lead	100	400
Mercury	4	16
Nickel	40	160
Petroleum hydrocarbons C_6-C_9	650	2,600
Petroleum hydrocarbons C_{10}-C_{36}	10,000	40,000
Polychlorinated biphenyls (PCB)	<50	<50
Polycyclic aromatic hydrocarbons (total PAH)	200	800
Toluene	288	1,152
Xylenes (total)	1,000	4,000

Note: N/A = not applicable (assessed using SCC1 and SCC2 values, only) see Table C-3

Table E-3 Waste Classification using TCLP and SCC Values

Contaminant	Maximum Values for Leachable Concentration and Specific Contaminant Concentration when used together			
	General Solid Waste		Restricted Solid Waste	
	Leachable Concentration	Specific Contaminant Concentration	Leachable Concentration	Specific Contaminant Concentration
	TCLP1 (mg/L)	SCC1 (mg/kg)	TCLP2 (mg/L)	SCC2 (mg/kg)
Arsenic	5.0	500	20	2,000
Asbestos	"Special Waste - Asbestos Waste" if ANY Asbestos is present			
Benzene	0.5	18	2	72
Benzo(a)pyrene	0.04	10	0.16	23
Cadmium	1.0	100	4	400
Chromium (VI)	5	1,900	20	7,600
Ethylbenzene	30	1,080	120	4,320
Lead	5	1,500	20	6,000
Mercury	0.2	50	0.8	200
Nickel	2	1,050	8	4,200
Petroleum hydrocarbons C_6-C_9	N/A	650	N/A	2,600
Petroleum hydrocarbons C_{10}-C_{36}	N/A	10,000	N/A	40,000
Polychlorinated biphenyls (PCB)	N/A	<50	N/A	<50
Polycyclic aromatic hydrocarbons (total PAH)	N/A	200	N/A	800
Toluene	14.4	518	57.6	2,073
Xylenes	50	1,800	200	7,200

Note: N/A = not applicable (assessed using SCC1 and SCC2 values, only)

APPENDIX E
REVIEW OF REMEDIAL OPTIONS & TECHNOLOGIES

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REVIEW OF REMEDIATION OPTIONS & TECHNOLOGIES

A number of soil remediation options were reviewed to examine the suitability of each method, in considering the remedial options available for the site, the surrounding lands and the geological and hydrogeological limitations, the following issues have been considered:

- Prioritisation of works in areas of most concern;
- Ability of remedial method to treat contamination with respect to natural and infrastructure limitations;
- Remedial timetable;
- Cost effectiveness;
- Defensible method to ensure the site is remediated to appropriate levels / validation criteria; and
- Regulatory compliance.

The following sections provide details on various remediation options for the material found on site.

F1 FILL, SOILS & RESIDUAL CLAYS

F1.1. BIOVENTING

Bioventing stimulates the natural in situ biodegradation of aerobically degradable compounds in soil by increasing oxygen flow to existing soil microorganisms. In contrast to soil vapour vacuum extraction, bioventing uses low air flow rates to provide only enough oxygen to sustain microbial activity. Oxygen is most commonly supplied through direct air injection into residual contamination in soil. In addition to degradation of adsorbed fuel residuals, volatile compounds are biodegraded as vapours move slowly through biologically active soil. Bioventing techniques have been successfully used to remediate soils contaminated by petroleum hydrocarbons, non-chlorinated solvents, some pesticides, wood preservatives, and other organic chemicals.

Factors that may limit the applicability and effectiveness of the process include:

- A high water table within 1-2 m of the surface, saturated soil lenses, or low permeability soils all may reduce bioventing performance.
- Vapours can build up in basements or underneath buildings within the radius of influence of air injection wells. This problem can be alleviated by extracting air near the structure of concern.
- Extremely low soil moisture content may limit biodegradation and the effectiveness of bioventing.
- Monitoring of off-gases at the soil surface may be required.
- Aerobic biodegradation of many chlorinated compounds may not be effective unless there is a co-metabolite present, or an anaerobic cycle.

F1.2 Enhanced Bioremediation

Enhanced bioremediation is a process in which indigenous or inoculated micro-organisms (e.g., fungi, bacteria, and other microbes) degrade organic contaminants found in soil and/or ground water, converting them to harmless end products. Nutrients, oxygen, or other additives are used to enhance bioremediation and contaminant desorption from subsurface materials. In the presence of sufficient oxygen (aerobic conditions), and other nutrient elements, microorganisms will ultimately convert many organic contaminants to carbon dioxide, water, and microbial cell mass. In the absence of oxygen (anaerobic conditions), the organic contaminants will be ultimately metabolized to methane, limited amounts of carbon dioxide, and trace amounts of hydrogen gas. Under sulfate-reduction conditions, sulfate is converted to sulfide or elemental sulfur, and under nitrate-reduction conditions, nitrogen gas is ultimately produced.

Factors that may limit the applicability and effectiveness bio remediation of the process include:

- Interaction between the soil matrix and microorganisms influence the results;
- Contaminants may be subject to leaching requiring treatment of the underlying ground water;
- Preferential flow paths may severely decrease contact between injected fluids and contaminants throughout the contaminated zones. The system should not be used for clay, highly layered, or heterogeneous subsurface environments because of oxygen (or other electron acceptor) transfer limitations.
- High concentrations of heavy metals, highly chlorinated organics, long chain hydrocarbons, or inorganic salts may be toxic to microorganisms;
- A surface treatment system, such as air stripping or carbon adsorption, may be required to treat extracted groundwater prior to re-injection or disposal; and
- The length of time required for treatment can range from 6 months to 5 years and is dependent on many site-specific factors.

F1.3 Capping and Containment

The "cap and contain" method employs a risk minimisation approach similar to "ongoing management", where impacted soils are managed on site so as not to pose an ongoing risk to the environment or human health. Impacted soils are contained by the placement of an impervious barrier or clean fill materials on top of the impacted material to prevent exposure to site occupiers, workers or the environment. The base of this "clean zone" would be clearly marked by a demarcation barrier to indicate that below this depth workers could potentially be exposed to contamination, which would then trigger additional health, safety and environmental controls.

Capping and containment may be an appropriate remedial option for soil containing both organic and inorganic contaminants that contain residual contamination, particularly if the mix of contaminants is not easily treated. The conditions for this remedial action alternative are:

- The contaminant is relatively non-mobile, including low volatility, insoluble and has low migration potential in a soil matrix;
- The primary exposure route to the contaminant and risk to human health is through direct dermal contact, dust inhalation or soil ingestion;
- The primary exposure route for the environment is mitigated through low leaching potential or migration to groundwater; and
- The contained area can be monitored and incorporated into any final land-use plans.

In the use of capping and containment, the focus of the response is to prevent contact with, or exposure to the contaminated soils by human receptors and/or eliminate transport by water to off-site receptors.

F1.4 Chemical Oxidation/Injection

Chemical oxidation remedial strategies involve the addition of an oxidising agent to the soil or groundwater. The rate and extent of degradation of a target chemical of concern is dependent on its susceptibility to oxidative degradation as well as the site conditions, such as pH, temperature, the concentration of oxidant, and the concentration of secondary oxidant-consuming substances such as natural organic matter.

Factors which may limit the applicability and effectiveness of chemical oxidation include:

- Requirement for handling large quantities of hazardous oxidizing chemicals due to the oxidant demand of the target organic chemicals and the unproductive oxidant consumption of the formation;
- Some chemicals of concern are resistant to oxidation; and
- There is a potential for process-induced detrimental effects.

F1.5 Excavation and Off-site Disposal

Excavation and disposal of contaminated wastes is a frequently used option, typically used when a rapid site remediation program is required or where significant subsurface contamination exists that is potentially impacting on sensitive off-site receptors. Wastes must be classified in accordance with the NSW EPA Guidelines.

Based on the required disposal of the landfill material, this option would adequately address the remediation goals through the removal of the contaminants from the site. Furthermore, with the removal of any identified contaminated fill soils, the long-term liability associated with soil contamination shall be minimised, along with substantial improvement of subsurface site conditions with regard to contamination of soil and groundwater.

F1.6 Ex Situ Bioremediation

Ex situ bioremediation is a proven treatment for petroleum hydrocarbon impacted soils. In general the higher the molecular weight or number of rings in a compound, the slower the degradation rate.

Factors that may limit the applicability and effectiveness of the land farming include:

- The large amount of space required;
- Conditions affecting biological degradation of contaminants (e.g., temperature, rain fall) are largely uncontrolled, which increases the length of time to complete remediation.
- Only suitable for organic contaminants.
- Volatile contaminants, such as solvents, must be pre-treated because they would volatilise into the atmosphere, causing air pollution.
- Dust control is an important consideration, especially during tilling and other material handling operations.
- Runoff collection facilities must be constructed and monitored.

F2 GROUNDWATER

F2.1 ENHANCED BIOREMEDIATION

Bioremediation is a process in which indigenous micro-organisms (i.e., fungi, bacteria, and other microbes) degrade organic contaminants found in soil and/or ground water.

Enhanced bioremediation attempts to accelerate the natural biodegradation process by providing nutrients, electron acceptors, and competent degrading microorganisms that may otherwise be limiting the rapid conversion of contamination organics to innocuous end products.

Oxygen enhancement can be achieved by either sparging air below the water table or circulating hydrogen peroxide (H_2O_2) throughout the contaminated ground water zone. Under anaerobic conditions, nitrate is circulated throughout the ground water contamination zone to enhance bioremediation. Additionally, solid-phase peroxide products (e.g., oxygen releasing compound (ORC)) can also be used for oxygen enhancement and to increase the rate of biodegradation.

Air sparging below the water table increases ground water oxygen concentration and enhances the rate of biological degradation of organic contaminants by naturally occurring microbes. Air sparging also increases mixing in the saturated zone, which increases the contact between ground water and soil. Oxygen enhancement with air sparging is typically used in conjunction with SVE or bioventing to enhance removal of the volatile component under consideration.

During hydrogen peroxide enhancement, a dilute solution of hydrogen peroxide is circulated through the contaminated ground water zone to increase the oxygen content of ground water and enhance the rate of aerobic biodegradation of organic contaminants by naturally occurring microbes.

Solubilized nitrate is circulated throughout ground water contamination zones to provide an alternative electron acceptor for biological activity and enhance the rate of degradation of organic contaminants. Development of nitrate enhancement is still at the pilot scale. This technology enhances the anaerobic biodegradation through the addition of nitrate.

Bio-enhanced remediation strategies are slow and may take several years for plume clean-up.\

F2.2 AIR SPARGING

In air sparging, air is injected into a contaminated aquifer where it traverses horizontally and vertically in channels through the soil column, creating an underground stripper that removes contaminants by volatilization. This injected air helps to flush (bubble) the contaminants up into the unsaturated zone where a vapour extraction system is used to remove the vapour phase contamination.

In principal the more volatile a contaminant the more appropriate air sparging as a remediation strategy is. Methane can be added to the system to enhance co-metabolism of chlorinated organics.

Factors that may limit the applicability and effectiveness of the process include:

- Preferential air flow pathways reducing the contact between sparged air and the contaminants;
- Air injection wells must be designed for site-specific conditions; and
- Soil heterogeneity may cause some zones to be relatively unaffected.

F2.3 CHEMICAL OXIDATION

In a chemical oxidation system oxidants are added to the system in order to oxidise the chemical of concern to less toxic species. The Chemical oxidants most commonly employed include peroxide, ozone, and permanganate. These oxidants cause the rapid and complete chemical destruction of many toxic organic chemicals while some chemicals are subject to partially degradation and subsequently reduced by bioremediation.

In general oxidants are capable of achieving high treatment efficiencies (e.g., > 90 percent) for unsaturated aliphatic (e.g., trichloroethylene [TCE]) and aromatic compounds (e.g., benzene), with very fast reaction rates (90 percent destruction in minutes). Field applications have clearly affirmed that matching the oxidant and in situ delivery system to the contaminants of concern (COCs) and the site conditions is the key to successful implementation and achieving performance goals.

Oxidation using liquid hydrogen peroxide (H_2O_2) in the presence of native or supplemental ferrous iron (Fe^{+2}) produces Fenton's Reagent which yields free hydroxyl radicals (OH-). These strong, nonspecific oxidants can rapidly degrade a variety of organic compounds. Fenton's Reagent oxidation is most effective under very acidic pH (e.g., pH 2 to 4) and becomes ineffective under moderate to strongly alkaline conditions. The reactions are extremely rapid and follow second-order kinetics.

Ozone gas can oxidize contaminants directly or through the formation of hydroxyl radicals. Like peroxide, ozone reactions are most effective in systems with acidic pH. Due to ozone's high reactivity and instability, O_3 is usually produced onsite, and requires closely spaced delivery points (e.g., air sparging wells). In situ decomposition of the ozone can lead to beneficial oxygenation and bio-stimulation.

The following factors may limit the applicability and effectiveness of chemical oxidation include:

- Requirement for handling large quantities of hazardous oxidizing chemicals due to the oxidant demand of the target organic chemicals and the unproductive oxidant consumption of the formation.
- Some COCs are resistant to oxidation.
- There is a potential for process-induced detrimental effects. Further research and development is ongoing to advance the science and engineering of in situ chemical oxidation and to increase its overall cost effectiveness.

F2.4 REACTIVE BARRIER WALL

Construction of a permeable reactive barrier (PRB) involves the subsurface emplacement of reactive materials through which a dissolved contaminant plume enters on one side of the PRB and treated water exits the other side. This in situ method for remediating dissolved-phase contaminants in groundwater combines a passive chemical or biological treatment zone with subsurface fluid flow management.

PRBs can be installed as permanent or semi-permanent units. The most commonly used PRB configuration is that of a continuous trench in which the treatment material is backfilled. The trench is perpendicular to and intersects the groundwater plume.

Alternately low-permeability walls can be used to direct a groundwater plume toward a permeable treatment zone.

F2.5 PUMP AND TREAT

As its name implies a pump and treat remedial involves the pumping of contaminated of ground water pumping include removal of dissolved contaminants from the subsurface, and containment and treatment the water. The treated groundwater is then either re-introduced into the aquifer or disposed off-site.

The criteria for well design, pumping system, and treatment are dependent on the physical site characteristics and contaminant type. While treatment options may include a train of processes such as gravity segregation, air strippers, and activated carbon filters designed to remove specific contaminants.

The first step in determining whether ground water pumping is an appropriate remedial technology is to conduct a site characterization investigation. Site characteristics, such as hydraulic conductivity, will determine the range of remedial options possible. Chemical properties of the site and plume need to be determined to characterize transport of the contaminant and evaluate the feasibility of ground water pumping. To determine if ground water pumping is appropriate for a site, one needs to know the history of the contamination event, the properties of the subsurface, and the biological and chemical contaminant characteristics. Identifying the chemical and physical site characteristics, locating the ground water contaminant plume in three dimensions, and determining aquifer and soil properties are necessary in designing an effective ground water pumping strategy.

The following factors may limit the applicability and effectiveness of ground water pump and treat options as a remedial option:

- The time frame required to achieve the remediation goal;
- The pumping system fail to contain the contaminant plume as predicted;
- Residual saturation of the contaminant in the soil pores cannot be removed by ground water pumping.
- A pump and treat option is not suitable for contaminants with:
  - high residual saturation;
  - high sorption capabilities; and
  - homogeneous aquifers with hydraulic conductivity less than 10^{-5} cm/sec.
- Potential high operating costs;
- Biofouling of the extraction wells and associated treatment stream may severely affect system performance;
- Subsurface heterogeneities, may severely affect system performance;
- Potential toxic effects of residual surfactants in the subsurface;
- Drawdown pumping generally produces large volumes of water requiring storage and or treatment

F2.6 EXCAVATION

Excavation and disposal of contaminated wastes is a frequently used option, typically used when a rapid site remediation program is required or where significant subsurface contamination exists that is potentially impacting on sensitive off-site receptors. Excavation can also be used to remove primary sources of any groundwater contamination (such as buried tanks or drums and waste disposal areas) and remove the secondary sources of impact (contaminated fill, residual soils and impacted bedrock and bedrock fractures such as joints and bedding planes).

F3 REMEDIATION OPTIONS

The various remediation options were reviewed in a technology matrix to assess their suitability against the various subsurface materials at the site and whether the option meets the primary objectives of the remediation works program, as discussed in **Section 5.3**.