Appendix C: Previous Investigations and Remediation

Appendix C: Summary of Management Order Works

C.1 Introduction

A summary of historical works and information is provided in the following sections, including:

- Key definitions and timeline relating to the Management Order.
- The current status of the Management Order.
- An overview remediation undertaken under the Management Order.
- A summary of historical contamination investigations undertaken within the Remediation Site under the Management Order.
- Data availability.

C.2 Key Definitions

A summary description of key definitions relevant to the Management Order are presented in the following table.

Table C.1 Key Definitions

Definition	Summary Description
Management Order	On 26 May 2011, the Management Order (number 20111403) was issued by the Chief Judge Brian Preston of the New South Wales Land and Environment Court (LEC) for the Remediation Site. This Management Order has been subsequently amended by the EPA on 28 August 2014, 27 February 2015, 9 February 2016 and 7 July 2017 as investigation and remediation works have progressed. The Management Order requires that a series of investigation, monitoring and remediation actions are taken at the Remediation Site, and approval of a Remedial Action Plan (RAP) (AECOM, Nov 2011d). The primary objectives of remediation activities being undertaken at the Remediation Site are to reduce dissolved concentrations of Significant Contaminants to meet Remediation Acceptance Criteria (RAC) and to satisfy the requirements of the AECOM RAP (AECOM, Nov 2011d).
Remediation Site	On 2 November 2005, the New South Wales (NSW) Environment Protection Authority (EPA) declared the presence of Significant Contaminants in groundwater as posing a significant risk of harm to human health and the environment (Declaration No. 21084) at (as defined in the Management Order): • Lot A&B in DP438772 and Lot 1 in DP89250 - LDC site. • Parts of Lot 3 in DP775039 - Young Street properties. • Parts of Lot 2 in DP 800705 (now Lot 2 in BP1203640) - Dahua Site (former Sydney Water Corporation Central Workshops Site). • Lot 1 in DP 88482 and Lot B in DP 88095 - Citywest Site (former Porters Paints and former Doug Up on Bourke (DUOB)). This area is referred to as the 'Remediation Site'. The Remediation Site area is presented in **Figure 1**.
Source Site	The LDC property has been designated as the "Source Site" in the Management Order. The Source Site area was amended by NSW EPA on 27 February 2015 to include a portion of Young Street properties and comprises: • LDC site. • Part of Young Street properties. The Source Site area is presented in **Figure 1**.

Definition	Summary Description
Significant Contaminants	The Management Order is related to the investigation, remediation and management of Significant Contaminants. Significant Contaminants comprise: • Tetrachloroethene (PCE). • Trichloroethene (TCE). • 1,2-dichloroethene (DCE). • Vinyl chloride (VC).
EISB	Enhanced *in-situ* bioremediation – the preferred remedial approach in the RAP (AECOM, Nov 2011d) implemented at the site.

C.3 Current Status of Management Order Actions

C.3.1 Timeline

The following timeline summaries works at the Remediation Site required under the Management Order or prior regulatory instruments.

Table C.2 Timeline

Key Date	Activity	Status
February 2003	Initial notification to EPA of the LDC site.	-
October 2003	Declaration of Investigation Area by NSW EPA (notice number 15026).	-
May 2004	Voluntary Investigation Proposal (number 19024). Initial contamination investigations and a Site Audit under *CLM Act 1997* were conducted.	Current
November 2005	Declaration of Remediation Site (number 21084) by NSW EPA under *CLM Act 1997*.	Current
November 2008	Voluntary Remediation Proposal (number 26112). A series of assessments and remediation tasks were conducted under the VRP, including preparation of a Remedial Action Plan and enhanced *in-situ* bioremediation (EISB) trial from February to September 2009 at Source Area 1. This was completed in June 2010, with EPA agreement in notice number 20101711.	Former
June 2010	Management Order (20101404) issued by NSW EPA.	Former
June 2010	Appeal against Management Order (20101404) lodged with NSW Land and Environment Court.	-
May 2011	Management Order (number 20111403) issued by LEC on 26 May 2011. Management Order 20111403 superseded the previous Management Order (number 20101404).	Current
2011	Approval of Remedial Action Plan (RAP) (AECOM, Nov 2011d).	Current
2011/2012	Further investigations required by the Management Order	Completed

Key Date	Activity	Status
2012	Hydraulic containment achieved and progressive implementation of full-scale active EISB per the RAP commences.	-
2015	EISB approach changes from an active system to passive sustainable approach for the Source Site.	-
26 May 2016	Successful clean-up of the groundwater plume – reduction in concentrations of Significant Contaminants in groundwater on land other than the Source Site to less than 0.5 mg/L – this was achieved prior to the due date of 26 May 2016, which was acknowledged by the EPA on 4 November 2016.	Completed
various	Management Order amendments dated by the EPA on 28 August 2014, 27 February 2015, 9 February 2016 and 7 July 2017.	-
25 May 2021	Order 15 of the Management Order requires remediation to treat to the maximum extent practicable DNAPL source zones and/or high concentrations of sorbed phase Significant Contaminants on the Source Site within 10 years of the date of the Management Order (25 May 2021).	Current

C.3.2 Current Status

A summary of the current status of key aspects of the Management Order is provided in the following table. The key remaining actions required under the Management Order are:

- Maintain the maximum concentrations of the Significant Contaminants (SCs) in groundwater migrating from the Source Site to any adjoining land to 0.5 mg/L.
- Treat to the maximum extent practicable DNAPL source zones and/or high concentrations of sorbed phase Significant Contaminants on the Source Site prior to 26 May 2021 – ongoing remediation actions are necessary under this Order.
- Ongoing monitoring of groundwater, air and soil vapour at specific locations off the Source Site.

Table C.3 Summary of Actions

Key Aspect	Current Relevant Actions	Status
Investigations	none	**Complete** The Management order included actions for additional investigations of sources and source zones of Significant Contaminants and deep groundwater conditions backfill materials at Sheas Creek. These actions were completed during the initial period of the Management Order.

Key Aspect	Current Relevant Actions	Status
Remediation of groundwater plume	14, 16, 17	**Complete** Containment of Significant Contaminants exceeding 0.5 mg/L on the Source Site and progressive remediation of Significant Contaminants in the groundwater plume (i.e. Significant Contaminants in groundwater on land other than the Source Site) was achieved in accordance with Orders 14, 16 and 17. Final remediation of the groundwater plume required by Order 17 was achieved prior to the due date of 26 May 2016, which was acknowledged by the EPA on 4 November 2016. Ongoing management is required to maintain the maximum concentrations of the Significant Contaminants (SCs) in groundwater migrating from the Source Site to any adjoining land to 0.5 mg/L.
Remediation of the Source Site	15	**Ongoing action necessary** While substantial progress has been made in relation to the remediation of the Significant Contaminants at the Remediation Site, ongoing operation and maintenance of the EISB remediation system, with management and monitoring optimised in accordance with the adaptive approach in the RAP, is required at the Source Site. This broadly comprises: • Extraction of groundwater at EW06, EW08, EW09 and EW10, with subsequent treatment at an on-site plant and discharge to sewer under a trade waste agreement. • EISB performance monitoring which includes sampling selected wells within and adjacent to source zones on a quarterly basis for VHCs and indicators of EISB performance as set out in the AECOM RAP – nominal wells used for performance monitoring are presented in the attached figure (noting these may change on the basis of review of monitoring data). Monitoring wells that are typically sampled to assess EISB performance depend on ongoing review of results, but typically include (in addition to those required to be sampled under the Management Order below): ▪ Quarterly: Source Area 1 – MW44, MW82; Source Area 2: IW506, IW807, IW804, IW805, MW06/MW107, MW111, EW05, IW801/IW802; Other: MW809, MW63A ▪ Biannual: as above and Source Area 2: IW507, IW806, IW808; Other: MW90/EW06, EW08, EW09, EW10, EW11/MW93, MW40. ▪ Field screening of general water quality parameters, and analysis for VOCs and selected samples for chloride, nitrate, TOC, dissolved gases, and microbial indicators (nPCR). • Targeted application of sodium lactate or emulsified vegetable oil (EVO) and buffer (usually sodium or potassium bicarbonate solution) to maintain groundwater conditions conduce to reductive dichlorination as set out in the AECOM RAP. • EVO was most recently applied in September 2020. The application comprised: ▪ Injection, over a period of approximately three weeks, of a total mass of approximately 4,500 kg EOSPro (a commercially available EVO and lactate product) and 209 m^3 potable water at wells IW506, IW507, IW806, IW807, IW808, MW106, MW107, MW111, EW05, IW802, RW901, RW903 and IW809. • Preparation of an annual report documenting the EISB works and monitoring. Order 15 requires remediation to treat to the maximum extent practicable DNAPL source zones and/or high concentrations of sorbed phase Significant Contaminants on the Source Site within 10 years of the date of the Management Order (25 May 2021).

Key Aspect	Current Relevant Actions	Status
Monitoring	9, 10, 11, 12	**Ongoing action necessary** A monitoring program under the Management Order was first implemented in 2011.This principally comprised periodic monitoring of groundwater, soil vapour, air within the Remediation Site or on immediately adjacent land, and surface water and vapour at Sheas Creek. The monitoring program has been amended as remediation progressed and Order conditions were achieved. The current monitoring program under the Management Order is defined in the amendment dated 7 July 2017, and includes biannual monitoring within the Remediation Site and at Bourke Street: • Groundwater at 10 locations (MW19 [a substitute for MW21], MW22, MW63A, MW80, MW88, MW89, MW113, MW114, MW206 [a substitute for MW115], MW211 [a substitute for MW116], MW201A and IW809). Sampling additional or supplementary wells occurs to support meeting the monitoring objectives. • Soil vapour and sub-slab vapour at five locations - SV1 and SV2 (Source Site), SV3 and SV305 (CityWest), SV4 and SV5 (Lot 4 Bourke Street). • Ambient air (via evacuated canister and sorption badges) at four locations - A801 (Source Site), A802 (Lot 3 Young Street), and A803 and A804 (Citywest). • Analysis of samples for VHCs, including of Significant Contaminants. Documentation of ongoing monitoring was most recent reported in Senversa (Aug 2020b).
Information sharing	23, 24, 25	**Ongoing actions necessary** The Management Order requires engagement with, and provision of information to, Affected Landholders.

C.4 Summary of previous remediation works

The primary objectives of remediation activities being undertaken at the Remediation Site are to reduce dissolved concentrations of Significant Contaminants to meet RAC and to satisfy the requirements of the AECOM RAP (AECOM, Nov 2011d).

In accordance with the AECOM RAP (AECOM, Nov 2011d), EISB is the remediation technology which has been implemented at the Remediation Site. EISB reduces concentrations of Significant Contaminants in groundwater by stimulating natural biological degradation activity. EISB remediation commenced as a pilot trial in March 2009 (e.g. see AECOM, Nov 2009; Geosyntec, Jan 2010), with full-scale implementation commencing in June 2013. The EISB approach broadly comprised amendment with sodium lactate and buffering agents in a series of recirculation 'loops' within the groundwater plume at the (now) Dahua site, Young Street properties and at the Source Site (see Geosyntec, Nov 2011a).

Containment to the Source Site of Significant Contaminant concentrations exceeding 0.5 mg/L was also required. This was achieved by groundwater extraction and treatment, and implementation of EISB within the Source Site, with assessment of containment in 2012 (AECOM, Nov 2012). Ongoing extraction and treatment of groundwater occurs from wells at the southwest corner of the Source Site (EW08, EW09, EW10, EW06 and MW90) with treatment and discharge under a Sydney Water Trade Waste Agreement consent.

As remediation of the groundwater plume was progressively completed (as defined by the reduction and maintenance of average Significant Contaminants concentrations in groundwater to be less than 0.5 mg/L), the active EISB recirculation loops were progressively turned off. In 2015 the EISB strategy was adapted as defined in the RAP to inject a longer-lasting amendment (emulsified vegetable oil - EVO) to treat residual Significant Contaminants within the Source Site. EVO was injected in events in

2015 (see AECOM, Jan 2016) and 2017 (Source Area 2 only) (see Senversa, Dec 2018b). Senversa (Aug 2020a) recommended further supplementary application of EVO at the Source Site and IW809 – this was conducted in September 2020.

An intensive monitoring program of the EISB system has been implemented – this has included regular (from weekly to quarterly frequency) system process monitoring, field screening and groundwater sampling and analysis. These data have been used to assess line-of-evidence of EISB performance as defined in the RAP (AECOM, Nov 2011d) – the most recent EISB performance was documented by Senversa (Aug 2020a).

The lines-of-evidence demonstrate that EISB continues to be an effective remediation technology to achieve compliance with the Management Order (Senversa, Dec 2018b). However, ongoing operation and maintenance of the EISB remediation system, with management and monitoring optimised in accordance with the adaptive approach in the RAP, is required at the Source Site and near IW809 on Bourke Street (Senversa (Aug 2020a)) – this relates to ongoing Management Order requirements, which will be addressed separately to the matter subject of this RAP.

A list and summary of key reports documenting investigation and remediation works associated with the Management Order was presented in the PSI (Senversa, Mar 2019).

C.5 Summary of historical contamination investigations

There has been substantial assessment of contamination within the Remediation Site, principally relating to chlorinated solvents. Initial investigations of the (now) Dahua and LDC sites were undertaken in the early and mid-2000s, with progressive assessment and works to support remediation planning/design of Significant Contaminants occurring within the Remediation Site and adjacent land up until 2011/2012. Since full-scale remediation commenced in 2012/2013, the focus has been on assessing remediation performance and monitoring as required under the AECOM RAP and Management Order.

A list and summary of key reports documenting investigation and remediation works associated with the Management Order was presented in the PSI (Senversa, Mar 2019) – this is appended and updated in **Attachment A**. Historical investigation locations are presented in **Figure 4A** – noting that many of these locations are off the site.

Consolidated available and relevant soil, groundwater, soil vapour and air analytical data are discussed in the report.

C.5.1 Historical Data Availability (prior to the DSI, Senversa Sep 2020)

A substantial contamination data set is available from historical soil, groundwater, vapour and air assessments. Environmental data have been historically collected for air/vapour (*circa* 490 samples), groundwater (*circa* 3,000 samples) and soil (*circa* 700 samples) under the Management Order (or prior EPA regulatory instruments), including from sampling locations within the site and off the site at (now) Dahua and CityWest sites and adjacent land.

A summary of available and recent historical analytical data for key contaminant groups and media for the site is provided in the following table. Recent (for groundwater and soil vapour data) is considered post-2016 on the basis that the site has been, and is subject to, remediation actions which have:

- likely resulted in changes to site contamination conditions since samples were collected and analysed; and
- will likely continue to result in changes to site contamination conditions in areas of remediation (e.g. at the Source Site); and
- progressive cessation of active EISB (lactate injection and recirculation system) until 2016; and
- clean-up of Significant Contaminants in the plume in 2016.

This is particularly the case for VCHs in groundwater (and associated vapour impacts), which were subject to remediation and generally behave dynamically in the environment. Further discussion is provided below.

Table C.4 Metadata Summary (prior to the DSI, Senversa Feb 2021)

Site Area	# Locations (site only)	Total # primary samples per key contaminant group (site only)								
		VHCs	Other VOCs	TPH	PAH^ / Phenols	Metals	Nutrients	PCBs	Other SVOCs	Asbestos
Groundwater (post-2016 only)										
LDC	48	324	254	42	29	41	77	10	7	-
Lot 3 Young Street	30	251	224	45	26	43	24	9	0	-
Lot 4 Bourke Street	5	37	37	29	3	14	19	3	2	-
Soil/Sub-slab Vapour (post-2016 only)										
LDC	1	22	22	-	22	-	-	-	-	-
Lot 3 Young Street	2	34	34	-	34	-	-	-	-	-
Lot 4 Bourke Street	2	46	46	-	46	-	-	-	-	-
Air (ambient air in buildings or personnel badges) (post-2016 only)										
LDC	2	32	32	-	32	-	-	-	-	-
Lot 3 Young Street	2	24	24	-	24	-	-	-	-	-
Lot 4 Bourke Street	0	0	0	-	0	-	-	-	-	-
Soil (all historical data)										
LDC	51	255	23	12	9**	10	0	0	0	0
Lot 3 Young Street	31	135	4	0	0**	1	0	0	0	0
Lot 4 Bourke Street	8	24	5	4	2	4	0	0	0	0

^Naphthalene only for air/vapour analyses.

#Additional sampling locations prior to 2016 – the most recent data was 2014

** Additional samples analysed for naphthalene

Available and potentially relevant historical analytical data associated with these historical investigations for sampling locations within the site were provided in the ORAP and are attached in Appendix B:

- Soil:
  - All available historical analytical data reported to mid-2018.
  - Available borelogs reported to mid-2018.
- Groundwater:
  - Recent (2017-2018) selected historical gauging and field parameter data.
  - Recent (since 2016 to mid-2019) historical analytical data.
- Soil vapour and ambient air within buildings:
  - Recent (since 2016 to mid-2018) historical analytical data.

Additional environmental data are available in referenced reports (but not presented in this report) for:

- field screening data including PID readings, field observations, hydrophobic dye testing and high-resolution site characterisation tool results;

- groundwater, vapour and air samples collected prior to 2016;
- samples collected off the site but within the Remediation Site and surrounding land under the Management Order (or previous regulatory instruments) – in particular, at the (now) Dahua and CityWest sites; and
- from soil, groundwater, vapour and hazardous building material investigations not undertaken under the Management Order – in particular, numerous investigations have been conducted at the (now) Dahua and CityWest sites.

C.5.2 Additional DSI Data Availability

The DSI comprised soil, groundwater, soil vapour and sub-slab vapour sampling across the site. A summary of the different site portions assessed, number of sample locations and samples is presented in the following table – this also includes historical soil data considered in the assessment.

Table C.5 DSI Sampling

Site Area	Historical Soil Locations / Samples	New Soil Locations / Samples	Groundwater Locations / Samples	Soil Vapour Locations / Samples ^
Stage 1 – Part Lot 3 Young Street				
Development Parcel 1	4 / 13	6 / 46	6 / 7	3 / 3
Development Parcel 4	13 / 53	3 / 23	12 / 15	2 / 2
Roadway	1 / 1	3 / 23	1 / 1	1 / 2
Roadway / pedestrian walkway	1 / 2	2 / 10	2 /3	1 / 2
SUB-TOTAL	**19 / 69**	**14 / 102**	**21 / 26**	**7 / 11**
Stage 2 – Part Lot 3 Young Street + Lot 4 Bourke Street				
Development Parcel 2	6 / 15	5 / 45	4 / 5	2 / 3
Stage 2 – Source Site				
Park	13 / 64	2 / 1	10 / 20	-
Roadway	13 / 56	-	9 / 9	1 / 2
Development Parcel 3	13 / 135	-	19 / 21	1 / 2
SUB-TOTAL	**58 / 255**	**2 / 1**	**38 / 50**	**2 / 4**

Notes: ^ Excludes sub-slab vapour sampling conducted under the Management Order. ^^ Approximate only

C.5.3 Available Data Quality Limitations

Key limitations on the provided data include:

Chemicals of concern: Historical (pre-DSI) available site data are predominantly derived from assessments related to the Management Order and are specific to VCHs (including Significant Contaminants) related to the historical LDC operations. While samples were commonly analysed for other volatile organic compounds (e.g. including monoaromatic petroleum hydrocarbons), there are limited data available for other COPC that may need to be assessed based on other potential historical or current sources of contamination identified within the PSI (Senversa, 2019).

This uncertainty has been addressed via:

- Site-wide GME (Senversa, Sep 2019b), which assessed a broad range of CoPC.
- DSI at Lot 3 Young Street and Lot 4 Bourke Street portions which assessed a broad range of CoPC in soil, groundwater and ground gas.

These investigations support the conceptual model that the key health and ecological risks driving remediation relate to VCH.

Sampling design: Current site buildings and infrastructure that restricted access to certain areas of the site for intrusive investigation works, and use of the preferred method to assess fill materials (test pitting), means there is a lower level of certainty in the representativeness of soil data in anthropogenic inclusion – in particular asbestos may be more prevalent than identified.

Soil vapour has not been sampled in all areas of the site. While vapour inhalation risks have been assessed via soil and groundwater sampling, in accordance with ASC NEPM, when assessing VCH, the preference is to use vapour sampling. However, the substantial environmental data set for soil, groundwater and soil vapour, and conceptual model, are considered to provide adequate information to inform preparation of the detailed RAP.

Representativeness: Senversa notes that the presented data are of variable representativeness of current contamination conditions – the site has been, and is subject to, remediation actions which have:

- likely resulted in changes to site contamination conditions since samples were collected and analysed; and
- will likely continue to result in changes to site contamination conditions in areas of remediation (e.g. at the Source Site).

This is particularly the case for VCHs in groundwater (and associated vapour impacts), which were subject to remediation and generally behave dynamically in the environment.

For this reason, for the purposes of this RAP the most relevant data are considered to be recent groundwater, vapour and air data including:

- All available soil data as considered in the DSI (Senversa, Sep 2020).
- Groundwater data collected in June/July 2019 (Senversa, Sep 2019b) and as part of the DSI (Senversa, Sep 2020). However, post-2016 historical data have also been considered due to the dynamic groundwater system and possible temporal variations – 2016 is considered reasonable as this was when active groundwater remediation outside the Source Site ceased, a series of broad-scale monitoring events occurred, and clean-up targets for plumes under the Management Order were achieved. Temporal data has also been considered via temporal plots of VCH concentrations for key locations previously presented in the ORAP.
- Soil vapour and sub-slab vapour data collected as part of the DSI (Senversa, Sep 2020). However, post-2016 historical data have also been considered due to the dynamic groundwater system and possible temporal variations in soil vapour conditions. Temporal data has also been considered via temporal plots of VCH concentrations for key locations previously presented in the ORAP.

Completeness: The provided available data includes historical data in Senversa's project database provided to and updated by Senversa. While Senversa has undertaken some checks to assess third-party data completeness, there could be other relevant third-party data available in referenced reports or other documents. However, the large dataset with frequent sampling for groundwater and soil vapour, which are considered the key risk drivers for remediation, and certainty in completeness of recent assessments undertaken by Senversa is considered to mitigate this uncertainty. Uncertainty in the completeness of historical data has been further mitigated via the DSI (Senversa, Sep 2020) and remediation design requirements in the RAP.

Petroleum hydrocarbons: Reported TPH and TRH concentrations are likely to be influenced by false positives due to:

- TRH C6-C10: PCE, TCE and cis-1,2-DCE (and other VHCs) are reported in this fraction.
- TRH C6-C16: It is likely that canola oil (present in remediation products applied within the Source Site as part of remediation works under the Management Order) is reported in this fraction (and possibly higher fractions).

On the basis that VCHs and canola oil are known constituents in groundwater at the site, TPH C6-C16 data should not directly be compared against assessment criteria intended to be applied to petroleum hydrocarbons. Exceptions include where the conceptual model support petroleum hydrocarbon impacts near MW29, former USTs in the north of LDC at near MW27/BH66 in southeast part of LDC where elevated naphthalene was reported in soil.

Methane in ground gas: Fermentation of excess vegetable oil applied as part of ESIB within the Source Site could result in temporary formation of methane – for this reason possible methane in the vicinity of the Source Site where EISB remediation has occurred has been identified as a contamination issue to be managed.

The DSI (Senversa, Sep 2020) reported elevated methane during field screening measurements at one soil vapour well sampled (SV08). However, laboratory analyses of soil vapour samples did not report methane above the LOR. Comparison of analytical and field measurements of methane suggest there could be interference (i.e. false positive results) from VCH in field measurement of methane using a landfill gas meter.

Well survey data: Historical well survey data have been used as provided to Senversa. Senversa surveyed new wells, but did not surveyed historical wells or verified the accuracy and quality of these data. Groundwater elevations and soil elevations calculated using these survey data are, thus, subject to the limitations of survey data.

Overall quality: Senversa has not assessed the quality of third-party data – rather the data are presented as provided to Senversa. Senversa has assessed the quality of data from Senversa investigations and assessments (i.e. since 2016) – this includes groundwater and soil vapour assessments, which are considered the key risk drivers for remediation. Uncertainty in the quality of historical data has been addressed via the DSI (Senversa, Sep 2020) and remediation design requirements in the RAP.

Appendix D: Remediation Targets

Appendix D: Remediation Drivers and Criteria

D.1 Remediation Drivers

Remediation drivers include requirement to address/meet:

- Remediation objectives (**Section 5.1**).
- Other relevant contaminated land regulatory guidance.

These drivers (and associated criteria or targets) are described in the following sections.

D.1.1 Primary Remediation Objectives – Site Development

Remediation targets to meet the Remediation Objectives to make the site suitable for the proposed development are discussed in **Table D1** (below). Some remediation targets are provisional and will be refined as part of pre-remediation assessments in this RAP. Remediation goals specific to the Management Order are discussed separately in **Section D1.2** for context, though will be addressed separately to the matter in this RAP.

Table D1: Remediation Targets – Site Suitability

Primary Remediation Objective	Target		Description
Objective 1 – Suitability for proposed development	A	Site suitability – future open space/park and roadways	Residual soil, groundwater and soil vapour contamination conditions should be suitable for future land use as open space (park) or roadway for dedication to City of Sydney. The aim is to dedicate a site that is unencumbered by any long-term management requirements (e.g. monitoring, substantial maintenance of engineered systems as defined in NSW EPA (2017)) to the extent practicable. Permission is required from City of Sydney if remediation to achieve this cannot practicable be achieved.
	B	Site suitability – future mixed residential/ commercial use	The development parcels will have a future use as a mixed residential/commercial development. Conservative interim screening levels have been adopted (see below) – these may be revised specific to each developable portion as described in **Section D.3** below. These criteria may be overly conservative from some exposure scenarios – review of these against specific development design is required as part of enabling works in this RAP.
Objective 2 – no ongoing contamination management requirements for public domain areas	C	No long-term management requirements on public domain land to be dedicated to City of Sydney.	Senversa understands that City of Sydney is unlikely to accept designation of land that contains residual contamination requiring active management (e.g. monitoring, substantial maintenance of engineered systems as defined in NSW EPA (2017)) - this is taken to be applicable to accessible soils underlying future roadways, pedestrian link and open space park to the extent practicable. For this purpose, accessible soils are considered to comprise soil above 1.5 m bgl or depth per guidance in City of Sydney (Nov 2016).
Objective 3 - liability reduction for Jeffman	D	No active long-term management requirements. High certainty in remediation outcome.	The other key consideration is to Jeffman in relation to Significant Contaminants. There are no specific remediation criteria relevant to this Remediation Objective, rather, the preferred remediation option has been assessed on a judgemental basis. However, some examples of unacceptable liabilities considered included: • excessive uncertainty in remediation effectiveness; • the need to maintain containment of groundwater with greater than 0.5 mg/L Significant Contaminants; or • other active long-term management requirements (e.g. requiring specific controls and procedures if undertaking maintenance works under roadways).
Objective 4 – Implementation	E	Minimise impacts on future development	Remediation should be conducted in a manner that aims to not materially impact: • corrosivity to future structures; or • hazardous ground gas / vapour mitigation requirements; or • future waste classification or volume.

Primary Remediation Objective	Target		Description
	F	Undertake remediation in a safe and lawful manner	Remediation should be undertaken in a safe and lawful manner consistent with relevant and applicable consent conditions, NSW and national laws.

D.1.2 Management Order

There are secondary remediation objectives that relate to complying with conditions of the Management Order – these do not directly relate to the suitability of the site for the proposed site development and will be addressed separately to the matter subject of this RAP. However, the proposed remediation to address the primary remediation objectives in this RAP has been designed to align with Management Order requirements, and discussion of these secondary objectives is provided in Section 5.1 of the RAP for context.

D.1.2 Other Regulatory Drivers

The ASC NEPM (NEPC, 2013) provides the following hierarchy to achieve desired and site-specific environmental outcomes under Principle 16 for contamination:

- **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.

In selecting the preferred remedial strategy for soil contamination, the following factors should be evaluated – listed in general order of priority or weighting:

- Level of risk posed to relevant receptors.
- Technical practicability.
- Remediation timeframe.
- Potential for remediation to cause a greater adverse effect than leaving the site undisturbed.
- Clean-up costs.

Other key regulatory drivers for remediation are summarised in **Table D2**.

Table D2: Other Regulatory Drivers

Aspect	Comment
Management of groundwater contamination in accordance with guidance in DEC (2007)	DEC (2007) provides guidance on the management of groundwater contamination. Where contamination is identified, the management objectives are to protect human and ecological health and to ultimately restore the groundwater to its natural background quality. To achieve these objectives, management responses outlined in the following table must be considered: 1. Control short-term threats arising from the contamination. 2. Restrict groundwater use. 3. Prevent or minimise further migration of contaminants from source materials to groundwater. 4. Prevent or minimise further migration of the contaminant plume. 5. Clean up groundwater in the following preferential order: • Clean up so natural background water quality is restored. • Clean up to protect the relevant environmental values of groundwater, and human and ecological health. • Clean up to the extent practicable. Assessment of extent practicable should include evaluation against each factor listed below: • Technical capability to achieve the clean-up. • Clean-up costs. • The value of the groundwater resource. • Threats the contamination poses to human or ecological health.
Remediation of non-aqueous phase liquids (NAPLs) in the subsurface in accordance with guidance in NSW EPA (2017) and DEC (2007).	Key aspects of guidance in DEC (2007) and NSW EPA (2015/2017) include: • *Where LNAPL or DNAPL are present in the subsurface, they must be removed or treated as much as practicable. Particular care, however, is required in the assessment and clean-up of DNAPL contamination to prevent mobilisation or an increased rate of dissolution.* • *Where complete removal or treatment of the NAPL is impracticable, as may be the case with some DNAPLs in complex geological media, ongoing monitoring and management of the contamination is required as a minimum for as long as necessary, to ensure the protection of human and ecological health.* • *Sources and plumes will need to be contained to the maximum extent practicable, and remediation to address the dissolved-phase contaminants may also be required.* • *Primary sources of groundwater contamination (e.g. leaking infrastructure) and secondary sources (e.g. non-aqueous phase liquids and adsorbed phase product) must be removed or otherwise addressed appropriately.* • *LNAPL must be cleaned up to such an extent that remaining LNAPL does not present an unacceptable risk to health or the environment. In any case, LNAPL clean-up should continue if the LNAPL is still spreading. The need for LNAPL clean-up would also be indicated by a dissolved phase plume that continues to spread.* NSW EPA (2015) is a technical note, rather than guidance. However, it provides a number of aspects to be considered in management of NAPL that have been considered here.
Long-term management of residual contamination	NSW EPA (2017) states that long-term management of contamination can be an effective means of ensuring the environment is protected, users of the site are not exposed to contamination remaining on site and the site remains suitable for the proposed use when: • Complete remediation of contamination affecting an area is not practicable. • Contaminants are being capped or contained on site. • Remediation is likely to cause a greater adverse impact than would occur if the site were left undisturbed. The requirements for long-term management are documented in an Environment Management Plan (EMP). Implementation of an EMP is not appropriate unless the following conditions have been met: • The EMP has been reviewed by the Site Auditor. • The EMP can reasonably be made to be legally enforceable. • There is a public notification mechanism (e.g. on a Planning Certificate issued under the *Environmental Planning and Assessment (EP&A) Act*). • Contamination within the site is managed or monitored so it does not present an unacceptable risk to either the on-site or off-site environments.
Sustainability	The ASC NEPM states that 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. The *Waste Avoidance and Resource Recovery Act 2001* (WARR Act) also includes objectives for the efficient use of resources and to reduce environmental harm in accordance with the principles of ecological sustainable development and reduction in waste generation.

Aspect	Comment
City of Sydney (2004) Contaminated Land Development Control Plan (DCP)	The DCP provides a number of environmental management provisions required to be implemented during remediation works. These have been incorporated into this RAP as minimum standards for the environmental management of remediation works.

These are aspects are considered as part of the remedial options appraisal (**Appendix E**).

D.2 Criteria

Assessment criteria are presented in the following sections. These are based on a tiered screening approach as follows:

1. **Tier 1 Screening Criteria**: Generic assessment criteria presented in ASC NEPM (or by other international regulatory bodies if not available) for the proposed land uses.
2. **Interim HSLs**: Site-specific criteria for Significant Contaminants with consideration of the vapour inhalation and other exposure pathways (see **Section 4.8** and **Section D.2.2** below) specific to the proposed subdivision and development concept – these criteria are considered interim as they are conservative and may be amended as part of the validation process in the RAP.

The Management Order includes specific criteria and conditions - these are to address requirements of the Management Order (which also includes consideration of off-site migration) – they are not relevant to assessing site suitability and are provided for context only.

D.2.1 Tier 1 Screening Criteria

Tier 1 screening criteria have been adopted to screen available environmental data to conservatively assess the nature and extent of possible contamination for the proposed land uses in the DA (i.e. not the current land use) (refer the following tables).

Table D-1 Proposed Land Use Types and Receptors

Proposed Land Use	Assumption	Possible Receptors
Residential/ commercial portions	• Medium- to high-density residential and commercial buildings. • Residential or commercial use on any floor above ground level. • One- or two-level basement carparking of uncertain configuration and extent. • Minimal access to soils.	• Future residents. • Future commercial workers. • Intrusive maintenance workers.
Roads	• Roadways and a paved pedestrian link. • Footpath easement along Bourke Street.	• Future road users / pedestrians. • Intrusive maintenance workers. • Ecology in landscaping areas.
Parks	• Open space park. • Landscaping with trees/shrubs in minor areas.	• Future park users. • Intrusive maintenance workers (gardeners). • Ecology in landscaping areas.

Senversa have not evaluated risks to construction workers – consideration of the potential receptors above is considered conservative. Nonetheless, there are potential contamination risks to construction workers that require management – these should be assessed and managed in accordance with remediation management requirements in **Section 9** of this RAP.

Table D-2 Tier 1 Screening Criteria

Media	Receptor	Criteria

Soil	**Human Health**	Direct contact and inhalation of dust:
		• ASC NEPM HIL B (residential/commercial portions), HIL C (park) and HIL D (roads).
		• ASC NEPM HSL B (residential/commercial portions), HSL C (park) and HSL D (roads) for asbestos.
		• CRC CARE (2011) HSL B (residential/commercial portions), HSL C (park), HSL D (roads) and intrusive maintenance workers (IMW) for BTEXN. The HSLs for TRH have not been used as the TRH will be influenced by the chlorinated compounds and vegetable oils and are not representative of petroleum hydrocarbons.
		• USEPA regional screening levels (RSLs) for Significant Contaminants as no HILs/HSLs are available in ASC NEPM. RSLs for residents have been used for residential/commercial portions.
		• Interim HSLs for Significant Contaminants for open space exposures (parks and roadways) (refer **Section D2.2** below).
		Vapour inhalation:
		• ASC NEPM HSL B (residential/commercial portions), HSL C (park and roads) for vapour intrusion (sand, 0 m to <1 m) for BTEXN. Criteria for the most conservative exposure scenarios (i.e. assumed depth to source < 1 m and sand) are adopted. The HSLs for TRH have not been used as the TRH will be influenced by the chlorinated compounds and vegetable oils and are not representative of petroleum hydrocarbons. HSL-C has been adopted for roads on the basis that the roads are effectively open space for the purposes of the vapour inhalation exposure pathway (i.e. there are no buildings proposed overlying roads).
		• Potential TRH impacts in soil will still require consideration as part of validation works set out in this RAP – this is principally addressed via analysis of samples for VOCs (which include BTEX, naphthalene and other monoaromatic hydrocarbons associated with TRH). Consideration should also be conducted by applying Management Limits, observations of petroleum impacts (e.g. staining, odours), and screening vapour intrusion HSLs for TRH where TRH cannot be attributed to interference from corresponding VCH impact – in particular, in areas or media of higher risk of petroleum hydrocarbon impact including fill materials, soils near former USTs, near MW29 at Source Site and SB06 at Lot 3 Young Street.
		• The ASC NEPM recommends soil vapour sampling for VCHs to evaluate vapour intrusion, and soil vapour data should be used to evaluate the vapour intrusion pathway. However, for screening purposes, site-specific soil interim HSLs have been derived for Significant Contaminants that are protective of (refer **Section D.2.2** below):
		  ▪ Inhalation when the contaminants partition into groundwater which seeps into a basement and volatilises.
		  ▪ Vapour intrusion in open space (park and roadways).

	Ecological	• ASC NEPM Ecological Screening Levels (ESL) and Ecological Investigation Levels (EIL) for urban residential areas (development parcels and park) and commercial/industrial areas (roadways and pedestrian walkway) assuming coarse soil. EILs have not been adjusted for ambient background concentrations per the ASC NEPM and are considered conservative. • Evaluation of health risks and aesthetic impacts are considered adequately conservative to address possible ecological risks for CoPC which do not have an EIL or ESL. • ESL/EIL are applicable to soils in the top 2 m of soil which correspond to the root zone and habitation zone (i.e. growing media).
	Aesthetics	• ASC NEPM Management Limits (ML Residential/Open Space) assuming coarse soil – noting that these are designed for assessing petroleum hydrocarbons (not VCHs) and relate to formation of LNAPL, fire and explosive risks and impacts on subsurface infrastructure. • Accessible soils or soil used as growing media should not be malodourous, heavily stained or contain gross anthropogenic materials. • The presence of LNAPL or DNAPL which could impact the integrity of subsurface structures. • Criteria for sulfate, chloride and pH protective of piles in Standards Australia (2009). *Piling – Design and Installation. Australian Standard: AS2159-2009*.

Media	Receptor	Criteria
Soil Vapour	**Human Health**	• ASC NEPM HSL B (residential/commercial portions), HSL C (park and roads) for vapour intrusion (sand, 0 m to <1 m) for BTEXN. The HSLs for TRH have not been used as the TRH will be influenced by the chlorinated compounds and are not representative of petroleum hydrocarbons. HSL-C has been adopted for roads on the basis that the roads are effectively open space for the purposes of the vapour inhalation exposure pathway (i.e. there are no buildings proposed overlying roads). • CRC CARE (2011) HSL for IMW for BTEXN. The HSLs for TRH have not been used as described above. • Interim HSLs for Significant Contaminants (refer to **Section D.2.2** below) – this includes exposure scenarios of: ▪ Vapour intrusion into a building with no basement (residential or commercial). ▪ Vapour intrusion to open space (park and roadways). • Hazardous ground gas in EISB areas that may accumulate in excavations, services or basements that represents an explosive or asphyxiant risk with consideration of NSW EPA (2019) *Assessment and Management of Hazardous Ground Gases, Contaminated Land Guidelines*. NSW EPA (2019) suggests the use of both gas concentrations and borehole flow rates to define a characteristic situation for a site based on gas screening value (GSVs). The GSV is determined by multiplying the maximum borehole flow rate (L/hr) with the maximum gas concentration (%). Although NSW EPA (2019) criteria are intended to be applied to landfills, where flow rate is not available, threshold values of methane at concentrations of 1% (v/v) and carbon dioxide at concentrations of 1.5% (v/v) above background levels are adopted.
Ground-water	**Human Health**	<u>Extraction and Beneficial Use:</u> The site is located within Botany Groundwater Management Zone 2 designated by the NSW Government. Within Zone 2, all domestic bore use is banned, including groundwater for drinking, watering gardens, washing cars and other domestic purposes. Furthermore, the PSI conducted a groundwater bore search and did not identify registered bores downgradient of the site with a recorded use other than for monitoring purposes. The extraction and use of groundwater is, therefore, not considered in this assessment. Senversa has assumed that groundwater extracted for remediation or construction dewatering purposes is appropriately managed. <u>CoPC other than Significant Contaminants:</u> • The concept development plans indicate two levels of basement for all the buildings on site - as the building basement will extend into the groundwater the HSLs for vapour intrusion in ASC NEPM are not relevant for residential areas. • ASC NEPM vapour intrusion HSL C for BTEXN (sand, 2 m to <4 m) is adopted to assess vapour intrusion to open space park and roadways. The HSLs for TRH have not been used as the TRH will be influenced by the chlorinated compounds and are not representative of petroleum hydrocarbons. HSL-C has been adopted for roads on the basis that the roads are effectively open space for the purposes of the vapour inhalation exposure pathway (i.e. there are no buildings proposed overlying roads). TRH should also be considered on a risk-based approach as outlined for soil above. • Incidental contact with groundwater that seeps into basements by basement maintenance workers is an unlikely exposure pathway, however, for conservative screening purposes, criteria have been adopted based on NHMRC and NRMMC (2011) *Australian Drinking Water Guidelines* (ADWG). ADWG have been adjusted by a factor of 10 in accordance with Health and Medical Research Council (NHMRC) (2008) '*Guidelines for Managing Risks in Recreational Water*' (GMRRW), which is also considered appropriate for maintenance workers. It is noted that NHMRC are currently revising the approach to assessing risks recreational users and these criteria may change (and become less stringent in most cases). This exposure scenario is considered to be of low likelihood, and it may be appropriate to further assess the health risks based on specific basement design. • Incidental contact with groundwater by intrusive maintenance workers is considered unlikely on the basis that the average depth to groundwater exceeds 2 m. • A methane concentration of 1 mg/L has been adopted as a screening level to trigger further assessment. <u>Significant Contaminants:</u> Site-specific interim HSLs for Significant Contaminants that are protective of the following scenarios are presented in **Section D.2.2** below: • Groundwater seepage into a basement and volatilisation. • Vapour intrusion in open space areas (park and roadways) Incidental contact by basement maintenance workers from seepage into basements is screened using ADWG criteria adjusted by a factor of 10 (on the basis that vapour inhalation is assessed using the site-specific interim HSLs) – this exposure scenario is for conservative screening purposes and that it may be appropriate to further assess the health risks based on specific basement design.

Media	Receptor	Criteria
	Ecological	There are no ecological receptors to groundwater identified on-site. Shallow groundwater on the site may migrate off-site and discharge to Sheas Creek drain, which is the nearest surface water body located to the west of the site. Near the site, the creek is a concrete box-culvert, which flows along a former natural drainage line to Alexandria Canal in the southwest. There are no ecological receptors in a concrete lined box culvert. As such, no significant off-site ecological receptors have been identified for the site. As a highly conservative step to assess possible impacts on ecological receptors (if they were present), groundwater data have been screened against Groundwater Investigation Levels (GILs) listed in NEPM (2013) for protection of aquatic ecosystems referenced in ANZECC (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. The ANZECC 2000 guidelines have been updated in ANZG (2019) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia (available at www.waterquality.gov.au/anz-guidelines). The Default Guideline Values (DGV) provided are concentrations of toxicants that should have no significant adverse effects on the aquatic ecosystem. The freshwater 95% level of protection was adopted. Some have been modified based on bioaccumulation or acute-toxicity or potential toxicity to particular species.
	Aesthetics	• The presence of LNAPL or DNAPL which could impact subsurface structures. • Criteria for sulfate, chloride and pH protective of piles in Standards Australia (2009). *Piling – Design and Installation. Australian Standard: AS2159-2009*.

D.2.2 Interim Screening Levels

Derivation of interim health screening levels (HSLs) are provided in Appendix K of the DSI (Senversa, Sep 2020) for Significant Contaminants for a variety of exposure pathways, land uses and scenarios. The screening levels have been derived for the following:

- Soil vapour - for open space and residential land use (where there is no basement or the basement does not intersect groundwater).
- Groundwater - protective of inhalation pathway in a residential building with basement when groundwater seeps into the basement and volatilises.
- Soil - protective of the inhalation pathway when the contaminants partition into groundwater which seeps into a basement and volatilises.
- Soil and groundwater - protective of the inhalation pathway in an open space environment (park or roadway) when groundwater is at least 2 m below ground surface.
- Soil – protective of direct contact and inhalation of dust in an open space environment (park or roadway).

These interim screening levels are specific to a set of conservative assumptions and the proposed subdivision and development concept in the DA – they may be subject to amendment specific to the detailed design of future buildings, but are considered appropriate for use in remediation planning only.

Table D-3 Site-Specific Interim HSLs

	Commercial / Residential Buildings			Open Space / Roadways			
	Soil HSL (Scenario C) (Leaching to Groundwater and Vapour Intrusion) (mg/kg)	Groundwater HSL (Scenario C) (Seepage / Vapour Intrusion) (mg/L)	Soil Vapour HSL (Scenario C) (Vapour Intrusion) (mg/m^3)	Soil HSL (Direct Contact) (mg/kg)	Soil HSL (Vapour Inhalation) (mg/kg)	Groundwater HSL (Vapour Inhalation) (mg/L)	Soil Vapour (HSL) (Vapour Inhalation) (mg/m^3)
PCE	50	7	43	4000	NL	NL	430
TCE	0.4	0.07	0.43	100	1	7	4
cis-1,2-DCE	1	0.3	1.7	600	6	51	20
trans-1,2-DCE	10	2	14	5000	30	192	140
VC	0.5	0.09	0.55	20	300	2.3	5

A range of interim screening levels were developed depending on the nature of the future basement (e.g. geometry, levels and connection between levels). ‘’Scenario C’’ was adopted for initial screening purposes as it is conservative – alternate scenarios in Appendix K of the DSI (Senversa, Sep 2020) may also be considered (e.g. Scenario A for a large single-level basement).

D.2.3 Management Order Criteria

Relevant criteria in the Management Order are described in the following table. These are not applicable to assessing site suitability and will be addressed separately to the matter of this RAP – however, they provide useful context as the remediation in this RAP is deigned to align with that of the Management Order requirements.

Table D-4 Management Order Criteria

Media	Criteria
Groundwater	Dissolved-phase concentration of sum of Significant Contaminants of 0.5 mg/L. This criterion can be applied to average concentrations off the Source Site or migrating from the Source Site within a defined area (e.g. a specific source zone and associated plume).
DNAPL and sorbed phases	Treat to the maximum extent practicable DNAPL and sorbed-phase Significant Contaminants. With consideration of the groundwater clean-up target, this should aim to be to a level that will result in a concentration of dissolved-phase total Significant Contaminants that does not exceed 0.5 mg/L. It is anticipated that the interim HSLs for soil and groundwater presented above are adequately protective of this aspect (i.e. there are no specific additional criteria).
Soil vapour	The Management Order refers to soil vapour impacts from Significant Contaminants migrating from the Source Site. It is envisaged that interim HSLs remedial works to address groundwater and DNAPL/soil phases (above) and criteria to achieve site suitability will also address this aspect (i.e. there are no specific additional criteria).

Comparison of the interim HSLs (**Section D.2.2**) against the Management Order criterion (sum of Significant Contaminants of 0.5 mg/L) indicates that the interim HSLs (basement Scenario C) are approximately aligned with the Management Order target on the basis of the current composition of groundwater (i.e. outside of source zones dominated by *cis*-1,2-DCE and VC) – however, the intent is that all the criteria need to be considered for their specific purposes.

This alignment is supported by the ORAP which found:

- The average composition of VCHs in groundwater (excluding the central portion of Source Zone 2 near where DNAPL has been reported and PCE is more prevalent e.g. EW05, IW801, IW802, MW111) comprises greater than 97% cis-1,2-DCE and VC. The sum of conservative Scenario C interim HSL of these compounds (0.33 mg/L) is less than the Management Order criterion (0.5 mg/L).
- Interim screening levels for soil (protective of ingress/seepage into a basement) that were based on Scenario C.

D.2.3 VCH Composition

Consideration of VCH composition and possible degradation of parent compounds is required during application of the interim HSLs and Tier 1 Screening criteria.

Consideration of possible degradation of PCE to TCE to *cis*-1,2-DCE to VC (i.e. the hypothesis that VC could be formed at concentrations greater than those reported currently) is needed for soil vapour and groundwater. However, Senversa considers that the screening criteria adopted in the DSI are adequately conservative on the basis that:

- The Management Order considered off-site migration of Significant Contaminants, with application of the 0.5 mg/L criterion for total Significant Contaminants.
- The ORAP assessed plume composition at the site, finding composition was dominated (exceeding 97% mol/mol) by cis-1,2-DCE and VC except for within the central portion of Source Area 2 and off-site at IW809, MW63/MW63A within Bourke Street where PCE was more prevalent. This suggests the key mechanism of concern is *cis*-1,2-DCE degradation to VC (rather than PCE and TCE degradation).
- The most elevated concentrations of *cis*-1,2-DCE and VC are generally co-incident (i.e. the extent of contamination of VC is similar to or greater than the extent of *cis*-1,2-DCE contamination).
- Vinyl chloride was not reported in soil vapour samples collected as part of the DSI, and generally not reported in vapour monitoring under the Management Order, supporting that VC rapidly degrades in the vadose zone.

D.3 Contingency

The interim screening levels described above used to define the extent of remediation may be overly conservative for:

- The specific development for each land portion.
- Vapour inhalation risks within open space areas (park, roadway, pedestrian link, shared access way).

There is also potential that development plans change and the assumptions on which the interim screening levels were based are no longer valid.

For these reasons this RAP requires that the suitability of the interim screening levels is reviewed by a suitably qualified and experienced person as part of enabling works, with any amendments documented in the RWP (or attachment) and subject to review by the site auditor.

Contingency Scenarios

Key scenarios that would trigger additional assessment of health risks for the specific development for each site portion or land use include:

- Changes in occurrence, dimensions, structure and construction method/quality of building basements (e.g. width, length and height of each basement level and connectiveness between basement levels, lifts, tanked or wet) that could alter the assumed air exchange within the basement and attenuation into overlying building levels.
- Change in dimensions, depth and construction quality of building basements (e.g. tanked or wet) that could change the groundwater seepage flux/rate into basements.
- Change in land use to that proposed in the concept development plans – this also includes change in ground floor use from the currently proposed mixed commercial and residential use (refer **Appendix A**).
- Different contamination conditions not considered in this RAP encountered during enabling works.
- Change in criteria and NSW EPA made or approved guidance prior to development of the RWP and RVP.
- Residual contamination that cannot practicably be remediated.

Criteria Review and Assessment

If the above scenarios occur, a quantitative risk assessment should be conducted specific to the proposed use and development design of each land portion to:

- refine remediation targets/criteria presented above; and/or
- refine the extent of remediation.

The risk assessment should consider the above factors, and relevant criteria and NSW EPA made or approved guidance on risk assessment available at the time of preparation.

Staging of the risk assessment(s) should be:

- Prior to development of the RWP and RVP.
- Prior to Stage 2 DAs based on proposed detailed design of developable parcels.

Appendix E: Remedial Options Review

Appendix E: Remedial Options Assessment

E.1 Remedial Options Assessment – VCH at Source Site

E.1.1 AECOM RAP (AECOM, Nov 2011) Requirements

The RAP (AECOM, Nov 2011) was prepared, independently endorsed and implemented as a requirement of the Management Order. The remediation objective of the AECOM RAP does not relate to site suitability – i.e. the AECOM RAP is not directly relevant to the subject matter of this RAP. However, the AECOM RAP is important to understand for context, and was considered in selection of the preferred remedial approach (i.e. in order to align the two approaches if effective and practicable).

An assessment of remedial options to address Management Order requirements was presented in the AECOM RAP (AECOM, Nov 2011). The assessment included consideration of the understanding of the nature and extent of Significant Contaminants, site constraints and Management Order requirements, at that time.

Site characteristics that have changed (or will likely do so) since the AECOM RAP include:

- Site access and operations – it is assumed that the sites will not be in use and buildings demolished to grade.
- Significant Contaminant conditions – e.g. clean-up of Source Zone 1 and plume; possible additional source near Bourke Street.
- Subsurface conditions (e.g. geochemistry) have changed due to EISB actions.
- Additional infrastructure (e.g. EISB wells, piping, plant) are present.
- Possible technology changes/advances.

Implementation of the AECOM RAP has resulted in substantial progress towards completion of actions required under the Management Order. However, persistent elevated concentrations of Significant Contaminants are still reported in Source Zone 2 (and off-site at Bourke Street) and, based on the remedial timeframe for Source Zone 1 of seven years, it is unlikely that the preferred approach in the AECOM RAP of EISB can achieve the required remediation targets within the timeframe of the Management Order.

However, the AECOM RAP was intended as an adaptive management approach, and identified several alternative measures to supplement the preferred containment/EISB approach, including:

- Injection of emulsified vegetable oil (EVO) – this was conducted at the site in 2015, 2017 and September 2020, and would likely require future replenishment.
- Multi-phase extraction (MPE).
- Thermal (potentially a combination of steam injection, thermal conductive or resistive) heating.
- Excavation and disposal.
- Soil vapour extraction (SVE) as a soil vapour remedial measure.

While on-going implementation of the AECOM RAP is necessary to meet ongoing requirements of the Management Order, unless a reasonable argument is made otherwise with approval by EPA, it is apparent that one or more of the supplementary remediation measures will be necessary to meet Management Order requirements – noting that the Management Order requires remediation of the Source Site to the ‘extent practicable’.

E.1.2 Supplementary Remedial Options Assessment

As discussed in **Section 4** of the report, the remediation requirements of the Management Order do not directly relate to the suitability of the site for the proposed site development. Additional remediation is necessary (or may become necessary as an outcome of pre-remediation investigations) to make the site suitable for the specific development due to more conservative remediation targets/criteria.

A review and ranking of remedial options adapted from the AECOM RAP (AECOM, Nov 2011d) and other potentially suitable technologies is presented in **Table E1** and **Table E2** (below). This review considers the following key factors:

- The remediation objectives and drivers (**Appendix D**).
- The nature and extent of contamination (**Section 4** of the report) – i.e. Significant Contaminants only with a practical extent comprising the site.
- A preference to undertake additional remedial works for Significant Contaminants in a manner that aligns with the AECOM RAP – i.e. adapt one of the alternative remedial measures identified in the AECOM RAP. Other remedial measures may be relevant to other COPC; however, a consistent approach is preferable to align with approved works under the Management Order.
- 'Treatment Train Remediation' and 'Proven Technology and Remedies' (PT&R) approach with reference to US EPA (2002).
- General consideration of:
    - Technical suitability
    - Practicability
    - Cost
    - Certainty
    - Timeframe
    - Approvals/Permitting
    - Sustainability
    - Compliance with the AECOM RAP

Selection of Remediation Technologies and "Treatment Train Remediation"

Often a single remediation technology is unable to adequately remediate a site's contaminated soil and/or groundwater to below acceptable levels. Some technologies are not able to completely remove DNAPL or highly concentrated sorbed and/or dissolved-phase groundwater contamination. Other systems can remove large amounts of contaminant mass, but are not able to reduce the concentrations below remediation targets within reasonable timeframes (in this case, by mid-2021 to meet Management Order requirements).

The ultimate preferred remedy for many sites will be a combination of more than one technology, referred to as a "treatment train". The treatment train approach uses multiple technologies to clean up (or manage) contaminants in different phases over a period of time. The AECOM RAP (AECOM, Nov 2011) incorporated a treatment train approach with phased remediation of:

- Hydraulic containment at the Source Site; then
- Progressive treatment of the plume using EISB; and
- Treatment to the extent practicable of residual DNAPL and sorbed phases sources at the Source Site.

Clean-up to the extent practicable of DNAPL source zones often results in residual contamination that cannot practicably be removed – an example may be residual contaminants that have diffused into the clay matrix underlying fill/sands at the site. For this reason, often final remedial phases may implement monitored natural attenuation (MNA) or institutional controls after the contaminant plume has stabilised or contaminant concentrations have been reduced. At the Source Site, this could also require on-going hydraulic containment. However, due to Remediation Objective 2 (minimising on-going liability), MNA or on-going containment is not considered a preferred option for Significant Contaminants at the Source Site.

Proven Technology and Remedies Approach

In the above context, it is considered that the most appropriate remediation strategy to meet the Remediation Objectives for Significant Contaminants should be based on a 'proven technology and remedies' (PT&R) approach, which allows for clean-up of sites contaminated with VCHs in the vadose zone and shallow saturated soils in a timely and reliable manner.

PT&R is based on non-biological, rapid, direct physical removal methods for DNAPL source zone treatment, combined with ex situ treatment and either on-site re-use or off-site disposal. This represents a different approach to the current in situ method, which was limited by the access restrictions of the LDC building footprint, but is possible if there is unimpeded access. Project and site characteristics that favour a PT&R approach include:

- Remediation Objectives that require a high degree of certainty in remedial outcomes with a goal of minimal on-going contamination liability.
- Relatively short timeframe (i.e. in the order of one year).
- Primarily VCH contamination (though other COPC will need to be assessed).
- Identified contamination is currently being managed (i.e. no emergency response / immediate actions required).
- Ability to address soil and groundwater impacts through separate remediation technologies.
- No off-site ecological habitat or sensitive receptors impacted.
- Exposure pathways and land use scenarios consistent with PT&R approach.

Table E.1: Supplementary Remedial Options Ranking – VCH at Source Site

Option (refer to Table E.2 below)	Technical Suitability (Effectiveness)	Technical Suitability (Practicability)	Cost	Certainty of Outcome	Timeframe	Approvals / Permitting	Sustainability	Compliance with AECOM RAP	Overall Score
Relative Weighting	*10*	*10*	*10*	*5*	*5*	*5*	*5*	*Yes / No*	*50*
EISB (high solubility carbon substrate)	4	6	6	2	1	5	5	Yes	29
EISB (low solubility carbon substrate)	4	6	6	2	1	5	5	Yes	29
In-situ Chemical Oxidation (ISCO)	4	6	4	2	3	2	2	Yes	23
In-situ Chemical Reduction (ISCR)	4	6	4	2	3	2	2	No	23
In-situ Thermal Treatment	9	8	2	5	3	1	1	Yes	29
Ex-situ Thermal Treatment	10	8	2	5	3	1	1	Yes	30
Groundwater extraction and treatment	0							No	0
Direct and multiphase recovery	0							No	0
In-situ flushing (water, co-solvents, surfactants)	3	2	4	1	2	2	1	No	15
In-situ soil vapor extraction (SVE)	0							Yes	0
Air sparging and SVE	3	5	5	2	2	3	2	No	22
Soil excavation and offsite disposal	10	10	1	5	5	4	1	Yes	36
Soil excavation, on-site treatment and reuse	10	9	3	5	5	4	3	Yes	39
Physical containment (cut-off wall)	4	8	7	2	1	4	4	Yes	30
Physical containment (cover)	3	8	8	2	1	4	4	Yes	30
Hydraulic containment (pump-and-treat)	4	8	3	2	1	5	2	Yes	25
Stabilisation	4	6	3	1	3	2	2	No	21
Permeable reactive barriers (PRB)	5	4	4	2	1	2	3	No	21
Monitored Natural Attenuation (MNA)	0							No	0
Institutional Controls	0							No	0
Do nothing	0							No	0

Notes:
Relative scores are between 1 (unfavourable) and 10 (most favourable) for key metrics and 5 (most favourable) for secondary metrics.
The overall score is the summation of each relative score.)
Technologies that will not be technically effective (i.e. will not achieve the remedial objective within a reasonable timeframe on their own) have been given a score of zero and not assessed further.

Table E.2: Review of supplementary remediation technologies – VCH at Source Site

Remediation Type	Technology	Method Description	Advantages	Disadvantages	Relative Cost	Consistent with AECOM RAP (AECOM, Nov 2011d)?	Retained?
Biological Treatment	Enhanced *in-situ* bioremediation (EISB) – high solubility carbon substrate	Approach used from 2010 – 2014 - Inject sodium lactate (or another soluble amendment) and nutrient/buffer amendments to create and maintain conditions conducive to biotic reductive dechlorination of contaminants. Could either apply via a recirculation system (as implemented previously per the RAP) or multiple injections and passive (i.e. with advective migration) distribution. Could use bioaugmentation to increase degradation rates of DCE and VC in low pH conditions. This approach would be intensive / targeted to Source Zone 2 or at eastern extent with continuous application for 2019-2021 (and ongoing). Would require installation of additional injection and extraction wells.	• EISB has proven to be effective for treatment of the plume and controlling migration off the Source Site. • Short lead time and fast acting. • Commercially available products. • Existing experience and knowledge can be utilised. • Existing infrastructure could be utilised, though additional wells and piping would be required. • Complementary to current remediation approach. • Materials, equipment and vendors are commercially and locally available. • Limited planning and approvals required – current approved approach.	• Will not likely meet Remediation Objectives: ▪ Unlikely to be effective within the timeframe based on the sustained elevated concentrations at Source Zone 2 and treatment period for Source Zone 1 – would require longer-term actions. ▪ Will not completely address residual DNAPL source zones based on observed source decay rates – residual liability. • Uncertainty in condition of existing recirculation infrastructure – e.g. belowground piping, signal cabling, controls. Existing recirculation infrastructure would require significant maintenance capital. • Aquifer fouling may limit ability to practicably apply and distribution within the aquifer. • Current EISB approach not readily applicable to other COPC.	Moderate	**Yes**	**No**
	EISB – low solubility carbon substrate	Approach used from 2015-current - similar to above, but injection of emulsified vegetable oil (EVO), nutrients and buffer amendments to create longer-lasting conditions conducive to biotic reductive dechlorination of contaminants. Application to target key zones of residual impact - primarily sands within Source Zone 2 and (potentially) off-site at Bourke Street. Would require installation of additional injection and extraction wells. Could use bioaugmentation to increase degradation rates of DCE and VC in low pH conditions. Expected lifetime of 1-2 years per application – would require applications in 2019 and 2021 (and potentially ongoing). Potentially ‘mothball’ the boundary hydraulic containment system.	• Proven to control plume (DNAPL dissolution, desorption/back-diffusion) at the Source Site. • Short lead time. • Longer lifetime – up to 2 years. • Commercially available products. • Complementary to current remediation approach. • Relatively easy to implement – could utilise existing infrastructure. • Limited planning and approvals required – current approved approach.	• Will not likely meet Remediation Objectives: ▪ Unlikely to be effective within the timeframe based on the sustained elevated concentrations at Source Zone 2 and treatment period for Source Zone 1 – would require longer-term actions. ▪ Will not completely address residual DNAPL source zones based on observed source decay rates – residual liability. • Aquifer fouling may limit ability to practicably apply and distribution within the aquifer. • The potential to mobilise/solubilise DNAPL needs managing. • Will be more difficult to implement in Young Street properties than previously. • Current EISB approach not readily applicable to other COPC.	Moderate	**Yes**	**Yes** – but only for residual off-site Significant Contaminant contamination at Bourke Street
Chemical Treatment	*In-situ* Chemical Oxidation (ISCO) or *Ex Situ* Chemical Oxidation (ESCO)	Ad or inject a chemical oxidant into subsurface or excavated material for oxidation/destruction of contaminants in soil and groundwater. Application could be via following approaches: Large-scale application to Source Zone 2 via direct injection or soil mixing. Groundwater extraction and treatment would be required to control the large volume of fluids requiring injection and unintended displacement. Application at base of excavation via direct spray/irrigation to address diffused VCH mass in residual clays. Ex situ application for ‘polishing’ excavated materials via spray or irrigation application. Potential oxidants include permanganate, hydrogen peroxide (catalysed or not), persulfate, ozone. Peroxide and ozone have shorter lifetimes in, whereas persulfate and permanganate are more sustaining oxidants. Treatability trials would be required to assess the most effective oxidant and potential for secondary impacts.	• Proven technology • Effective at treating dissolved phase. • Commercially available products and vendors. • Applicable to Significant Contaminants and many petroleum hydrocarbons.	• Unlikely to address residual DNAPL source zones by 2021 as a standalone approach – will not likely address DNAPL and sorbed mass in clays/peats (i.e. would expect ‘rebound’ issues). • Significant chemical volumes would be required to treat source zones. • Aquifer fouling may limit ability to practicably apply and achieve distribution of chemicals within the aquifer. • Strong oxidants require careful handling and may affect subsurface infrastructure. • Organic rich sediments (e.g. peats) will consume a large mass of oxidant. • Potential for secondary water quality issues. • Not complementary with EISB, though literature suggests restoration of natural conditions can occur. • Need treatability trials. • Significant planning and approvals effort.	Moderate to High	No – but could be a supplemental technology	**Yes** – as a supplemental technology to address residual contamination by VCHs or other organic COPC

Remediation Type	Technology	Method Description	Advantages	Disadvantages	Relative Cost	Consistent with AECOM RAP (AECOM, Nov 2011d)?	Retained?
	In-situ Chemical Reduction (ISCR)	Inject a chemical reductant (e.g. polysulfide) or nano- or micro-scale zero valent iron (ZVI) into subsurface in Source Zone 2 to promote abiotic reductive degradation of Significant Contaminants. Could be applied as for ISCO/ESCO (above). Treatability and injection trials would be required to assess the most effective agent and distribution.	• ZVI has been proven to be effective for Significant Contaminants. • Complementary with EISB. • Commercially available products and vendors.	• Unlikely to address residual DNAPL source zones by 2021 as a standalone approach – will not likely address DNAPL and sorbed mass in clays/peats (i.e. would expect 'rebound' issues). • Not applicable to petroleum hydrocarbons. • Significant chemical volumes would be required to treat source zones. • Aquifer fouling may limit ability to practicably apply and achieve distribution of chemicals within the aquifer. • Treatability / injection trials would be required to show adequate distribution and destruction can be achieved. • Potential for secondary water quality issues. • Moderate planning and approvals effort.	Moderate to high	No	No
Thermal Treatment	*In-situ* thermal conductive heating (TCH)	Electrically powered heater rods or blankets are installed in the ground to heat the aquifer (soil and water) via radiation and conduction. Rod / element spacing may be in the order of 5 m (close spacing may be required due to the shallow geometry of treatment zone. As the temperature rises (to about 100°C), increased dissolution, desorption and volatilisation of Significant Contaminants occurs. DNAPL is also mobilised as temperatures increased. Volatilised contaminants are captured at the ground surface with a vapour extraction and treatment system. Hydraulic control is necessary (i.e. 'pump-and-treat' or containment) to reduce the flux of groundwater flowing through the treatment zone and as a contingency to capture condensate.	• Applicable to Significant Contaminants and light-fraction petroleum hydrocarbons and aquifer materials. • A 'sledge hammer' approach (depending how applied). • High likelihood of effectiveness in treatment zone. • May treat low permeability clays/peat layers. • Low temperature desorption would have lower energy costs.	• Difficult to install and operate. • Presents risks to adjacent site structures (from heat, potential geotechnical issues) and workers (heat, stored energy, hazardous gases). • Not applied in Australia at full scale and no local commercial vendors. • Not complementary with EISB in area of heating. • Requires a significant power source/infrastructure. • Significant planning and approvals effort. • Requires efficient and effective dewatering to control energy and heating demand (dry soils easier to heat than wet soils)	High-Very High	**Yes**	No – noting low temperature thermal desorption could be an option for *ex situ* treatment of soils.
	In-situ steam enhanced extraction (SEE)	Steam is injected into the subsurface in wells, while simultaneously extracting steam, heated water, DNAPL and vapour at other wells. Rod / element spacing may be in the order of 10 m (close spacing may be required due to the shallow geometry of treatment zone. This process results in an increase in DNAPL mobility (via displacement, increasing solubility and reducing interfacial tension) and volatilisation of Significant Contaminants. Captured fluids and steam/vapour at the ground surface requires treatment. There is less need for hydraulic control (i.e. 'pump-and-treat') to reduce the flux of groundwater flowing through the treatment zone, though control of condensate is required. It is noted that the aquifer near Source Zone 2 is already heated to approximately 30 °C (hypothesised to be related to hot wash-water leaking from a sump).	• As above for TCH. • Lower density of steam injection rods / elements required.	• As above for TCH • More sensitive to geological heterogeneity (than other thermal methods). • Not suited to low-permeability units. • Would require steam source.	High	**Yes**	No
	In-situ electrical resistive heating (ERH)	ERH uses electrical current passed through closely spaced electrodes to heat the aquifer and volatilise contaminants. Volatilised contaminants are then captured at the ground surface with a vapour extraction and treatment system. Would require hydraulic control (i.e. 'pump-and-treat') to reduce the flux of groundwater flowing through the treatment zone. Rod / element spacing may be in the order of 5 m (close spacing may be required due to the shallow geometry of treatment zone. Generally produces uniform heating of heterogeneous soils, requires moisture (often water is added), operates at low to moderate temperatures (about 100°C). Less volatile compounds may not be removed with temperature limit. ERH may be more suited to targeting low permeability clay units rather than permeable zones. Timeframe of months to install and commission, and months to operate. Planning approvals likely required.	• As above for TCH. • More suitable to target low permeability clays/peat layers (e.g. at base of sand aquifer) in small areas.	• As above for TCH • May not be suited to shallow treatment zone (minimum heating thickness is about 2.5 m). • Would require additional power source/infrastructure.	High-Very High	**Yes**	No
	Ex situ thermal desorption	Thermal desorption treatment of excavated fill/soils to volatilise VCH and other organic compounds. Low temperature thermal desorption would likely be most appropriate for VCHs. Requires excavation of contaminated materials (see below) and off-gas treatment.	• As above for TCH. • More reliable treatment of materials compared to *in situ* thermal applications. • May allow reuse of soils on-site.	• Requires excavation • Sensitive to understanding of source zone characteristics (i.e. could 'miss' unidentified contamination). •	High	**Yes**	**Yes** (as part of excavation option below)

Remediation Type	Technology	Method Description	Advantages	Disadvantages	Relative Cost	Consistent with AECOM RAP (AECOM, Nov 2011d)?	Retained?

Physical Removal	Source Area groundwater extraction and treatment	Extraction of groundwater within Source Zone 2 and Bourke Street area, and *ex-situ* treatment. Would require installation of additional wells and piping in the former 'lunch room' and potentially the 'Coffee Shop'. Extraction of high strength groundwater within the source zone will result in increased mass reduction (compared to a boundary containment system) and increased dissolution of DNAPL and sorbed phase contaminants.
		This may form part of a multi-phase recovery system.
		Extraction would cease at current boundary wells, with a focus on Source Area 2. Existing infrastructure could be utilised, though the treatment plant will require upgrade/expansion (due to higher strength groundwater).
		Would not be applicable to residual sources in vadose zone (e.g. Source Zone 1).
			• Applicable to all dissolved phase COPC and aquifer materials.
			• Will result in substantial mass removal.
			• Status quo.
			• High reliability / proven technology.
			• Technology suited to high permeability aquifer.
			• Use existing infrastructure.
				• Will not address residual DNAPL source zones by 2021.
				• Limited mass removal - risk pathway control only.
				• Will not likely meet Remediation Objectives:
				  ○ Unlikely to be effective within the timeframe based on the sustained elevated concentrations at Source Zone 2– very long time to clean-up (limited by DNAPL dissolution and matric back-diffusion / desorption).
				  ○ Will not completely address residual DNAPL source zones based on observed source decay rates – residual liability.
				• Requires disposal of treated water via trade waste.
				• Costly to operate over lifecycle.
					Moderate	**Yes**	**Yes –** only if combined with other approaches such as dewatering

	Direct and multiphase recovery	Extraction of NAPL, groundwater and vapour (under high vacuum) from wells. Extracted fluids and vapour requires treatment. Direct extraction of NAPL can also be applied. This will result in increased mass recovery (compared to just groundwater extraction) as NAPL and vapour is also extracted. Direct recovery of mobile NAPL (there is potentially mobile DNAPL at IW802 and LNAPL at MW29) would result in significant mass reduction, but there have been few observations of mobile NAPL. Can either be via a series of 'events' using mobile equipment/plant, or a continuous permanent system. A permanent system / continuous operation would be more suited to the site. Would require blower and vapour treatment, but could utilise existing treatment plant for liquid treatment (with an expansion to cope with increased concentrations/mass). Proprietary technology (Accelerated Remediation Technologies, Inc) available that combines in-well fluid extraction, air sparging and vapour extraction. A short trial would be required (per SVE option).	• Will likely result in significant mass reduction (more than just groundwater extraction). • Also effective for vadose (shallow unsaturated zone underlying slabs) zone. • Direct DNAPL recovery can be an efficient and certain method of mass removal.	• Requires additional wells, equipment and piping. • Requires vapour treatment system and blower, and location to install these. • Unlikely to be significant volumes of mobile DNAPL without enhancement. • If direct recovery of NAPL is applied, NAPL disposal will be necessary (existing treatment system not capable).	Moderate	**Yes**	No
	In-situ flushing (water, co-solvents, surfactants)	Injection of a flushing agent to displace and/or increase dissolution of DNAPL for downgradient capture via an extraction and treatment system. Existing wells could be supplemented with additional wells in Source Zone 2 or vadose zone sources. Upgrade/expansion of the treatment plant, or a separate plant (depending on the agent), would be required. Flushing agents can include water (to force gradients), surfactants and co-solvents (e.g. ethanol). Laboratory and/or field trials would be required.	• More aggressive (i.e. increased mas removal) than current approach. • Would complement a pump-and-treat approach. • Could potentially target vadose zone.	• Will not meet Management Order requirements - needs to be combined with groundwater extraction and treatment. • Secondary water quality issues and increased risk of loss of 'capture'. • Already a highly disturbed aquifer – may not be practicable to achieve 'contact' or control flushing agent pathways. • Longer lead time as field trials would be required. • Substantial planning and approvals anticipated.	Low-moderate	No	No
	Soil vapor extraction (SVE) – *in situ* or *ex situ* within stockpiled materials	SVE comprises vacuum extraction of soil gas from the vadose zone or stockpile, with *ex-situ* treatment. As Significant Contaminants are volatile, gaseous concentration gradients drive volatilisation of volatile compounds in pore water, DNAPL and sorbed phases in vadose zone, resulting in mass removal from the vadose zone. The SVE system would comprise a surface seal (probably just the existing building slab), series of vapour extraction wells, and extraction system (blower, piping) to a vapour treatment unit. The most likely location would be residual shallow impacts at Source Zone 1 and Source Zone 2. Lowering the water table would result in greater effective extent. While the formation is anticipated to be suitable for SVE, a short field trial would be required to assess radius of influence, formation response and vapour quality/mass recovery. There may be planning and approvals requirements.	• Will likely effectively address residual contamination in vadose zone. • Will address main risk exposure pathways (vapour intrusion). • Monitoring data shows significant Significant Contaminant concentrations in vadose zone at LDC. • Applicable to Significant Contaminants and other volatile COPC. • Existing surface seal present.	• No effect on groundwater and DNAPL - will not meet Management Order requirements - needs to be combined with air sparging or other method for the aquifer. • Limited to vadose zone, which will have limited mass reduction capacity (relative to DNAPL and sorbed phases). A lowering the water table by extraction or air sparging would be required to increase mass recovery. • The vadose zone is relatively shallow - mass reduction limitations. • May be incomplete surface seal (i.e. end up 'treating' ambient air in the LDC facility). • Field trial required.	Low-moderate	**Yes**	**Yes –** in combination with other remedy that targets the saturated zone.

Remediation Type	Technology	Method Description	Advantages	Disadvantages	Relative Cost	Consistent with AECOM RAP (AECOM, Nov 2011d)?	Retained?
	Air sparging and SVE	Air sparging involves injection of air or inert gas (like nitrogen) into the subsurface to volatilise Significant Contaminants and other volatile compounds. Air sparging is required to be combined with SVE to capture the vapours. Will require installation of injection wells, sparging piping and blower. Proprietary technology (Accelerated Remediation Technologies, Inc) available that combines in-well fluid extraction, air sparging and vapour extraction. Remediation of contaminants could be limited by channelled flow through sand units, diffusion and ability to inject air at reasonable injection pressures, onsite and offsite. Vapour recovery and injection potential need to be evaluated. Pilot testing required. Sparging with air will introduce oxygen that will create locally oxidising conditions not conducive to EISB. However, literature suggests this effect is localised and can be combined with EISB. Sparging with an inert gas like nitrogen will not introduce oxygen and maintain reducing conditions compatible with EISB, though is more costly (due to nitrogen source required).	• Possible substantial progress towards addressing residual DNAPL source zones by 2021. • As for SVE but is more aggressive as it will result in mass removal from the aquifer. • Can be compatible with EISB if nitrogen is used. Otherwise would have to be in a separate treatment zone.	• Not compatible with EISB unless nitrogen is used (costly) – separate treatment zone in cross-gradient required. • Preferential flow of sparge air can occur, limiting effectiveness for low permeability units or sub-regions of treatment zones. • Potential increase in hazard to site workers from increase in ground gases. • Field trial required.	Moderate	No	No
	Soil excavation and offsite disposal	Remove source material within source zones via dewatering and excavation with offsite disposal at a licenced facility. Excavation using standard equipment. Excavation would require shoring for geotechnical purposes and integrity of adjacent structures / infrastructure, and dewatering. Odour/vapour emissions control would be required. Effectiveness and certainty of outcome depends on delineation and removal of source material – complete excavation of site would provide the most certain outcome, whereas partial excavation targeting source zones means there is likely to be some residual material remaining (e.g. diffused mass in residual clays). Requires delineation of source areas (if improved certainty required), dilapidation survey and (possibly) a structural/ geotechnical assessment.	• Capable of addressing Remediation Objectives, including Management Order requirements, with high degree of certainty. • Simple and easily verifiable approach with high reliability / certain outcome – effectiveness is directly related to access to remove contaminated source material. • Shallow and mostly sandy nature of fill/soils is favourable for excavation. • Effectively removes source material within low permeability soils and limits potential groundwater impacts. • Minimal ongoing monitoring required. • Relatively rapid. • Commercially available and local equipment/ vendors. • Retention structure/wall may have a secondary function of hydraulic containment.	• Remediation effectiveness reliant on certainty in characterisation of extent of contamination and access to these materials. • Significant excavation stability requirements / risks. Excavation retention structures will be challenging to construct if maximising excavation extent due to shallow rock and adjacent structures. • Substantial groundwater throughflow – will require control of groundwater / dewatering. • Significant offsite disposal costs and materials transport. • Volatile COPCs may require an emission control structure. • Will require staging areas – may be difficult at the site. • Would require imported material to reinstate excavation (unless tied into redevelopment). • Will require further investigation / delineation of contamination extents. • Potential for cross-contamination of materials.	Very high (but would be lower if combined with redevelopment)	**Yes**	**Yes**
	Soil excavation, on-site treatment and reuse	As above but excavated source materials are treated onsite and reused to backfill the excavation. Effectiveness also is dependent on treatment efficacy and reliability. Onsite treatment may include physical screening, SVE, thermal desorption or volatilisation-type system, with off-gas treatment.	• As above for excavation and offsite disposal. • Minimises import/export of materials for reinstatement. • Minimises waste generation / disposal costs.	• As above for excavation and offsite disposal, but minimises offsite disposal costs and material import/export. • Will require treatment trial. • Additional effort in planning/approvals for soil treatment – may extent timeframe.	High	**Yes**	**Yes**

Containment / Mobility Reduction	Physical containment (cut-off wall, vapour barrier)	Install a physical barrier or 'cut-off wall' to isolate the source zone to minimise downgradient migration via groundwater and soil vapour. Various configurations could be used but would comprise a hydraulic barrier wall (for groundwater) and vapour barrier (if required). The cut-off wall would be keyed into clays underlying the sand aquifer.
		Hydraulic barrier wall construction methods include sheet pile walls, secant or diaphragm walls and soil-bentonite slurry walls. The barrier is typically installed using a backhoe, cutter-soil-mixer, trenching equipment or piling rig.
		The system would need to be paired with a cover (or buildings) to minimise infiltration – otherwise, minor extraction and treatment of groundwater from within the cut-off wall may be required on an ongoing basis to mitigate the 'bath tub' effect.
		Treatment/disposal of spoil required.
		A subset of this method could also comprise a building basement design to preclude groundwater seepage ingress.
			• Proven technology.
			• Minimal ongoing operation/monitoring required.
			• Can be incorporated into re-development.
				• No/limited mass removal - risk pathway control only.
				• May also require pump-and-treat to control groundwater heads due to infiltration / leaking services.
				• Will not likely meet Remediation Objectives:
				  ○ Will not 'treat' VCHs to extent practicable.
				  ○ Will not minimise future liability - residual mass is unchanged and long-term maintenance of cut-off wall and vapour barrier is required.
					Moderate	**Yes**	**No** – however, may be retained as a contingency and a form of cut-off wall is likely to be required for excavation retention / dewatering mitigation purposes.

Remediation Type	Technology	Method Description	Advantages	Disadvantages	Relative Cost	Consistent with AECOM RAP (AECOM, Nov 2011d)?	Retained?
	Physical containment (cap/cover, vapour barrier)	Install a cover overlying contaminated materials to: (a) provide physical separation between site receptors and contamination; and/or (b) reduce infiltration and leaching of impacted soils in the vadose zone; and/or (c) mitigate vapour intrusion into buildings. Covers can comprise suitable soils, pavement, buildings and geomembranes. They are installed using commercially available and conventional equipment and materials, though installation of geomembranes and other vapour mitigation systems requires specialist skills.	• Proven technology. • Minimal ongoing operation/monitoring required. • Can be incorporated into re-development.	• No/limited mass removal - risk pathway control only. • Approvals / audit could be difficult if the buildings form part of the cover. • Will not likely meet Remediation Objectives: ▪ Will not 'treat' VCHs to extent practicable. ▪ Will not minimise future liability - residual mass is unchanged and long-term maintenance of cut-off wall and vapour barrier is required.	Low	**Yes**	**Yes** – as a supplementary method to minimise long-term management requirements.
	Hydraulic containment (pump-and-treat)	Groundwater extraction downgradient of the residual source zone (e.g. LDC boundary) and *ex-situ* treatment, to effectively stop contamination migrating further. This is currently used to supplement EISB to meet Order #14. However, with depletion of EVO, additional wells and expanded treatment system would be required. This containment approach is different to a mass removal approach via groundwater extraction, whereby high-concentration groundwater within Source Zone 2 is extracted and treated.	• Status quo • High reliability / proven technology. • Technology suited to high permeability aquifer. • Use existing infrastructure. • Complimentary with EISB, though additional EVO injection may cause operational difficulties in the treatment plant (biofouling).	• Will not address residual DNAPL source zones. • Limited mass removal - risk pathway control only. • Will not likely meet Remediation Objectives: ▪ Will not likely 'treat' VCHs to extent practicable. ▪ Will not minimise future liability - residual mass is largely unchanged and long-term operation and maintenance of system is required. • Difficult to incorporate into future development. • Very long time to clean-up (limited by DNAPL dissolution and matric back-diffusion / desorption). • Requires disposal of treated water via trade waste. • Costly over lifecycle.	Moderate-high	**Yes**	No
	Stabilisation	In situ or ex situ stabilisation of contaminated materials via soil mixing. The aim would be to reduce the permeability and/or leachability of the material so that the contaminant flux is reduced.	• Proven technology for low solubility hydrocarbon compounds and metals. • Commercially available. • Various reagents available.	• Limited mass removal - risk pathway control only. • Will not likely meet Remediation Objectives: ▪ Will not likely 'treat' VCHs to extent practicable. ▪ Will not minimise future liability - residual mass is largely unchanged and long-term management of materials is required. • Low to moderate reliability in effectiveness for VCHs. • Requires treatability trials. • Requires disposal of spoil.	Low to moderate	No	No
	Permeable reactive barriers (PRB)	A trench installed perpendicular to the plume downgradient of the source zone (e.g. LDC boundary or 'Coffee Shop' area. The trench would be filled with granular zero valent iron (ZVI) that then causes abiotic degradation of Significant Contaminates to harmless by-products (in a series of processes somewhat similar to EISB) as they flow through. Treatability and additional hydrogeological investigations would be required.	• Moderate reliability / proven technology. • Passive – minimal operational requirements, more sustainable. • Complimentary with EISB.	• Will not address residual DNAPL source zones. • Limited mass removal - risk pathway control only. • Will not likely meet Remediation Objectives: ▪ Will not likely 'treat' VCHs to extent practicable. ▪ Will not minimise future liability - residual mass is largely unchanged and long-term maintenance of system is required, including period replacement and disposal of reactive media. • Difficult to incorporate into future development. • Spoil during PRB installation and spent media requires disposal. • Costly to install.	High	No	No
No Active Remediation	Monitored Natural Attenuation (MNA)	A process of assessing, proving and monitoring natural attenuation processes that control migration and eventual clean-up of a plume and (potentially) source area. Only relevant when there is a stable or decreasing plume and no unacceptable risk from residual contamination.	• Passive and sustainable approach. • Well-developed understanding of contaminant behaviour at the site. • Natural attenuation processes known to occur in the aquifer.	• Not currently effective - will not likely meet Remediation Objectives.	Low	No (except in the case that active remediation was to the extent practicable)	No
	Do nothing	No further active remediation. Ongoing monitoring.	• Low cost and simple	• Will not meet Remediation Objectives.	Very low	No	No

Notes:
1. Adapted from AECOM (Nov 2011) considering Remediation Objectives and current understanding of current land use, current site access and conditions.
2. Relative costs are those for anticipated works in addition to current monitoring, operation and reporting requirements under the Management Order for the period to 2021.

E.2 Remedial Options Assessment – Other Areas / CoPC

As discussed in **Section 4** of the report, the remediation requirements of the Management Order do not directly relate to the suitability of the site for the proposed site development. Additional remediation is necessary (or may become necessary as an outcome of pre-remediation investigations) to make the site suitable for the specific development due to:

- CoC other than VCHs within the Source Site.
- CoC outside the Source Site.

While VCHs associated with the LDC are considered to represent the most significant contamination issue requiring remediation, and the supplementary remedial options to meet Management Order requirements (assessed above in **Section E.1**) may address remediation requirements for some other CoPC (depending on the approach), consideration of additional remediation measures is provided in the following section.

A review of remedial options potentially appropriate to address remediation requirements to address Remediation Objective 2 (site suitability) additional to remediation of the Source Site (see above) is included in **Table E3** and **Table E4** (below).

This review considers the following key factors:

- The remediation drivers (**Appendix D**).
- The nature and extent of contamination (**Section 4** of the report).
- General consideration of:
  - Technical suitability
  - Practicability
  - Cost
  - Certainty
  - Timeframe
  - Approvals/Permitting
  - Sustainability

The review assumes contamination associated with VCHs at the Source Site has been remediated – i.e. the remediation has addressed groundwater or soil vapour impacts migrating from the Source Site onto the adjacent site areas. Additional measures will be required to manage the contamination migration via:

- Design and installation of a containment system to control offsite migration of groundwater or ground gas impacts from the Source Site onto adjacent land on the site.
- Design and construction of the site basement to preclude groundwater and vapour infiltration.
- Ongoing management of open space and roadways to control possible exposure to intrusive maintenance / construction workers.

Table E.3: Remedial Options Ranking – Site Suitability / Additional to VCHs at the Source Site

Option (refer to Table E.2 above)	Technical Suitability (Effectiveness)	Technical Suitability (Practicability)	Cost	Certainty of Outcome	Timeframe	Approvals / Permitting	Sustainability	Overall Score
Relative Weighting	*10*	*10*	*10*	*5*	*5*	*5*	*5*	*50*
In-situ Chemical Oxidation (ISCO)	3	3	4	2	3	3	2	20
In-situ soil vapor extraction (SVE)	3	3	4	2	3	2	2	19
Soil excavation and offsite disposal	10	10	1	5	5	4	1	36
Soil excavation, on-site treatment and reuse	9	8	3	4	5	4	4	37
Physical separation / containment	8	8	7	4	4	4	4	39
Stabilisation	4	6	3	1	3	2	2	21
Monitored Natural Attenuation (MNA)	0							0
Institutional Controls	2	5	5	1	1	5	5	24
Do nothing	0							0

Notes:
Relative scores are between 1 (unfavourable) and 10 (most favourable) for key metrics and 5 (most favourable) for secondary metrics.
The overall score is the summation of each relative score.
Technologies that will not be technically effective (i.e. will not achieve the remedial objective within a reasonable timeframe) on their own have been given a score of zero and not assessed further.

Table E.4: Review of remediation technologies – Site Suitability / Additional to VCHs at the Source Site

Remediation Type	Technology	Method Description	Advantages	Disadvantages	Relative Cost	Retained?
Chemical Treatment	*In-situ* Chemical Oxidation (ISCO) or *Ex Situ* Chemical Oxidation (ESCO)	Ad or inject a chemical oxidant into subsurface or excavated material for oxidation/destruction of contaminants in soil and groundwater. This could be applicable to hotspots of organic COPC (if identified as part of pre-remediation assessments). Potential oxidants include permanganate, hydrogen peroxide (catalysed or not), persulfate, ozone. Peroxide and ozone have shorter lifetimes in, whereas persulfate and permanganate are more sustaining oxidants. Treatability trials may be required to assess the most effective oxidant and potential for secondary impacts.	• Proven technology • Effective at treating dissolved phase. • Commercially available products and vendors. • Applicable to VCHs and petroleum hydrocarbons.	• Unlikely to practicably address gross contamination. • Not suitable for metals, heavy-end petroleum or PAH compounds. • Requires substantial chemical use. • Potential for secondary water quality issues. • Need treatability trials. • Significant planning and approvals effort.	Moderate to High	No
Physical Removal	Soil vapor extraction (SVE) – *in situ* or *ex situ* within stockpiled materials	SVE comprises vacuum extraction of soil gas from the vadose zone or stockpile, with *ex-situ* treatment. SVE may be applicable to hotspots of volatile organic COPC (e.g. BTEXN) is identified as part of pre-remediation assessments in areas inaccessible to other more direct methods or if diffuse and widespread impacts in eth vadose zone are found. While the formation is anticipated to be suitable for SVE, a short field trial would be required to assess radius of influence, formation response and vapour quality/mass recovery. There may be planning and approvals requirements.	• Will address main risk exposure pathways (vapour intrusion). • Applicable to VCHs and other volatile COPC. • Existing surface seal present.	• Limited to volatile COPC (e.g. VCH, BTEXN) • Limited to vadose zone. • May be incomplete surface seal (i.e. end up 'treating' ambient air). • Field trial required.	Low-moderate	**Yes –** but only as a contingency measure if diffuse and widespread impacts in the vadose zone are identified as part of pre-remediation assessments OR to treat excavated materials impacted by volatile COPCs to lower waste classification or for site re-use.
	Soil excavation and offsite disposal	Remove contaminated material via excavation with offsite disposal at a licenced facility. Would most likely target fill materials. Excavation using standard equipment. Excavation would require shoring for geotechnical purposes and integrity of adjacent structures / infrastructure, and dewatering for deeper excavations. Odour/vapour and dust emissions control may be required. Requires delineation of contamination.	• Simple and easily verifiable approach with high reliability / certain outcome – effectiveness is directly related to delineation and access to contaminated material. • Shallow and mostly sandy nature of fill/soils is favourable for excavation. • Minimal ongoing monitoring required. • Relatively rapid. • Commercially available and local equipment/ vendors.	• Deeper excavations (if required) will require control of groundwater / dewatering and excavation retention. • Significant offsite disposal costs and materials transport. • Odorous COPCs (if present) may require an emission control structure. • Will require staging areas – may be difficult at the site. • Would require imported material to reinstate excavation (unless tied into redevelopment). • Will require further investigation / delineation of contamination extents.	High (but would be lower if combined with redevelopment)	**Yes**
	Soil excavation, on-site treatment and reuse	As above but excavated materials are treated onsite and reused to backfill the excavation. Effectiveness also is dependent on treatment efficacy and reliability. Onsite treatment may include physical screening, SVE (as described above) or stabilisation (as described below). 'Treatment', as defined under EP&A Act can also include encapsulation or containment – however, this is included below under ''containment''.	• As above for excavation and offsite disposal. • Minimises import/export of materials for reinstatement. • Minimises waste generation / disposal costs.	• As above for excavation and offsite disposal, but minimises offsite disposal costs and material import/export. • Not applicable to asbestos and many recalcitrant chemical compounds. • May require treatment trial. • Additional effort in planning/approvals for soil treatment – may extent timeframe.	High	**Yes**
Containment / Mobility Reduction	Physical separation / containment	Install a physical barrier to isolate contaminated materials from future site users/workers or root zones of future vegetation in the park and planted areas. Various configurations could be used but would generally comprise a cover layer and marker layer. This could also comprise a vapour barrier and basement design to preclude vapour intrusion and groundwater seepage (as discussed above for VCHs).	• Proven technology. • Minimal ongoing operation/monitoring required. • Can be incorporated into re-development.	• Does not remove liability - risk pathway control only. • May require long-term management under an EMP. • Vapour barriers are more complex systems requiring long-term maintenance.	Moderate	**Yes**
	Stabilisation	In-situ or ex-situ stabilisation of contaminated materials via soil mixing. The aim would be to: • Reduce the permeability and/or leachability of COPC in the material. Treated materials would then be retained at the site. • Meet requirements for offsite disposal under a General Immobilisation Approval. Most likely applicable to materials containing high concentrations of metals or non-volatile organic COPC, if identified during pre-remediation assessments.	• Proven technology for low solubility hydrocarbon compounds and metals. • Commercially available. • Various reagents available.	• Limited mass removal - risk pathway control only. • Will not likely meet Remediation Objectives: ○ Will not minimise future liability - residual mass is largely unchanged and long-term management of materials is required. • Low to moderate reliability in effectiveness for volatile COPCs. • Requires treatability trials.	Low to moderate	No Retained as a contingency measure only

Remediation Type	Technology	Method Description	Advantages	Disadvantages	Relative Cost	Retained?
No Active Remediation	Monitored Natural Attenuation (MNA)	A process of assessing, proving and monitoring natural attenuation processes that control migration and eventual clean-up of a plume and (potentially) source area. Only relevant when there is a stable or decreasing plume and no unacceptable health risk from residual contamination – i.e. focussed on mitigation of off-site migration.	• Passive and sustainable approach. • Well-developed understanding of contaminant behaviour at the site. • Natural attenuation processes known to occur in the aquifer.	• Not currently effective - will not likely meet Remediation Objectives.	Low	No - however, MNA may be appropriate as a contingency action to address residual impacts in deeper groundwater
	Institutional Controls	Management of residual contamination via implementation of a long-term EMP. Requires notification and a legally enforceable mechanism.	• Mechanism to manage residual contamination that cannot practicably be remediated.	• Residual liability present	Low	**Yes –** for residual contamination that cannot practicably be remediated (if any)
	Do nothing	No further active remediation. Ongoing monitoring.	• Low cost and simple	• Will not meet Remediation Objectives.	Very low	No

Appendix F: Management Order

Notes: On 7 July 2017, the Environment Protection Authority issued notice No.20174410 to amend this Management Order.

On 9 February 2016, the Environment Protection Authority issued notice No. 20154444 to amend this Management Order.

On 27 February 2015, the Environment Protection Authority issued notice No. 20154405 to amend this Management Order.

On 28 August 2014, the Environment Protection Authority issued notice No. 20144422 to amend this Management Order.

Management Order 20101404 was revoked and replaced by the following Management Order (No. 20111403) by the NSW Land and Environment Court on 26 May 2011 in proceedings 10/10446.

MANAGEMENT ORDER

Section 14 of the Contaminated Land Management Act 1997

Date of this order: 26 May 2011

PERSONS SUBJECT TO THIS ORDER

Jeffman Pty Ltd (ACN 000 121 291)

Lawrence Dry Cleaners Pty Ltd (ACN 002 408 040)

LAND TO WHICH THIS ORDER APPLIES

This order applies to the significantly contaminated land in declaration number 21084 made on 2 November 2005 by the Environment Protection Authority of NSW ("EPA"), comprising:

Description	Address
Lots A and B in DP 438772 and Lot 1 in DP 89250	887-893 Bourke Street, Waterloo
Lot 1 in DP 88482	895-899 Bourke Street, Waterloo
Lot B in DP 88095	901 Bourke Street, Waterloo
Parts of Lot 3 in DP 775039	Parts of 207-229 Young Street, Waterloo
Parts of Lot 2 in DP 800705	Parts on 903-921 Bourke Street, Waterloo

NATURE OF CONTAMINATION AND RISK OF HARM AFFECTING THE LAND

The substances causing the contamination (the "Significant Contaminants") are:

Chlorinated hydrocarbons, including tetrachloroethene (PCE), trichloroethene (TCE), dichloroethene (DCE), and vinyl chloride (VC).

The Significant Contaminants are Dense Non-Aqueous Phase Liquids ("DNAPL").

The Significant Contaminants are classified as:

1.VC is classified by the International Agency for Research on Cancer (IARC) as a Group 1 human carcinogen (known human carcinogen);

2.TCE and PCE are classified by IARC as Group 2A (probably human carcinogen); and

3.DCE is classified by IARC as Group 3 (not classifiable as to its carcinogenicity to humans).

The EPA believes that the land is contaminated and that the contamination is significant enough to warrant regulation, for the following reasons:

1.Groundwater beneath the land is contaminated with the Significant Contaminants at concentrations substantially exceeding relevant levels in the ANZECC Guidelines for Fresh and Marine Water Quality. VC concentrations substantially exceed the Drinking Water Guideline value.

2.Contaminated groundwater has migrated from the southwestern (down-gradient) boundary of the site at 887-893 Bourke Street, Waterloo, and impacted on the adjoining sites. The contaminated groundwater plume may continue to spread.

3.The offsite migration of contaminated groundwater may put potential future users of groundwater at risk.

No current users of groundwater have been identified. NB. The contaminant plume is within an area of restricted groundwater use (see www.dnr.nsw.gov.au/water/pdf/zone2.pdf).

DEFINITIONS

"Affected Landholders" means the registered owners of Lot 2 in DP 800705 located at 903-921 Bourke Street, Waterloo, Lot B in DP 88095 at 901 Bourke Street, Waterloo, Lot 3 in DP 775039 at 207-229 Young Street, Waterloo and Lot 1 in DP 88482 at 895-899 Bourke Street, Waterloo.

"Management Order" is this Management Order.

"Remediation Site" means the properties as shown on the attached map comprising Lots A and B in DP 438772, Lot 1 in DP 89250, parts of Lot 3 in DP 775039, Lot 2 in DP 800705, Lot 1 in DP 88482 and Lot B in DP 88095.

"Source Site" means Lots A and B in DP 438772, Lot 1 in DP 89250.

ACTION REQUIRED BY THIS ORDER

The persons subject to this order must take the actions specified by the times specified in the orders below.

A. INVESTIGATIONS

1. Investigate source of contamination

(a) Investigate and determine the existence, nature, location and extent of the Significant Contaminants, including the DNAPL source.

(b) Provide a written report to the EPA and Affected Landholders within 4 months of the date of the Management Order, setting out the results of that investigation.

2. Investigate whether any ongoing contamination

(a) Investigate whether Significant Contaminants are still being released, spilled or otherwise being allowed to escape into the soil and groundwater from the continued operation of the dry cleaning business on the Source Site.

(b) Provide a written report to the EPA and Affected Landholders within 4 months of the date of the Management Order, setting out the results of the investigation and describing in detail the measures to be taken to prevent any ongoing release, spill or escape of the Significant Contaminants into the soil and groundwater.

(c) Implement the preventative measures proposed in the report as soon as practicable after completion of the investigation required by this order.

3. Investigate deep groundwater contamination

(a) Investigate the nature and extent of the deeper groundwater contamination beneath the Source Site, parts of Lot 3 in DP 775039 and Lot 2 in DP 800705, Lot 1 in DP 88482 and Lot B in 88095 to determine whether any significant risk is posed to human health or the environment.

(b) Provide a written report to the EPA and Affected Landholders within 6 months of the date of the Management Order setting out the results of the investigation.

4. Investigate possible contamination of backfill next to Shea's Creek culvert

(a) Install a minimum of five groundwater monitoring wells in the backfill next to Shea's Creek culvert down to the base level of the culvert, take samples from the wells, and analyse the samples to assess the possibility of the migration of the Significant Contaminants in groundwater through the backfill along the side of the culvert.

(b) Provide a written report to the EPA and the Affected Landholders within 1 month of the date of the Management Order confirming completion of the installation and sampling and reporting on the results of the sampling and analysis.

5. Investigate potential effects of remedial works on buildings

(a) If and when any remediation design works propose excavation works or the utilisation of thermal treatment technology or demolition or the drilling of holes through any concrete slab on, under or adjacent to the building located on Lot B in DP 88095 ("Proposed Works"), promptly engage a suitably qualified and experienced structural engineer to assess the potential for the Proposed Works to affect the structural integrity of the building and provide a report to the EPA and all Affected Landholders of that assessment. The report is to include the recommendations of the structural engineer as to what measures, if any, should be implemented to ensure that the carrying out of the Proposed Works does not compromise the structural integrity of the building.

(b) Implement the recommendations of the structural engineer prior to carrying out any of the Proposed Works, but first obtain the consent of each Affected Landholder on whose land it is proposed that any measures recommended by the structural engineer are to be implemented.

B. MONITORING

6. Monitoring Shea's Creek

(a) Monitor quarterly the concentrations of the Significant Contaminants in Shea's Creek culvert and ensure that contaminated water and vapours are not discharging into Shea's Creek at concentrations that could cause harm to human health or the environment.

(b) Provide a written report to the EPA and Affected Landholders setting out the results of the quarterly monitoring on a quarterly basis beginning 3 months from the date of the Management Order.

7. Monitoring risk to human health in Shea's Creek culvert

Undertake vapour monitoring of the airspace in the Shea's Creek culvert prior to any person having access to the culvert to ensure that there is no unacceptable risk to human health.

8. Monitoring at particular groundwater wells

(a) Install groundwater wells at the western end of Lot 1 in DP 88482 and Lot B in DP 88095, take samples from the wells, and analyse the samples to assess the concentration of Significant Contaminants.

(b) Provide a written report to the EPA and Affected Landholders within 1 month of the date of the Management Order confirming completion of the installation, sampling and analysis and reporting on the results of the sampling and analysis.

9. Monitoring the spread of the groundwater plume

(a) Assess and monitor the potential spreading of the groundwater plume on and outside the Remediation Site onto as yet unaffected lands.

(b) Provide a written report to the EPA and Affected Landholders on the monitoring results on a quarterly basis beginning 3 months from the date of the Management Order.

10. Monitoring the spread of vapour phase contaminants

(a) Assess and monitor the potential spreading of the vapour phase contaminants on and outside the Remediation Site onto as yet unaffected lands.

(b) Provide a written report to the EPA and Affected Landholders on the monitoring results on a quarterly basis beginning 3 months from the date of the Management Order.

11. Vapour monitoring in buildings in Remediation Site

(a) (i) Monitor vapour levels of all Significant Contaminants in all buildings located on the Remediation Site every quarter using static and personal monitoring methods to ensure protection of human health in accordance with *Environment Health Risk Assessment - Guidelines for Assessing Human Health Risks from Environmental Hazards: June 2004* (enHealth 2004) and evaluation against Australian air quality guidelines or, if unavailable, WHO air quality guidelines;

(ii) undertake pre-sampling surveys prior to monitoring to ensure:

confounding from other sources does not occur;

worst case exposure conditions are evaluated; and

(iii) undertake concurrent soil vapour and sub-slab monitoring within the building footprints to understand the contribution to indoor air from sub-surface vapours as opposed to ambient air sources.

(b) Provide written reports to the EPA and Affected Landholders on the results of all such monitoring on a quarterly basis beginning 3 months from the date of the Management Order with a further copy being provided to the expert panel referred to in Order 18 below.

12. Management consequential upon vapour monitoring

(a) If levels of Significant Contaminants are identified in buildings from the quarterly monitoring referred to in Order 11 exceeding target acceptable criteria developed in accordance with enHealth 2004 and WHO air quality guidelines, implement appropriate management measures as soon as reasonably practicable to ensure the health and safety of the occupants and any visitors.

(b) If such management measures are required and implemented, notify the EPA in writing.

13. Monitor ecological and human health risks

(a) Ensure that all ecological risks and risks to human health including risks from inhalation that may arise from exposure to DNAPLs and the Significant Contaminants are assessed using a site-specific risk-based approach consistent with *Schedule B(5) - Guideline on Ecological Risk Assessment* of the *National Environment Protection (Assessment of Site Contamination) Measure 1999* (NEPM 1999), the *Environmental Health Risk Assessment - Guidelines for Assessing Human Health Risks from Environmental Hazards: June 2004* (enHealth 2004), the *National Environment Protection (Assessment of Site Contamination) Measure 1999* (NEPM 1999) and the *Vapour Intrusion* : *Technical Practice Note* , September 2010 (DECCW 2010), in each case as amended or replaced from time to time, that includes, as a minimum, a process of data consolidation, gap analysis, data acquisition (soil gas profiling, sub-slab analyses, and ambient and indoor air sampling), site-specific predictive modelling, analysis of variable sensitivity, pre-sampling surveys and above-ground concurrent air sampling and assessment against toxicity reference doses as approved by relevant Australian government agencies and, if appropriate, relevant international agencies.

(b) Where an unacceptable risk has been identified to the environment or to human health, implement as soon as reasonably practicable measures to ensure any risk is prevented or minimised.

C. REMEDIATION ACTIONS

14. Containment on Source Site

Reduce and maintain the combined maximum concentrations of the Significant Contaminants in groundwater migrating from the Source Site to any adjoining land to 0.5 mg/L or less within 14 months of the date of the Management Order.

15. Treatment of Significant Contaminants on Source Site

Implement one or more remediation technologies to treat to the maximum extent practicable DNAPL source zones and/or high concentrations of sorbed phase Significant Contaminants, on the Source Site, within 10 years of the date of the Management Order.

16. Interim treatment of groundwater plume

Implement one or more remediation technologies to reduce the combined maximum concentration of Significant Contaminants in groundwater, other than at the Source Site, to less than 5 mg/L within 2 years of the date of the Management Order.

17. Final treatment of groundwater plume

Implement one or more remediation technologies to reduce the combined maximum concentration of the Significant Contaminants in the groundwater, other than at the Source Site, to 0.5 mg/L or less within 5 years of the date of the Management Order and thereafter to maintain the combined maximum concentration of Significant Contaminants at or below that level.

D. APPROVAL AND IMPLEMENTATION OF REMEDIATION ACTION PLAN

18. Review by independent expert panel of draft Remediation Action Plan

(a) Within 6 weeks of the date of the Management Order, appoint an expert panel of at least 3 independent remediation experts approved by the EPA and Affected Landholders acting

reasonably to review and certify that the detailed remediation design and programme is suitable and appropriate for the purpose of achieving Orders 1 - 17 above.

(b) Within 10 weeks of the date of the Management Order, lodge a draft remediation action plan with the expert panel.

(c) Within 12 weeks of the date of the Management Order, obtain the written review and recommendations of the expert panel.

(d) Within 6 months of the date of the Management Order, implement any recommendations of the expert panel through revisions to the draft remediation action plan including to the detailed remediation design and programme.

19. Approval of Remediation Action Plan

Prepare, and submit to the EPA within 6 months of the date of the Management Order, and provide to all Affected Landholders, a remediation action plan with a detailed outline of the works which you propose to implement, or have implemented, to achieve Orders 1 - 17 above. The plan must:

(a) Specify the reports which will be developed and propose dates for submission of these reports to the EPA.

(b) Contain a detailed design plan including supporting information such as numerical modelling results for the implementation of EISB (and other complementary "hot spot" treatment technologies, including pump and treat, excavation and thermal, as selected by the applicants) on the Remediation Site (having regard to Exhibit J2 and J3 in Land and Environment Court Proceedings 10446/10 attached to these Orders) to allow compliance with the above Orders 1 - 17.

(c) Specify a timeline, interim triggers and thresholds by which progress towards achieving compliance with the targets and environmental goals in Orders 1 - 17 are measured by you and reported in writing to the EPA, on a regular basis for 20 months from the date of this Management Order.

(d) Specify and describe workable, realistic and costed alternative remediation measures for the application of other remediation techniques (which may include pump and treat, excavation and thermal amongst other commercially available techniques) for reaching the targets and environmental goals in the Management Order, on and after two years from the date of the Management Order, which are to apply in the event that you have not demonstrated to the EPA's satisfaction, by 22 months after the date of the Management Order, that your preferred technique, EISB, has made substantial progress towards achieving compliance with all targets in Directions 1 - 17 above by 22 months after the date of the Management Order.

(e) Adopt an adaptive management strategy to the achievement of Orders 1 - 17 which may include, for example, proposed methods for "hot spot" treatment in the context of ongoing EISB treatment that will allow the targets in Orders 1 - 17 to be achieved.

(f) Be approved by and in accordance with the further recommendations of the independent expert panel referred to in Order 18 above.

20. Implement approved Remediation Action Plan

Upon approval by the EPA of the remediation action plan, implement the approved remediation action plan.

21. Carry out orders consistent with EPA Guidelines

Carry out the orders in the Management Order consistent with any relevant guidelines made or approved by the EPA under s 105 of the *Contaminated Land Management Act* 1997. In the event

of any inconsistency between the guidelines and the Management Order, the Management Order shall prevail.

22. Obtaining consent of Affected Landholders to access their land

Consult with the Affected Landholders to seek consent to enter onto, and carry out any actions required by the Management Order on the land they own and consider their reasonable requests in relation to access, including, without limitation, reasonable requests regarding:

(a) indemnification for any loss or damage that may be suffered by the Affected Landholders, including for economic loss caused by interference with the business activities carried on by the Affected Landholders; and

(b) making good the land of the Affected Landholders on conclusion of the implementation of the actions required by the Management Order.

E. ACCESS TO INFORMATION

23. Public access to information on remediation actions

(a) Make available for inspection by any person, free of charge, any report on the action taken under the management order, and provide a copy of such a report to any person for a reasonable fee.

(b) Make available for inspection by any person, free of charge:

(i) all reports disclosing the results of the investigations required to be conducted pursuant to any of the Orders 1 - 17 above;

(ii) all reports disclosing the results of monitoring under any of the Orders 1 - 17 above, at least once every three months;

(iii) all documents disclosing the recommendations of the expert panel referred to in Order 18 above;

(iv) documents disclosing the remediation action plan referred to in Order 19 above; and

(c) provide a copy of any such report or document to any person for a reasonable fee.

24. Provide correspondence to Affected Landholders

(a) Provide all the Affected Landholders with copies of any correspondence exchanged between you and the EPA (or any site auditor or expert panel) at any time and at least once every 3 months during implementation of the remediation action plan report to the EPA and the Affected Landholders in writing on:

(i) the effectiveness of any remediation technologies in treating the Significant Contaminants;

(ii) whether any barrier between the Source Site and the other affected properties is effective of should be replaced by more effective containment works; and

(iii) the practicability of any medication or replacement.

(b) Comply with all reasonable requests by any Affected Landholder for copies of documents or raw data obtained through the investigations required by the Management Order.

25. Invite Affected Landholders to meetings

Invite all the Affected Landholders to participate in any meetings between you and the EPA or the site auditor or expert panel.

DOC16/275925

Mr Jason Clay
Senior Principal
Senversa Pty Ltd
Level 14, 309 Kent Street
SYDNEY NSW 2000

Dear Mr Clay,

Management Order No. 20111403 issued by the NSW Land and Environment Court
Lawrence Dry Cleaners Site, Waterloo

I refer to your letter dated 20 May 2016 in relation to Management Order No. 20111403 dated 26 May 2011, issued for the Lawrence Dry Cleaners site, Waterloo and adjacent properties.

Your letter makes reference to remediation action #17 of the Management Order, which requires the combined maximum concentration of the significant contaminants in the groundwater, other than the source site, to be less than 0.5 mg/L.

While a concentration of 25.5 mg/L is reported in MW201, the Environment Protection Authority (EPA) notes that two rounds of sampling undertaken in replacement well MW201A since April 2016 reported groundwater contaminant concentrations within the target criterion (i.e. below 0.5 mg/L). The EPA considers that the well construction in MW201A is more likely to be continuous with the aquifer and therefore more representative than MW201.

Based on a weight of evidence approach with due consideration of all relevant data and information reported to the EPA to date, the EPA considers that remedial action #17 of the Management Order has been achieved.

If you have any queries in relation to the above, please contact Ulli Manuel on 9995 5611 or via e-mail on Ulli.Manuel@epa.nsw.gov.au.

Yours sincerely

3 NOVEMBER 2016

ARMINDA RYAN
A/Director Contaminated Land Management
Environment Protection Authority

CC: Jeff Eisman
Sarah Mansfield, Elizabeth Wild, Tom White - Henry Davis York
Mr Levy Lu - Dahua Group
Adriana Malin – TSA Management
Steven De Pasquale - City West Housing
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