AMPOL AUSTRALIA PETROLEUM PTY LTD

MAY 2021

REMEDIATION ACTION PLAN (RAP)

CALTEX HOLT SERVICE STATION (SITE ID: 22546), 1 HARDWICK CRESCENT HOLT ACT

Remediation Action Plan (RAP)
Caltex Holt service station (Site ID: 22546), 1 Hardwick Crescent Holt ACT

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2	7 December 2020	Draft – Incorporation of Auditor comments
3	9 December 2020	Final – Incorporation of Additional Auditor comments
4	6 April 2021	Revised Final – Incorporation of Auditor comments following EPA Review
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ABBREVIATIONS

ACT	Australian Capital Territory
BTEX	Benzene, toluene, ethyl benzene, xylene
°C	Degrees Celsius
C6–C10	Light hydrocarbon chain groups (for example, petrol)
C10–C16	Medium hydrocarbon chain groups (for example, kerosene)
C16–C34	Heavy hydrocarbon chain groups (for example, diesel)
C34–C40	Heavy hydrocarbon chain groups (for example, lube oil)
CSM	Conceptual site model
EA	Environmental authorisation
EPA	Environment Protection Authority
ESA	Environmental Site Assessment
GAC	Granulated activated carbon
GME	Groundwater monitoring event
Hr	Hour
IBC	Intermediate bulk container
HSL	Health screening level
ISCO	In Situ Chemical Oxidation
K	Hydraulic Conductivity
kg	Kilogram
kg/hr	Kilograms per hour
kPa	Kilopascal
L	Litre
LCSM	LNAPL conceptual site model
LNAPL	Light non-aqueous phase liquid
LOR	Limit of reporting
LPG	Liquid Petroleum Gas
L/s	Litres per Second
L/min	Litres per minute
mAHD	Metres Australian Height Datum
mBGL	Metres below ground level
mBTOC	Metres below top of casing
mg/L	Milligrams per Litre
min	Minute
m	Metres
mm	Millimetre
mV	Millivolt
m^3/h	Metres cubed per hour
mg/m^3	Milligrams per metres cubed

$Na_2S_2O_8$	Sodium persulfate
NATA	National Association of Testing Authorities
NSW	New South Wales
Pa	Pascal
PAH	Polycyclic aromatic hydrocarbon
pH	Potential of hydrogen
PID	Photo-ionisation detector
ppm	Parts per million
ppm_v	Parts per million by volume
PULP	Premium unleaded petrol
PVC	Polyvinyl chloride
ROI	Radius of influence
SAC	Site Assessment Criteria
SOP	Standard operating procedure
SWL	Standing water level
SVE	Soil Vapour Extraction
TDS	Total Dissolved Solids
TPH	Total petroleum hydrocarbons
TRH	Total recoverable hydrocarbons
µg/L	Micrograms per litre
µS/cm	Millisiemens per centimetre
UPSS	Underground petroleum storage system
UST	Underground storage tank
VOC	Volatile organic compounds
WSP	WSP Australia Pty Limited

EXECUTIVE SUMMARY

Ampol Australia Petroleum Pty Ltd (Ampol) (previously Caltex Australia Petroleum Pty Ltd) engaged WSP Australia Pty Limited (WSP) to prepare a Remediation Action Plan (RAP) for the Caltex Holt service station, located at 1 Hardwick Crescent, Holt, Australian Capital Territory (ACT) (the site).

During February 2020, in response to a suspected loss of fuel at the site, Ampol engaged WSP to assist in the spill response investigations and works to mitigate the loss of product at the service station. Following the information gained from the initial spill response works, subsequent detailed intrusive site assessment and an onsite remediation pilot trial, WSP has compiled this RAP for the site.

The RAP was required as part of the staged remediation program in response to a reported loss of fuel at the service station. The overall objectives of the RAP include the following:

- Review and assess the suitability of clean up options to manage and mitigate the identified hydrocarbon impacts at the site;
- Ensure the effectiveness of the clean up options is clear and based on all available data;
- Provide Ampol with practical clean up options that offer value and assist in moving the site (and affected sites) towards project closure in a timely fashion; and
- Provide Ampol with recommended additional measures which will assist with refining the final remedial strategy.

Based on the works completed to date, there are no unacceptable risks to receptors based on the current on-site and off-site land uses.

While the risks to receptors are low and acceptable, light non-aqueous phase liquid (LNAPL) at a thickness of more than 3mm has been identified at site and in the immediate off site areas during all gauging events since February 2020, and thus in accordance with ACT *Contaminated Sites Information Sheet 9: Management of groundwater impacted by light non-aqueous phase liquids (LNAPL)* (dated April 2019) (Information Sheet 9) ongoing management of the LNAPL and the associated dissolved phase plume is required.

Therefore, given the absence of unacceptable risks to receptors, and taking the regulatory guidance from Information Sheet 9 into consideration, the clean up goals for the site are to:

- Remove all observable LNAPL contamination[1] from the groundwater on and off the site such that the LNAPL thicknesses are <3mm for at least three consecutive months; and
- Reduce the dissolved phase hydrocarbons to the maximum extent practicable, ensuring that there remains no unacceptable risk to human health and the environment and the beneficial uses of the groundwater; and
- Ensure that the LNAPL and dissolved phase plumes are not spreading.

While Information Sheet 9 acknowledges that the level of clean up will be guided by risks, and the nature of the LNAPL and / or dissolved phase plumes (e.g. expanding, stable or contracting), there is no guidance on when clean up has been conducted to the "*extent practicable*" (or similar). In lieu of such guidance in the ACT, it is proposed that the Environment Protection Authority Victoria (EPA Victoria) Publication 840.2 "*The Clean Up and Management of*

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[1] The ACT EPA in their published guidance: *Information Sheet 9 – Management of light non-aqueous phase liquids (LNAPL)* (Information Sheet 9) defines LNAPL as hydrocarbons that exist as a separate, immiscible phase when in contact with water, that has a density less than that of water. For the purpose of practicality and application to site assessments, the ACT EPA broadens the definition to be: "*a liquid with low solubility in water that is in sufficient quantity to form a discrete layer or separate phase*". A discrete layer in this context is defined by Information Sheet 9 as being "*a thickness of NAPL of 3mm or greater as measured by an interface probe*".

Polluted Groundwaters" (April 2016) (Publication 840.2) is used as the basis for determining the practicable limit of groundwater clean up. This document recognises the impracticability in some cases of full clean up, to the point where groundwater contamination no longer compromises any potential beneficial uses. In this case, the option is available for clean up to be carried out (to the extent practicable), and for this to be demonstrated to EPA Victoria in a formal submission (which in this case would be ACT EPA via the Site Auditor).

Only where the Site Auditor and ACT EPA agrees that clean up has been conducted to the extent practicable, will it be acceptable for further clean up efforts to be ceased. Cessation of clean up works under a '*clean up to the extent practicable*' (CUTEP) scenario would then be subject to ongoing groundwater management (via a long term management plan), including any measures required to ensure the risks remain low and acceptable, monitoring (i.e. a Monitored Natural Attenuation (MNA) Strategy, as per Information Sheet 9), and contingency measures should conditions worsen. It is also subject to periodic EPA review that may determine that clean up efforts need to be revisited.

A desktop assessment review of the options for the clean up of the gross impacts sourced from the site to meet these objectives was completed. Based on the advantages and limitations of all the available options, the potential clean up options assessment determined that soil vapour extraction (SVE), SVE + Pumping, multi-phase vacuum extraction (MPVE) and in-situ chemical oxidation (ISCO) were potentially suitable clean up options for the site.

A remediation pilot trial investigating the effectiveness of each of these clean up options was undertaken at the site in September 2020. The pilot trial results for the various clean up approaches indicate that the extraction and injection approaches trialled would be effective in reducing hydrocarbon mass.

Based on the outcomes of the pilot trials, the extent of impacts, the logistics of installation, SVE + Pumping (in-situ system) was selected as the most appropriate clean up method to address the bulk LNAPL/hydrocarbon contamination in the on-site areas and a series of MPVE events was selected as the most appropriate clean up method to address the bulk LNAPL/hydrocarbon contamination in the off site areas.

A suitable location for the installation of an on-site clean up system is identified in the north-western portion of the site, where the current groundwater/LNAPL collection tank is located. The absence of residential properties immediately adjacent to the clean up system should minimise potential issues related to the operation of an on-site clean up system at the site (e.g. noise). Similarly, the off-site MPVE events will only be conducted during working hours (i.e. Monday to Friday, 7:00am to 6:00pm).

A monitoring plan is outlined for the proposed active clean up works and includes monthly well gauging and quarterly groundwater sampling from selected wells, and a bi-annual (6-monthly) groundwater sampling campaign covering all groundwater wells, on and off the site.

Following validation that the clean up has achieved the clean up goals (in agreeance with the Site Auditor and ACT EPA), a post-clean up Management Plan will be implemented (if required) to monitor and manage residual contamination (if any). The management plan (if required) will be prepared and implemented in accordance with ACT EPA Information Sheet 9 and ACT EPA "*Environmental guidelines for preparation of an Environment Management Plan*".

This executive summary must be read in conjunction with the report proper, including all tables, figures and appendices. The findings of this report should be read in the context of the statement of limitations outlined the end of this report.

1 INTRODUCTION

Ampol Australia Petroleum Pty Ltd (Ampol) (formally Caltex Australia Petroleum Pty Ltd (Caltex)) engaged WSP Australia Pty Limited (WSP) to prepare a Remediation Action Plan (RAP) for the Caltex Holt service station, 1 Hardwick Crescent, Holt, Australian Capital Territory (ACT) (Site ID: 22546). The site regional location setting plan and site layout plan is presented in Figures 1 and 2, of Appendix A, respectively.

1.1 BACKGROUND

During February 2020, in response to a suspected loss of fuel at the site, Ampol engaged WSP to assist in the spill response investigations and works to mitigate the loss of product at the service station. Following the information gained from the initial spill response works, subsequent detailed intrusive site assessment and an onsite remediation pilot trial, WSP has compiled this RAP for the site.

1.2 STATUTORY REGULATION OF THE SITE

Following the formal notification of the product loss to the ACT EPA, on 3 March 2020 the EPA issued Environmental Protection Order (EPO) No: 50048. Amongst other actions relating to the management and mitigation of the suspected fuel loss, the order required Caltex to *"undertake an assessment of the risk to human health of the occupants and visitors of the site to demonstrate that the site is suitable to continue operating"*. This assessment was conducted during mid to late March 2020 and a report was produced by WSP and was submitted to the EPA (Ref: PS118985-CLM-AVIR-8115 Rev2, dated 31 March 2020) (WSP March 2020a).

In addition to the EPO, the EPA issued a notification requiring Caltex to commission an environmental audit of contaminated land for the site (letter file ref: 10/3998, dated 13 March 2020). A NSW EPA and ACT EPA approved contaminated land site auditor was engaged by Ampol for the purpose of the audit. The audit is to address the following key requirements:

1. Determine the nature and extent of contamination both on and off-site from the identified release of petroleum product at the site;
2. Determine the appropriateness of all investigations and remedial actions undertaken to date and the appropriateness of any proposed assessment and management strategies for the site;
3. Provide commentary on the consultant's findings, past current and future, with respect to the level of risk the contamination posed to both on and off-site receptors;
4. Provide a conclusion as to the suitability of all impacted areas (both on and off-site) for their current permitted uses under the ACT Territory Plan from a contamination perspective; and
5. Be undertaken and submitted in accordance with the requirements of the Authority's Contaminated Sites Environment Protection Policy 2017 and the Authority's endorsed guidance.

1.3 OBJECTIVES

The objectives of the RAP include:

- Review and assess the suitability of options to manage and mitigate the identified hydrocarbon impacts at the site;
- Ensure the effectiveness of the remedial options is clear and based on all available data;
- Provide Ampol with remedial options that offer value and assist in moving the site (and affected sites) towards end point classification in a timely fashion; and

- Provide Ampol with recommended additional measures which will assist with refining the final remedial strategy.

1.4 SCOPE OF WORK

The RAP will consist of the following:

- Outline clean up goals for the site;
- Summarise the results of the remediation trial;
- Summarise the remediation option assessment;
- Outline the proposed clean up system design; and
- Outline the validation plan.

1.5 TECHNICAL FRAMEWORK

The environmental and contaminated land management works at the site are to be conducted in general accordance with the relevant statutory legislations, guidelines and standards as detailed in the following documents:

- ACT EPA 2017, *Contaminated Sites Environment Protection Policy;*
- ACT EPA 2019, *Environmental Guidelines for Petroleum Storage in the ACT;*
- Environment ACT 2000, *ACT's Environmental Standards: Assessment & Classification of Liquid & Non-liquid Wastes;*
- *Environmental Protection Act 1997;*
- *Environmental Protection Regulation 2005;*
- *National Environment Protection (Assessment of Site Contamination) Measure 1999* (NEPM; as amended 2013);
- NSW EPA 2014, *Technical Note: Investigation of Service Station Sites*;
- NSW EPA 2020, *Assessment and Management of Hazardous Ground Gases: Contaminated Land Guidelines;*
- NSW EPA 2020, *Guidelines for Consultants Reporting on Contaminated Land: Contaminated Land Guidelines; and*
- Work Health and Safety Act (2011).

Further to the above, ACT Government provides a number of information sheets which outline some additional considerations relevant to the site. These include:

- ACT EPA 2019, Information Sheet 8 – *Requirements for the Classification and Reuse of Drilling Mud Waste in the ACT;*
- ACT EPA 2019, Information Sheet 9 – *Management of groundwater impacted by light non-aqueous phase liquids (LNAPL); and*
- ACT EPA 2020, Information Sheet 11 – *Environment Protection Authority Report Submission Requirements.*

2 SITE INFORMATION

2.1 SITE IDENTIFICATION

The site is located within a mixed commercial and residential area in Holt, ACT. Figure 1 shows the regional site location and setting. General site details are summarised below in Table 2.1. The site layout is shown in Figure 2 of Appendix A.

Table 2.1 Summary of general information

SITE NAME	CALTEX KIPPAX HOLT SERVICE STATION
Site address	1 Hardwick Crescent, Holt ACT 2615
Ampol site identification	22546
Legal identification	Block 1, Section 53, Holt, Belconnen
Latitude & Longitude	35°13'27.22"S 149° 1'15.49"E
Geographic Coordinates	683925.187 E 6100219.083 N (Zone 55)
Current Site Owners / Occupiers	Ampol Australia Petroleum Pty Ltd
Site Area	~2083 m^3
Local government area	ACT Government
Zoning	CZ2: Business Zone
Current land use	Service station with on-site retail shop and mechanic workshop

2.2 FUEL STORAGE INFRASTRUCTURE

There are five known underground storage tanks (USTs) and one decommissioned aboveground former liquefied petroleum gas (LPG) storage tank at the site. The location of the USTs is shown in Figure 2. The storage information is given below in Table 2.2, based on the information provided from Ampol. There are no records for other storage tanks outside of the current tank farm other than an above ground waste oil tank behind (to the south-west) the mechanical workshop building.

Table 2.2 Petroleum storage information

TANK NUMBER	PRODUCT	SIZE (L)
T1 UST	Vortex 95 premium unleaded petrol (PULP)	27,400
T2 UST	Diesel	27,400
T3 UST	Unleaded petrol with 10% ethanol (E10)	27,400
T4 UST	Former Vortex 98 PULP (out of service from 14 February 2020 and temporarily abandoned from 1 April 2020 – tank currently empty)	20,000
T5 UST	Unleaded petrol with 10% ethanol (E10)	59,400
T6 AST	Decommissioned (formerly LPG)	7,500

3 SITE CONDITION & SURROUNDING ENVIRONMENT

3.1 SURROUNDING LAND USE

Surrounding land uses include:

- **North:** Hardwick Crescent with residential properties (Zara Gardens) to the north-east (approximately 22 m from the site boundary) and commercial properties (Scott Chambers Building) north (approximately 29 m from the site boundary);
- **East:** Flack Street with the Raiders Belconnen and open-air recreation sports field beyond to the north-east (approximately 20 m from the site boundary);
- **South:** Hardwick Crescent with residential properties (Canberra Masonic Homes) beyond to the south-west (approximately 21 m from the site boundary); and
- **West:** open-air bitumen carpark (immediately adjacent to the site boundary).

Utility facilities including maintenance pits, drains and inspection covers relating to electrical, communications, water, sewer and stormwater infrastructure are located in all cardinal directions surrounding the site.

3.2 GEOLOGY AND HYDROGEOLOGY

3.2.1 GEOLOGY

Based on a review of Abell 1992, *Canberra 1: 100,000 scale geological map*, the site is underlain by the Late Silurian Deakin Volcanics, which is predominantly comprised of rhyodacitic ignimbrite with minor volcaniclastic and sedimentary units. Further, the 1:50,000 Geology of Canberra, Queanbeyan, and Environs (1980) geological map also indicates that the site is underlain by the Deakin Volcanics. The geological legend indicates that volcanic bedrock comprises Tuff and Tuffaceous Shale. Structurally, there are a number of major faults that have displaced the bedrock in close proximity of the site. A north-north west splay of the Deakin Fault having an orientation of approximate 165° crosses through the site. Although this fault is the dominant fault in the area there is likely to be a number of structures/joints that would be subparallel to the fault, and also conjugate joint sets which would strike approximately 45° to the main fault direction (Abell, 1992).

The subsurface conditions at the site observed in the monitoring well boreholes drilled during previous assessment works comprised a thin layer of Gravelly Silt Topsoil to approximately 0.2 mBGL in the grassed areas adjacent to the site, to a Sandy Gravel Road base to approximately 0.3m below the bitumen in the roads. At some locations the bedrock was exposed at the surface. The upper part of the bedrock comprised a yellow orange, highly to moderately weathered Tuff with alternating bands of harder and softer rock. Below approximately 8 m the profile continued as moderately to slightly weathered, grey brown Tuff. The Tuff comprises coarse phenocrysts in a finer grained matrix. At two locations MW07 and MW19 the bedrock has been recrystalised and fragmented and is likely to be the result of heating of the bedrock during faulting and these locations are likely to have been drilled into the fault zone.

Overall, it appears that the geology encountered at the site is consistent with the geological desktop study.

3.2.2 HYDROGEOLOGY

The 1:100,000 Hydrogeology of the Australian Capital Territory and Environs (1984) map indicates that groundwater is anticipated to be hosted in layers of dacitic, rhydodacitic, ignimbrite and bedded tuffs with minor shale, sandstone, limestone and ashstone of the Late Silurian era. The hydrogeological units are fractured with higher yielding zones associated with the upper and lower portions of the individual ash-flow tuffs and interbedded sediments. Groundwater quality tends to be variable with an estimated yield > 1.0 litres per second (L/s) and a total dissolved solid (TDS) concentration between 500-1000 milligrams per litre (mg/L). Previous assessment works 21 new groundwater wells were installed that target the shallow aquifer with groundwater intersected at 8 mBGL to 10 mBGL with groundwater inferred to flow in a north-east direction. Yields were noted to be variable when developing the wells ranging from <0.1 L/minute to 4.5 L/minute.

A search of ACT EPA records for groundwater monitoring bores associated with potential contaminated sites within a 1 km radius of the site was requested by WSP on 4 June 2020. The ACT EPA provided the following information on 5 June 2020:

> *"Office of the Environment Protection Authority records indicate that there are environmental monitoring bores at the 7 Eleven service station located at Block 1 Section 52 Holt. These bores are associated with environmental monitoring required under the site's environmental authorisation (EA) under the Environment Protection Act 1997.*
>
> *Dissolved phase hydrocarbon impacts have been detected in groundwater samples at the site in perched groundwater and a shallow aquifer (at depths of between 6.0 and 10.0 mBGL). Groundwater flow has been found to be to the north-northeast."*

Block 1 Section 52 Holt is located approximately 400 m north of the ESA investigation area. Potential off-site dissolved phase hydrocarbon impacts associated with Block 1 Section 52 Holt are unlikely to have impacted the site and nearby surrounding properties, as the ESA investigation area being approximately 400 m upgradient from the groundwater flow direction identified at Block 1 Section 52 Holt.

A review of the ACTmapi Cadastre and imagery water bore layer and the Bureau of Meteorology Australian Groundwater Explorer portal (which references the National Groundwater Information System) both undertaken on 23 April 2020 indicated that there are no registered bores within a 500 m radius of the site. To confirm that no potential unregistered groundwater abstraction bores were located within the near vicinity of the site, WSP performed a desktop survey of the area by review of aerial photographs from December 2019 (a period where Canberra was in drought and any significant water usage on gardens would be highlighted) and a walkover of the nominated area looking for evidence of possible groundwater bores (well covers, signs and pumps). The result of the desktop survey and walkover by WSP of nominated area surrounding the site undertaken on 4 June 2020 provided no visual evidence of potential unregistered groundwater abstraction bores in those areas mentioned.

The nearest surface water feature is an unnamed water body, a stormwater outlet and creek line, located approximately 580 m north of the site that empties into Ginninderra Creek, approximately 870 m to the north of the site. The stormwater outlet diverts water flow captured from runoff in the Holt area with a number of stormwater drains marked in the area that the stormwater flows directly into Ginninderra Creek. Ginninderra Creek is a tributary of the Murrumbidgee River, which is a major water body located approximately 7.35 km west of the site.

3.3 LOCAL LITHOLOGY

The lithology or geology encountered across the study area underlying paved and unpaved area observed during the drilling investigations generally comprised a thin layer of fill, silty or gravelly clay (either natural or disturbed natural) in the unpaved areas. However, in some instances the surface directly overlies the rock formation. The underlying rock is characterised by highly and moderately weathered orange/brown Tuff to a depth of approximately 6 mBGL. This geologic unit is underlain by grey brown slightly weathered Tuff to depths of generally approximately 9 to 10 mBGL. Beyond these depths and to the lower vertical extent of the borehole excavation (to the end of the boreholes) the Tuff is darker grey in appearance and can generally be considered "unweathered" rock.

The saturated zone within the rock profile was observed to occur towards the base of the slightly weathered bedrock at depths between 7.5 m BGL and 9.5 m BGL. These observations were made during drilling of 14 boreholes via a sonic drill rig.

In addition to the boreholes drilled using sonic and auger/air hammer methods, two boreholes (S2-D1 and S2-D2) were installed using diamond core techniques. Diamond coring allows a solid core to be obtained from the subsurface with minimal disturbance where structural features of the profile could be observed and aligned with depth. Key findings of the diamond coring are listed below:

- The primary structural features identified during logging were steeply dipping fractures of between 45°and 60° which are mostly joints associated with the main fault that crosses through the site;
- Sub-horizontal to 20° dipping flow surfaces were also identified in the drill cores; and
- A number of fractures were associated with high PID readings indicative of volatile impacts.

Field observations of the cored profiles and borehole imaging support the presence of discontinuities in the rock geology profile in the study area. These discontinuities are in the form of parted fractures, both open (void spaces) and closed (infilled or partially infilled with clay or other minerals), flow surfaces and other minor preferential flow structures. These structures are likely relatively short in length compared to the wide distribution of impacts across the study area.

The fracture/flow surface network is likely to be a vast network of discontinuous, relatively narrow preferential flow paths (predominantly approximately ≤1 mm aperture thickness) that intersect other discontinuities in both the sub-horizontal and sub-vertical planes leading to a complex system of structurally controlled preferential groundwater migration pathways. These preferential flow structures (fractures, flow surfaces and discontinuities) are the likely mechanism by which hydrocarbon impacted groundwater and light non aqueous phase liquid (LNAPL) has migrated away from the source area at the site to areas of the study area that are not only hydraulically down gradient, but hydraulically cross-gradient and upgradient (in some instances). Likewise, this mechanism explains the occurrence of non-impacted wells adjacent or nearby impacted wells.

3.4 TOPOGRAPHY

Regionally, there is an elevated land area to the south of the site and the overall regional fall is to the north. Surveyed heights of the ground surface show the greatest elevations for the vapour pin location along Powell St, south-west of the site (S2C10: 582.239 mAHD). The wells located along Hardwick Crescent on the southern side of the service station are lower than Powell Street (MW25: 577.079 mAHD; MW24: 576.776 mAHD & MW23 576.517 mAHD) and lowest for wells in the park area on the northern side of Zara Gardens (S2P6: 568.819 mAHD; S2P7: 566.881 mAHD) (refer to Appendix B for surveyed plan of the site area). Thus, the current investigation area shows a topographical fall of approximately 15.4 m, from south to north over a distance of 250m, which equates to an average topographical gradient of approximately 6.16%.

4 SITE HISTORY

The site where the current service station sits today was vacant land up until sometime between 1975 to 1976. During this period a building appeared in the south-eastern portion of the site. A 1976 sewer plan for the site states that this building is owned by "Caltex Oil (Australia) P/L" which is assumed to be the service station that stands there currently. The majority of the remaining site area was observed to be paved, except for the small long strip areas along the south-western and north-eastern site boundaries. A number of trees were planted along the southern site boundary after 1978. From 1983, the site layout remains generally unchanged.

The surrounding areas were generally undeveloped prior to the 1960's. A temporary road connecting the major road to the north of the site (Southern Cross Drive) and the development area to the south-east direction of the site (Holt Oval) was observed in the 1968 photograph. The development for the surrounding areas occurred between 1978 and 1983, and began with the Kippax shopping centre and carpark located to the north-west of the site. After 1987, the local area generally comprised of commercial properties to the north and east, carpark to the west, and residential properties to the south of the site. The land use settings generally remained unchanged except for the commercial property to the north of the site being replaced by residential units sometime between 1993 and 1995.

Historical information for properties to the immediate site vicinity (including shopping centre carpark, Zara Gardens, Scott Chambers, Raiders Belconnen Sports Club, Canberra Masonic Homes Retirement Village and the parkland) are further discussed in detail with the October 2020 ESA report.

4.1 PREVIOUS INVESTIGATIONS

The known environmental reports, management plans and authorisations for the site are listed below in chronological order. A summary of the scope or outcome of each is outlined in detail within the Appendix C.

- GHD 2010, *Report for Holt Caltex Service Station, 1 Hardwick Crescent, Phase 2 Environmental site assessment*;
- AECOM 2011, *Groundwater Monitoring Well Report, Caltex Holt (22546), Corner Hardwick Crescent and Flack Street, Holt, ACT*;
- Caltex Australia 2013, *Environmental management plan Caltex Holt (22546)*;
- WSP (formerly Parsons Brinckerhoff) 2013, *2013 Round 1 – ACT Groundwater monitoring event*;
- WSP 2014, *2013 Round 4 – ACT Groundwater monitoring event*;
- WSP 2015, *Classification of stockpiled material at Caltex Holt Service Station (22546) Corner Hardwick Crescent and Flack Street, Holt, ACT*;
- URS Australia 2015, *Final Groundwater Data Memo – Kippax service station (22546);*
- ACT EPA 2016, *Environmental authorisation letter*;
- GHD 2017, *22546 – Caltex Kippax Service Station, 1 Hardwick Crescent, Holt, ACT, 2615 Groundwater monitoring event – September 2016*;
- WSP 2017, *Caltex Kippax Holt service station (Site ID: 22546), 1 Hardwick Crescent, Holt ACT 2615: Groundwater monitoring event*;
- WSP 2018, *Caltex Kippax Holt service station (Site ID: 22546), 1 Hardwick Crescent, Holt ACT 2615: Groundwater monitoring event*;
- WSP 2019, *Caltex Kippax Holt service station (Site ID: 22546), 1 Hardwick Crescent, Holt ACT 2615: Groundwater monitoring event*;

- WSP March 2020a, *Caltex Kippax Holt service station (Site ID: 22546), 1 Hardwick Crescent, Holt ACT 2615: Assessment of Vapour Risks*;
- WSP May 2020b, *Tier 1 Risk Assessment (Off-site), Caltex Holt Service Station, 1 Hardwick Crescent Holt, ACT, Site ID: 22546 (Rev0 – Draft)*; and
- WSP August 2020c*, Environmental Site Assessment Report, Caltex Holt service station (Site ID: 22546), 1 Hardwick Crescent Holt ACT.*
- WSP December 2020d*, Environmental Site Assessment Report, Caltex Holt service station (Site ID: 22546), 1 Hardwick Crescent Holt ACT.*
- WSP December 2020e*, Vapour Risk Assessment (Off-Site), Caltex Holt service station (Site ID: 22546), 1 Hardwick Crescent Holt ACT.*
- WSP December 2020f*, Remediation Pilot Trial Report, Caltex Holt service station (Site ID: 22546), 1 Hardwick Crescent Holt ACT.*
- WSP May 2021a*, Draft Groundwater Monitoring Event, Caltex Holt service station (Site ID: 22546), 1 Hardwick Crescent Holt ACT.*
- WSP May 2021b*, Draft Summertime Vapour Sampling, Caltex Holt service station (Site ID: 22546), 1 Hardwick Crescent Holt ACT.*

4.2 SUMMARY OF CLEAN UP WORKS TO DATE

4.2.1 ACTIVE REMEDIATION / RECOVERY

In addition to the assessment activities outlined above, active remediation / recovery of the LNAPL has been undertaken at the site since the fuel loss was identified.

Initial spill response efforts commenced on 15 February 2020, with contractors (InSite) mobilising to site remove LNAPL from on-site groundwater monitoring wells using (mobile) pneumatically-driven, down hole pumps. The recovery was initially conducted from EW1 on 15 February 2020, with the pumping works were progressively expanded to include EW02, MW01 and MW02 in the following days. The recovered liquids were initially stored in (bunded) 1000L intermediate bulk containers (IBCs) prior to off-site disposal.

A (semi-) permanent system was also progressively installed at the site. A storage tank (supplementing the on-site IBCs) was installed at the site in the week commencing 17 February 2020, and permanent air and liquids recovery lines initially run to EW01, EW02, MW01 and MW02 through a combination of trenches in unpaved areas and heavy duty, rubber speed humps (with cable channels) in paved areas.

Initial pumping efforts on 15 February 2020 were conducted during the day. However, pumping was quickly extended to include extraction throughout the night from 16 February 2020 and continuous pumping (24 hours/day) was conducted up until 2 March 2020, at which point pumping reverted to day time pumping.

The operation of the system was initially manned while the high level and high-high level switches were installed, commissioned and confirmed to be operating properly within the tank. On 10 April 2020 the system commenced operation in auto mode (unmanned), and thus this system was able to be operated 24 hours / day (whenever the site air compressor is on). Due to the operations of the on-site mechanics workshop, the site air compressor is only operational during normal working hours, and thus the system is accordingly only operational during these hours too.

The system (and / or mobile pumping) has been progressively expanded to include recovery from wells EW01, EW02, MW01, MW02, MW05, MW06, MW07, MW08, MW10, MW12, MW15 at various stages of operation. At the time of writing (May 2021), the system was pumping from wells EW02, MW05, MW06 and MW10.

MPVE was also conducted at EW01 and EW02 as part of these initial emergency response works on 18-19 February 2020.

Table 4.1 below provides a summary of all the liquids recovered up until 31 March 2021.

Table 4.1 LNAPL / Water Recovery Summary

EXTRACTION PERIOD	LNAPL RECOVERED (L)	WATER RECOVERED (L)	TOTAL TPH RECOVERED AS DISSOLVED PHASE (L)	TOTAL LIQUIDS RECOVERED (L)	% LNAPL RECOVERED
February 2020 (15/02 - 20/02)	8,341	8,211	2.5	16,552	50.4
February 2020 (21/02 – 28/02)	5,938	14,124	4.3	20,062	29.6
March 2020 (1/03 – 31/03)	4,553	35,459	10.8	40,012	11.4
April 2020 (1/04 – 30/04)	3,055	31,635	9.6	34,690	8.8
May 2020 (1/05 – 31/05)	928	26,243	8.0	27,171	4.9
June 2020 (1/06 – 30/06)	694	10,541	3.2	11,235	6.2
July 2020 (1/07 – 31/07)	194	18,752	5.7	18,946	1.1
August 2020 (1/08 – 20/08)	167	21,805	6.6	21,972	0.3
September 2020 (1/09 – 31/09)	0	7,620	2.3	7,620	0.0
October 2020 (1/10 – 31/10)	14	11,659	3.5	11,673	0.2
November 2020 (1/11 – 30/11)	0	29,898	9.1	29,898	0.0
December 2020 (1/12 – 31/12)	0	23,416	7.1	23,416	0.0
January 2021 (1/01 – 31/01)	14	9,036	2.7	9,050	0.2
February 2021 (1/02 - 28/02)	0	16,212	4.9	16,212	0.0
March 2021 (1/03 – 31/03)	0	19.529	5.9	19.529	0.0
Totals (15/02 – 30/11)	**23,898**	**264,631**	**86.2**	**288,529**	**8.3**

As can be seen in the above summary of the liquids recovered to date, a total of 23,898 L of LNAPL has been recovered up until 31 March 2021. Approximately 60% of the LNAPL recovered to date was recovered in the first two weeks of extraction (15 – 28 February 2020), with LNAPL recovery rates progressively reducing over time. No LNAPL was recovered in September 2020, as the system was shut down due to the remediation trials being conducted at the site (refer to Section 4.2.3). The most recent reported data (over the last six months, September 2020 to March 2021), indicates only 28 L was recovered, which represents approximately 0.12 % of the overall LNAPL volume recovered to date.

The LNAPL thicknesses at the site have been declining since February 2020, and while the pumps have been moved / adjusted to maximise LNAPL recovery since installation, the declining LNAPL thicknesses have corresponded with declining LNAPL recovery rates by the system. It is considered that the declining LNAPL thicknesses and LNAPL recovery at the site is due to the ongoing product recovery measures and / or the rise in groundwater levels across the general area, which have risen approximately 1.0m across the site.

4.2.2 REMEDIATION OPTIONS ASSESSMENT

In September, WSP conducted a desktop assessment of the options for the clean up and management of the gross impacts sourced from the site. A wide range of clean up technologies were assessed taking into consideration factors such as the reasons for the remediation work and any constraints on it, risk management, technical suitability and feasibility, stakeholders' views, cost/benefit ratio and wider environmental, social and economic impacts (i.e. waste generation, sustainable development, etc.). The Remediation Options Assessment is presented in Appendix D.

Based on the nature and extent of impacts, the geology / hydrogeology, site setting, and the ability for the clean up technologies to remove / reduce / transform contaminant mass, costs and treatment time of implementation, the remediation screening process prepared for the site showed that the clean up technologies that are retained for further consideration are:

- Soil Vapour Extraction (SVE) (with / without pumping);
- Multi-Phase Vacuum Extraction (MPVE);
- In-situ Chemical Oxidation (ISCO); and
- (Continued) pumping.

4.2.3 REMEDIATION PILOT TRIAL

Following the completion of the remediation options assessment, WSP conducted Remediation Pilot Trials at the site. A copy of the Remediation Pilot Trial report is attached in Appendix E. The objectives of the pilot trials were to:

- Determine an appropriate clean up technology for the future implementation at the site;
- Evaluate the mass recovery rates;
- Determine key design parameters (e.g. radius of influence (ROI), hydrocarbon mass recovery rates, well vacuums, flow rates, etc.) for the application of the future clean up strategy; and
- Provide data to better assess the hydraulic characteristics of the underlying aquifer within the fractured rock.

The pilot trial program commenced in September 2020 consisted of the following works:

- Installation of eight additional wells onsite:
  - 1 x 100mm central extraction well – PRW1;
  - 4 x 50mm monitoring wells – PMW1 to PMW4; and
  - 3 x 50mm injection wells – IW1 to IW3.
- A series of rising head slug tests at well locations MW04, MW09, MW10 MW11, MW15, and EW03 to estimate the aquifer hydraulic parameters;
- A series of LNAPL bail down tests across the study area to estimate the LNAPL transmissivity were planned, but due to the small LNAPL thicknesses present in wells, these tests were not able to be conducted;
- SVE test to estimate the mass removal rates, and pneumatic ROI in the unsaturated formations for this clean up technology;
- SVE + Pumping test to estimate the mass removal rates, and pneumatic and hydraulic ROI in the saturated and unsaturated formations for this clean up technology;
- MPVE test to estimate the mass removal rates, and pneumatic and hydraulic ROI in the saturated and unsaturated formations for this clean up technology; and
- ISCO injection of chemical oxidising reagent (persulfate) into the three 50mm injection wells (IW1 to IW3) to determine the flow rates achievable and the response in surrounding monitoring wells.

The rising head tests were conducted on wells MW04, MW09, MW10, MW11, MW15 and EW05. The hydraulic conductivity, calculated using Bouwer-Rice and Hvorslev methods, were found to range between 0.0017 m/day and 0.65 m/day using the Bouwer-Rice method, and between 0.0025 m/day and 1.0 m/day using the Hvorslev method.

The results of the hydraulic conductivity tests performed on wells MW04, MW09, MW10, MW11, MW15 and EW05 are consistent with the variable lithology identified beneath the site (clay and fractured rock (tuff)).

The pilot trial results for the various clean up approaches indicate that the extraction and injection approaches trialled would be effective in reducing hydrocarbon mass.

As there has been off-site LNAPL impact noted, it is expected that off-site extraction points will be required in a full-scale clean up system, hence transferring fluids over some distance will be required (e.g. to the north, across Hardwick Crescent). It is considered that SVE + Pumping and MPVE will be more effective than SVE and more efficient than chemical injection in the short to medium term in reducing the bulk of the hydrocarbon mass.

SVE + Pumping can achieve similar mass recovery and ROI as MPVE, with lower applied vacuum (and accordingly lower energy requirements), and with more efficient transfer and treatment of fluids, and therefore SVE + Pumping was considered to be most appropriate extraction clean up technology for the site.

Based on the overall results of the SVE + Pumping pilot trial conducted at PEW1, the expected operational parameters for any further SVE + Pumping works at the site are as follows:

- **Applied wellhead vacuum** -10 to -20 kPa
- **Groundwater extraction rate** up to 2.5 L/min
- **Extraction wellhead flow** 40 - 55 m^3/hr
- **Hydrocarbon mass removal rate** 1 to 3 kg/hr per well
- **Pneumatic ROI** 18 m (conservatively, assume 10-15 m for remediation design)

A suitable location for the installation of a clean up system was identified in the north-western portion of the site, where the current groundwater/LNAPL collection tank is located. The absence of residential properties immediately adjacent to the clean up system should minimise potential issues related to the noise of the operation of a clean up system at the site.

5 RESULTS

5.1 SOIL IMPACTS

During Stage 1 ESA (WSP, March 2020), soil samples were collected and analysed from the eight site boundary wells and the 13 wells drilled in the outer ring. Most of the sampling locations were on the surrounding roads, and were distant from the site's UPSS and thus the vadose zone of the profile was not expected to have been impacted by the fuel spill. The laboratory testing results confirmed the assumption, with no detections of hydrocarbons in soil above the saturated zone. The shallowest depth at which an impacted soil sample was detected was 9 m at MW15. All samples with detections of hydrocarbons were in the saturated zone.

Detections of TRH and BTEXN compounds were identified at depth in boreholes MW05, MW06, MW10, MW15 and MW17, however the detected concentrations in the majority of the samples do not exceed the site assessment criteria; with the exception of the following:

- benzene in sample MW05_12.0-12.1 which recorded a concentration of 23.2 mg/kg, which exceeds the HSL D criterion of 3 mg/kg for a sample depth >4 mBGL;
- benzene in sample MW15_10.5-10.6 which recorded a concentration of 1.4 mg/kg, which exceeds the HSL A criterion of 0.5 mg/kg for a sample depth >4 mBGL; and
- TRH C_6-C_9 less BTEX (F1) in sample MW15_10.5-10.6 which recorded a concentration of 391 mg/kg, which exceeds the HSL A criterion of 200 mg/kg for a sample depth >4 mBGL.

It is noted that the groundwater in these equivalent locations has detections of significant TRH and BTEXN impacts and are likely to be the source of the impacts identified in the soil.

During the Stage 2 ESA, field screening of the boreholes for VOCs with a PID indicated the following:

- Nil to low concentrations of VOCs (<10 ppm) were detected in the majority of the soils and weathered rock screened with a PID;
- Elevated PID readings (>50 ppm) were detected at sampling locations S2-P2 (from 7 to 9.5 mBGL) and S2-P10 (from 8 to 10.5 mBGL). The maximum PID reading was detected was 1,679 ppm detected at a depth of 9 mBGL within the borehole S2-P2; and
- Olfactory indications and field screening of soils with a PID suggest that potential soil impacts are likely to be present near the depth were hydrocarbon impacted groundwater is intersected.

The laboratory results indicated that most of the COPCs scheduled for analysis in soil samples collected during Stage 2 ESA works including TRH and BTEXN, were not detected above the laboratory LOR, with the exceptions of the following:

- Minor detections of toluene were detected at the sample locations, S2-C3_0.1m, S2-C4_0.1m, S2-C5_0.1m, , S2-C6_2.0m, S2-C6_8.0m, S2-C6_9.0m and S2-P1_12.0m ,S2-P9b_1.0m. The toluene concentrations detected were below the adopted site assessment criteria.
- The TRH F2 and F3 concentrations of 88 mg/kg and 250 mg/kg respectively were above the LOR but below the adopted site assessment criteria at sampling location S2-P5_0.1m within the topsoil profile. The soil samples collected at further depths from the same borehole did not reveal any detectable concentrations. Hence the TRH F2 and F3 detections are considered to be attributed to natural organic matter (NOM) rather than petroleum impacts related to the fuel spill.

— Minor BTEXN concentrations were recorded within the sample S2-P2_7.0m and S2-P2_8.0 m. All recorded concentrations were below the adopted site assessment criteria. The BTEXN concentration detected are located within the capillary fringe or saturated zone and are representative of the groundwater plume.

In summary, all the Stage 2 ESA soil samples collected and analysed recorded analytical results below their respective assessment criteria and are not considered posing significant risks to receptors. The soil results data from the Stage 2 ESA is presented in Table F4, Appendix F.

It is noted that toluene detections within the soil samples are likely attributed to a manufacturing, handling or laboratory process fault causing minor contamination to the sampling containers. The minor toluene detections were also noted in the field rinsate blank samples collected from 8 September to 14 September 2020, which also supports potential contamination of the sampling container, rather than insufficient decontamination processes, as no other analytes were detected.

5.2 LNAPL

5.2.1 LNAPL OCCURRENCE AND TRENDS

During the groundwater monitoring event (GME) undertaken as part of the Stage 2 ESA works (28 September 2020), gauging indicated the presence of LNAPL in wells MW02, MW07, MW15 and MW16 with apparent LNAPL thickness ranging from 0.003 m in wells MW02 and MW07, to 0.061 m in MW15. It is noted that 0.002m of LNAPL was observed in well S2-P2 post the development of the well with a sample collected for fingerprint analysis. However, LNAPL has not been detected in the well following collection of the LNAPL sample. Apart from the identification of LNAPL in well S2-P2, no other wells installed as part of the Stage 2 ESA works recorded detections of LNAPL.

During the February 2021 GME, gauging indicated the presence of LNAPL in off-site wells MW15 and MW16 at measured thicknesses of 0.065 m and 0.071 m respectively. LNAPL was not detected in any other wells where presence was identified during the September 2020 GME (MW02, MW07, MW10 and S2-P2) or previous gauging events conducted since the February 2020 fuel release (EW01, EW02, MW01, MW05, MW06, MW12, and MW17).

Since the commencement of the works program at the site, regular gauging events of the entire groundwater monitoring well network available at that time have been undertaken, with the gauging data including apparent LNAPL thicknesses presented in Table F1 and F2, Appendix F.

Over the gauging events, apparent LNAPL thickness declined in the monitoring well network, refer to Table 5.1 for a monthly summary of LNAPL impacts. For instance, wells EW01, EW02, MW01, MW02, MW05, MW06, MW07, MW10 and MW12 have either no longer have apparent LNAPL or having a thicknesses of apparent LNAPL less than 0.005 m or 5 mm.

The LNAPL thicknesses have generally declined across the monitoring well network in the recent investigations. The declining thicknesses of LNAPL on site is at least partially due to the ongoing product recovery measures, and / or the rise in groundwater levels across the general area encompassing the well network. It is acknowledged that higher standing water levels can mask the presence of LNAPL, and conversely, when the water level drops, previously submerged LNAPL can be liberated presenting as LNAPL in monitoring wells.

Table 5.1 Summary of LNAPL impacts from 15 February 2020 to 24 February 2021

WELL ID	MEASURED LNAPL THICKNESS (m)								
	15 FEB 2020	20 APR 2020	13 MAY 2020	15 JUN 2020	23 JUN 2020	23 JUL 2020	20 AUG 2020	28 SEPT 2020	24 FEB 2021
EW01	2.988	0.093	0.0036	0.033	-	0.448	0.202	-	-
EW02	2.695	Sheen	-	-	-	-	-	-	-
MW01	0.975	0.147	0.015	0.019	0.006	0.004	-	-	-

WELL ID	MEASURED LNAPL THICKNESS (m)								
	15 FEB 2020	20 APR 2020	13 MAY 2020	15 JUN 2020	23 JUN 2020	23 JUL 2020	20 AUG 2020	28 SEPT 2020	24 FEB 2021
MW02	1.424	0.324	0.110	0.295	0.007	-	0.014	0.003	-
MW05	N/A	0.578	0.430	0.499	0.007	-	-	-	-
MW06	N/A	0.022	Sheen	-	-	-	-	-	-
MW07	N/A	0.174	0.002	-	-	-	-	0.003	-
MW10	N/A	Sheen	-	0.012	0.004	0.002	-	0.003	-
MW12	N/A	0.099	-	-	-	-	-	-	-
MW15	N/A	0.759	0.650	0.601	0.603	-	0.079	0.061	0.065
MW16	N/A	0.002	Sheen	0.010	0.045	-	0.173	0.050	0.071
MW17	N/A	0.002	-	-	-	-	-	-	-
S2-P2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.002*	-

Notes: * The LNAPL thickness measured in well S2-P2 was identified during post well development on 22 September 2020.

5.2.2 LNAPL COMPOSITION AND AGE

During the earlier stage 1 ESA works (April 2020), five samples of the LNAPL were collected from wells EW01, MW05, MW07, MW12 and MW15 and submitted for fingerprinting analysis at Leeder Analytical laboratory. All samples were found to have a chromatographic profile typical of a slightly degraded Vortex 98 unleaded petrol. The estimated time that the product had been in the environment was between three to seven years.

Because the estimated age was older than the date of the leak from the Vortex 98 tank, which was believed to have commenced about December 2019, during the Stage 2 ESA works (September 2020) three samples of the LNAPL were collected from wells MW15, MW16 and S2-P2 and scheduled for composition and age analysis at Leeder Analytical laboratory. All samples were found to have a chromatographic profile typical of a slightly degraded Vortex 98 unleaded petrol, with an estimated time in the environment of 1.5 to 2.5 years.

As per the two fingerprinting analytical results outlined above (where the LNAPL from the same fuel loss provided two different results), LNAPL ageing is subject to variation (inaccuracies) due to factors such as bio-stimulation, aeration, remediation, etc. We note that the leak from the tank was believed to have commenced in approximately December 2019, which is consistent with the analytical results from pre-existing wells such as EW01, EW02, MW01 and MW02, which all detected minimal (or no) hydrocarbon impacts during the sampling events prior to December 2019, including in the (September 2019) GME prior to the leak starting (assumed to be in late 2019). These four wells all detected LNAPL and / or hydrocarbons concentrations at, or nearing saturation levels in the GMEs / gauging subsequent to the leak being detected in February 2020. On the basis of the above, it is considered that the ageing results overestimate the age of the LNAPL impacts.

A compositional analysis of the BTEXN component of the LNAPL was also undertaken. The BTEXN compositional analysis was undertaken to explain characteristic compositional features of the soil vapour from measurements undertaken in earlier and concurrent phases of the overall investigations, WSP August 2020 and WSP October 2020. Benzene had been a relatively small component of the measured vapours in the majority of vapour measurements and naphthalene was not detected in any soil vapour sample.

In the MW15 LNAPL sample, BTEXN made up 18.2% of the total product, somewhat lower than the 34.2% and 33.8% for MW16 and S2-P2 wells, respectively. The latter are more typical of petrol composition. Of note is the consistent percentage of benzene which was close to 1% in all three samples. In Australia the benzene content of petrol is regulated to 1%. Naphthalene was, as expected, at very low percentage composition, ranging from 0.15% to 0.2%.

The compositional analysis was not undertaken to examine the similarities or differences between the product at the three wells, but the BTEXN composition does indicate a common source and aging. MW15 did show considerably less toluene than the other two wells, but it is not unexpected to have differential degradation at different locations. The percentage composition of the other compounds was almost identical between samples. The low percentage composition of benzene (around 1%) and naphthalene (around 0.2%) was consistent with the small proportion of benzene, and non-detection of naphthalene in the vapour samples (reported in WSP August 2020 and WSP October 2020).

5.3 GROUNDWATER GAUGING / GRADIENT

During the February GME the stabilised water levels varied between 11.3 metres below ground level (mBGL) (S2-C4, located in the park north of Zara Gardens) and 15.4 mBGL (S2-C10, located south of the Masonic Homes on Powell Street), with a corresponding elevation range of 564.8 metres relative Australian Height Datum (mAHD) to 568.1 mAHD. Relative to the previous GME conducted in September 2020, groundwater levels have increased by approximately 0.3 m across the site and surrounding investigation areas. The gauging summary table for the GME is provided in Table F1, Appendix F.

Groundwater is inferred to flow generally in a north to north east direction towards the open space parkland (Block 47 Section 51). The groundwater contour plan is presented as Figure 9 in Appendix A, and shows measured groundwater elevations at each of the monitoring well locations and the estimate of groundwater flow direction based on the data collected in February 2021.

Since the commencement of the works program at the site, regular gauging events of the entire groundwater monitoring well network available at that time have been undertaken, with the historic gauging data presented in Table F2, Appendix F. In general, groundwater water levels have been rising, with an approximate increase of 1.0 m across the investigation area since the commencement of the works program at the site. Graphs of the gauged depth to water, depth to LNAPL (if present) and the apparent LNAPL thickness in each well since 15 February 2020 are provided in Appendix F.

5.4 GROUNDWATER IMPACTS

Prior to the loss of fuel, the 2019 GME (WSP, 2019) identified minor concentrations of medium fraction hydrocarbon chains (TRH C_{10}-C_{16}) in wells EW2 and MW02 and low concentrations of benzene in well EW2. Naphthalene, lead and ethanol was not detected in any of the monitoring wells samples. All analytical results were either below the laboratory LORs or below the adopted assessment criteria; indicating that historic site conditions have had a negligible effect on the current site conditions.

Since February 2020, the Stage 1 and 2 ESA have installed a number of wells on the service station or in the very near vicinity, which brought the total number of wells near the source area to 23 (EW01 - EW03; IW1 - IW3; MW01 – MW11; PEW1; PMW1 – PMW4; and RW01). Of those 23 near-source wells, 16 were heavily impacted with dissolved phase hydrocarbon impacts and some showed the presence of LNAPL. For the purposes of this report, the descriptor ‘heavily impacted’ has been nominated as dissolved phase concentrations of total BTEX of greater than 80,000 ug/L, with or without the presence of LNAPL. These results show that there was widespread impact to groundwater at and in the near vicinity of the service station.

The groundwater wells installed in three stages of ‘step-out’ at increasing distances from the service station, have shown that hydrocarbon impacts in groundwater have migrated outwards from the service station in several directions along separate migration pathways. Although the potentiometric levels show there is a clear north-easterly gradient to the groundwater, the hydrocarbon impacted groundwater has migrated in a radial pattern away from the site along preferential pathways formed by fractures in the Tuff bedrock, within the saturated zone, and along zones of softer rock due to greater weathering. The lateral extent of an individual fracture or series of fractures, or zones of softer rock, could not be determined. The borehole imaging shows a multitude of fine fractures that are typically short in length, but frequently interconnect. However, it is likely that some of the zones of preferential migration may terminate, thus limiting the migration of the hydrocarbons, other than by the much slower process of diffusion and seepage through more competent rock.

The monitoring wells installed for the second and third 'step-out', i.e. the wells designated S2-P1 to S2-P12, and at greater distance, wells S2-C1 to S2-C10, effectively defined the extent of the preferential migration pathways for identified pathways with the exception of the migration beneath the Raiders playing field.

On the basis of the degree of hydrocarbon impact (hydrocarbon dissolved phase concentrations and periodic appearances of LNAPL, the most prominent migration pathways have been to the north towards Scott Chambers, north-northeast towards Zara Gardens, and north-east towards the Raiders playing field. Those north to north-easterly preferential migration pathways are generally consistent with the hydraulic gradient and their flows are likely to be enhanced by the gradient.

The outermost wells, S2-C1 to S2-C10, have defined a zone of non-impacted groundwater and thus define the extend of the impacts, with the exception of the migration pathway beneath the Raiders playing field (i.e. due to the impacts detected in one well in Flack Street (S2-P2)). As a result of the undelineated impacts in S2-P2, six additional wells were installed and sampled in November 2020 to determine the extent of the contaminated groundwater within the Raiders Belconnen property away from the source on the service station.

The six wells located surrounding the playing field, within the Raiders Belconnen property (S2-R1 to S2-R6), all reported concentrations of hydrocarbon (TRH and BTEXN), lead and ethanol below the laboratory limit of reporting / applicable site assessment criteria, and thus it is considered that the impacts reported at S2-P2 is now delineated.

A sewer main and stormwater pipe traverse the open space to the north of the Zara Gardens residential complex. Comparing the invert levels of those pipelines with the standing water levels of wells in that open space area, shows that the pipelines are not in contact with the groundwater at the time of measurements. As the groundwater is currently around 1.2 m below the stormwater invert level (referenced to well S2-P6) and 0.7 m below the sewer main (referenced to well S2-P7), those conduits are not likely to be impacted by possible future hydrocarbon impacted groundwater – in the event that migration were to travel to the open space to the north of Zara Gardens.

The nearest surface water feature is an unnamed channel, a stormwater outlet, that flows only during rain events, located approximately 580 m north-west of the site. The unnamed channel is very unlikely to be used for recreational purposes but could potentially support a down-stream freshwater ecosystem. However, it is too far distant to have any reasonable probability of being a receptor of the hydrocarbons in groundwater in the future, and the current extent of the contamination has been shown to be less than 100 m. The more substantial surface body, Ginninderra Creek, is more distant from the service station, at 870 m and is thus out of reach of the hydrocarbon plume. On this basis, the ecological receptor risk pathway is considered incomplete.

5.4.1 PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS)

In response to queries from Icon Water related to the presence of per- and polyfluoroalkyl substances (PFAS) in extracted groundwater, PFAS sampling was conducted in 14 selected wells (EW01, IW03, MW01, MW12, MW13, MW18, MW23, MW25, PMW1, PMW3, S2-C1, S2-C10, S2-P1 and S2-P10) on 6 April 2021.

Pertinent groundwater PFAS analytical results are summarised below:

- Nine wells, IW03, MW01, MW12, MW13, PMW3, S2-C1, S2-C10, S2-P1 and S2-P10, had concentrations of perfluoro hexane sulfonate (PFHxS) above detection limits. Although no guidance criterion is provided for PFHxS, the presence of this compound is considered to be primary indicator of the presence of a broad range of PFAS compounds which resist physical, chemical and biological degradation.
- Two wells, EW01 and IW03, had concentrations of perfluoro octane sulfonic acid (PFOS) in exceedance of 99% freshwater protection criteria (0.00023 µg/L) at 0.003 µg/L and 0.006 µg/L respectively. It is noted that off-site wells to the north (i.e. PMW3, MW18, and S2-P10) (and approximately hydraulically downgradient) did not detect PFOS. It is also noted that the 99% protection levels were applied based on guidance provided in the PFAS NEMP

however, the reported concentrations remain below the 95% freshwater protection value of 0.13 µg/L, indicating a low risk of impact to potential off-site ecological receptors.

- All 14 wells had low concentrations of at least one perfluoro alkane carboxylic acid (PFCA), such as perfluoro butanoic acid (PFBA), perfluoro hexanoic acid (PFHxA), perfluoro pentanoic acid (PFPeA), perfluoro heptanoic acid (PFHpA), perfluoro octanoic acid (PFOA), perfluoro decanoic (PFDA) and/or perfluoro nonanoic acid (PFNA) above detection limits. Apart from PFOA, no guidance criteria are provided for the PFAS compounds listed above however, PFCAs are considered to be highly bioaccumulative, persistent in the environment, toxic if ingested and a suspected carcinogen for aquatic species (ECHA Annex III Inventory).
- The distribution and magnitude of PFAS in all wells across the investigation area, including hydraulically upgradient wells such as S2-P1, S2-C1 and S2-C10, suggests that the concentrations of PFAS is largely background concentrations (i.e. a regional issue), rather than site-sourced.
- Concentrations of the remaining PFAS analytes including perfluorododecane sulfonate (PFDoS), perfuolohexadecanoic acid (PFHxDA), perfluorononanesulfonic acid (PFNS) and perfluoroalkyl sulphonamides were below detection limits in all 14 wells.

Overall., the results of PFAS sampling indicate regional impacts rather than an on-site source of PFAS contamination. While it is considered that the PFAS are a regional issue, any future trade waste agreement will require the removal of the PFAS prior to discharge.

5.5 SOIL VAPOUR IMPACTS

5.5.1 2020 VAPOUR ASSESSMENTS

Investigations into the possible risk from vapour intrusion into the service station buildings – the sales building and mechanic workshop – comprised the testing of soil vapour beneath the forecourt at three locations outside the buildings and the measurement of surface floor fluxes and indoor air concentrations in the buildings. The on-site vapour testing showed low and acceptable vapour intrusion risks to the commercial occupants of the on-site buildings.

Initial off-site soil vapour investigations showed hydrocarbon vapours to be present at the 6 m depth in six off-site soil vapour bores located on the surrounding roads and open space. Lower concentrations were measured at the 2 m sample depth indicating that attenuation of the hydrocarbon vapours with decreasing depth is occurring.

Further vapour investigations were conducted using receptor targeted soil vapour and indoor air and indoor flux measurements at the Raiders Belconnen sports club, residential buildings within the Zara Gardens complex, and shops in the Scott Chambers commercial building.

The primary line of evidence for the determination of vapour intrusion risk for occupiers of residential units at Zara Gardens and commercial shops at Scott Chambers was indoor air measurements of VOCs. Secondary lines of evidence, soil vapour and surface vapour flux, were used to assist in the interpretation of the ambient air data. All the lines of evidence supported the conclusion that at those two properties there was no unacceptable vapour intrusion risk at the time (during the season) of testing. There remains uncertainty as to the possible influence of warmer weather on the risk. Limited and targeted re-testing in warm weather would likely resolve the uncertainty of seasonal effect on risk level.

For the Raiders Belconnen property, screening level risk indicators – from sub-slab soil vapour measurements, were sufficient evidence on which to conclude that indoor air sampling was not required to confirm the absence of unacceptable vapour intrusion risk. However, the same caveat over seasonal effects applies.

A further consideration concerning uncertainty is the possibility of an increasing degree of soil vapour impacts affecting the targeted properties. It is possible that the vapour intrusion risk level may increase if contaminant migration in groundwater increases in the form of an expansion of phase separated hydrocarbons, or other changes to the vadose zone occur having an effect on vapour generation and diffusion. Such uncertainty was examined through seasonal re-testing.

5.5.2 2021 VAPOUR ASSESSMENT

As noted above, the was a low-level uncertainty as to the possible influence of warmer weather on the potential risk posed by soil vapours, and thus targeted re-testing in warm weather was to conducted to resolve the uncertainty of seasonal effect on risk level.

The summer season sampling did not show an overall upward bias in vapour concentrations. The differences that were observed were not consistent across locations and across compounds and evidence for difference due to seasonal change was lacking. As such, the summertime sampling confirmed the outcome and conclusions from the earlier cool-season sampling that vapour intrusion risk for those targeted properties were acceptable.

There were, however, differences in detail between the winter and summer sampling events as were most apparent in the soil vapour bores of the roadways and outside the Zara Gardens residential units. These differences are not attributed to seasonal effects as they were not consistent across analytes and locations. These small scale and temporal differences had also been seen in groundwater sampling which showed marked temporal and spatial variability.

The determinant data for risk assessment was that of indoor air concentrations in the Zara Gardens ground floor units and Scott Chambers shops 1 and 2.

There was an apparent overall trend towards lower indoor air concentrations of VOCs for the February 2021 sampling, but caution should be exercised when interpreting the possible trend. There are a number of factors which may be influencing the concentrations. Units 1 and 6 had had changes in occupants leading to potential differences in products used in the homes and ventilation rates of the homes is likely to have increased in the summer period.

The driver for vapour intrusion risks from the intrusion of petroleum hydrocarbon sourced soil vapours is typically benzene and to a lesser extent, the other aromatics. Soil vapour concentrations had convincingly shown in both seasonal sampling events that aromatics were at low concentrations in bores outside the Zara Gardens ground floor units. It was concluded that the presence of the aromatic compounds within the indoor air of the units was largely a result of indoor sources plus the low ambient background outside air. In the wintertime sampling benzene concentrations had been somewhat elevated in unit 1. Summertime sampling showed benzene to have fallen to typical outdoor ambient levels, following a change in occupancy of that unit. Other units, 2, 5 and 10 also showed benzene levels typical of outdoor ambient air concentrations. Unit 6 had slightly elevated concentrations, both in wintertime and summertime sampling, but less than the criterion unadjusted for exposure (i.e.,< 1.7 $\mu g/m^3$). However, unit 9 showed one result that exceeded the criterion (5.05 $\mu g/m^3$ at sample Unit 9 AA2). That result has prompted a resampling in April 2021 for which results showed lower concentrations considerably less than the criterion (i.e.,< 1.7 $\mu g/m^3$).

The other compound that could have had an influence on vapour intrusion risk was naphthalene. It had been found in unit 9 in the winter sampling at concentrations exceeding the acceptable ambient air criterion (unadjusted for exposure duration). However, its presence was attributed to the use of ‘mothballs’ and sufficient evidence was available from soil vapour and indoor flux to conclude that there was little or no contribution from the soil vapours. In the summertime sampling naphthalene was detected at even higher concentrations in unit 9, and at increased, but acceptable concentrations in units 2, 5, 6 and 10.

In summary, the observed changes in concentrations between the winter and summer sampling events is considered more likely to be due to changes in occupancy of the units and to greater ventilation rates in summer. No overall summertime increase is apparent in the data.

Finally, concerning the results for the Scott Chambers shops 1 and 2, the February 2021 sampling indoor air hydrocarbon concentrations were low and largely reflective of outdoor ambient air. The high indoor air concentrations of toluene, ethylbenzene and xylene that had been found in shop 1 in winter-spring sampling were not present in the summertime sampling – assumed to be a consequence of the disappearance of volatiles from the painted floor and walls. In shop 2, which had not been affected by repainting in winter, there was no overall sign of an increase for the summer sampling. Concentrations were low on both occasions, so the small differences were of no significance.

In conclusion, following the summertime resampling of indoor ambient air, plus the supporting lines of evidence from indoor vapour fluxes and soil vapour concentrations, it is evident that the risk profile for the three properties investigated has not changed and all remain at acceptable risk levels.

6 CONCEPTUAL SITE MODEL

Environmental assessment works at the site are continuing and the conceptual site model (CSM) is being developed as more data is gathered. The sections below present is an update to the CSM (previously presented in the Stage 1 ESA (WSP, August 2020) and Stage 2 ESA (WSP, December 2020)) based on relevant findings from the recent February GME works (WSP, May 2021). The CSM relates to vapour source, pathways and receptors. Figures 4a to 4g shows the cross-section location plans, and Figures 5a through 5e inclusive present five selected cross sections through the site and provides a graphical depiction of the site CSM. The alignments for the five cross sections were chosen as they were considered to provide the best overview of the study area in terms of the interaction of the source area with the various receptors in the surrounding areas.

6.1 PHYSICAL SETTING

The physical setting of the site, including topography, geology, hydrogeology, and surrounding land use is detailed in Section 3.

6.2 CONTAMINANTS OF CONCERN

The analytical results from the groundwater monitoring have provided clear evidence that the contaminants in groundwater are sourced from petrol. Additionally, samples for fingerprinting of the LNAPL encountered in some wells were also collected. The fingerprinting report identified the LNAPL as premium unleaded petrol having been in the environment for between one and a half to two and a half years, however the fuel loss was identified in February 2020; approximately seven months prior to LNAPL sampling. The results of the fingerprinting analysis identified the source of the LNAPL to be slightly degraded Vortex 98 unleaded petrol, which is the same type of fuel that was released from UST 4 in the fuel loss incident.

The contaminants of concern are therefore the compounds comprising premium unleaded petrol, largely characterised by:

- BTEXN; and
- petroleum hydrocarbon fractions C_6-C_{10} and >C_{10}-C_{16} as indicators of petrol.

Lead and ethanol are not considered contaminants of concern at the site resulting from the fuel loss, they are however required to be analysed (in certain circumstances) as stipulated in the site's Environmental Authorisation (EA number 0749, dated 3 May 2016).

6.3 CONTAMINATED MEDIA

The media impacted by contamination includes the following:

- Vadose zone in the immediate vicinity of the original fuel loss incident;
- Saturated soil within the water bearing zone of the Tuff formation;
- Groundwater on and off site. Although the potentiometric levels show there is a clear northly gradient in the groundwater, the hydrocarbon impacted groundwater has migrated in a radial pattern away from the site along preferential pathways formed by fractures in the Tuff bedrock, within the saturated zone, and along zones of softer rock due to greater weathering; and
- Vapours within the pores of soil in equilibrium with soil and groundwater within the area of impact on site as referred to in the previous bullet point.

6.4 CONTAMINANT MIGRATION MECHANISMS

Fuel known to have leaked from the base of the tank is likely to have entered the weathered Tuff and be distributed (predominantly) vertically, with some radial distribution due the head pressure of the fuel and / or fracturing within the Tuff. The fuel is likely to have intercepted groundwater at a depth of approximately 9 mBGL.

As previously identified, there are two dominant mechanisms controlling the migration of groundwater at the site. The predominant flow is controlled by the gradient resulting in a northerly flow, and the secondary groundwater migration is influenced by preferential pathways caused as a result of a network of discontinuities within the Tuff geology. The dominance of the natural groundwater flow gradient is observed by the pattern of hydrocarbon impact showing much of the impacted wells to the north of the site. The occurrence of impacts in other cardinal directions can be explained by taking into account the influence of preferential pathways.

Exposure to volatile hydrocarbons through the inhalation of vapours is the risk driving pathways to human receptors. Groundwater contaminated with volatile hydrocarbons can diffuse through vadose zone from the impacted groundwater. In terms of mass flux of vapour, the major source is the groundwater smear zone which contains the 'smeared' hydrocarbon mass in the profile above the saturated zone.

Off-site, away from the source of fuel loss, the contaminated medium is the saturated ground horizon in which the contamination is migrating in a dissolved and phase separated form. The groundwater smear zone intercepting unsaturated soil may be considered a distinct medium within the lithology. While groundwater migration is the mechanism for the lateral transport of the contamination, the smear zone above the transient level of the saturated zone (i.e. the potentiometric level), is the source of the diffusive vapour pathway. Thus, the physical nature, thickness and porosity of the smear zone is a major controlling factor in the generation of vapours.

The structure and features of the vadose zone, above the smear zone, including air filled porosity, will influence the flux rates, more so than concentration of vapours in the profile. Existence of vertical preferential migration pathways may have a significant bearing on the vapour flux rates towards the ground surface.

Weather influences, particularly rainfall and temperature can have strong influence on the vertical migration pathway for soil vapours. Diffusive flux rates of contaminant vapours are greatly influenced by water filled porosity within the vadose zone – as affected by rainfall, and soil profile temperature affects vapour pressures of VOCs and hence the resulting diffusive flux rates.

6.5 SOURCE – PATHWAYS – RECEPTORS EVALUATION

6.5.1 SOURCE AND PATHWAYS

The primary source of the contaminants was fuel loss of unleaded petrol (Vortex 98 PULP) from an underground storage tank (Depot 4) and the primary migration pathway is as liquid transport in groundwater flows, as dissolved phase and phase separated hydrocarbons.

A secondary subsequent source of contaminants is hydrocarbon vapour diffusion from the dissolved and phase separated hydrocarbons in the groundwater upwards through the vadose zone. The ultimate pathway leading to vapour intrusion into buildings as diffusive and advective flows into buildings.

6.5.2 RECEPTORS

ECOLOGICAL RECEPTORS

The nearest surface water feature is an unnamed channel, a stormwater outlet, that flows only during rain events, located approximately 580 m north-west of the site. The unnamed channel is unlikely to be used for recreational purposes but could potentially support a down-stream freshwater ecosystem, however groundwater analytical results for the perimeter wells to the north and north-west, S2-P7, S2-C3, S2-C4, S2-C5 and S2-C6, approximately 80 – 100 m from the site, indicated no hydrocarbon impacts. Furthermore, the depth at which groundwater was intersected within the investigation area ranged from 6 mBGL to 17 mBGL, and it is likely that the groundwater depth at the stormwater drain is too deep to discharge into the drain. The more substantial surface body, Ginninderra Creek, is more distant from the service station, at 870 m and is thus out of reach of the hydrocarbon plume. On this basis, the ecological receptor risk pathway is considered incomplete.

HUMAN HEALTH RECEPTORS

The local area is served with reticulated town water and a review of the ACTMapi (www.actmapi.act.gov.au) groundwater database conducted on 29 October 2020 indicated that there are no registered groundwater boreholes within a 500 m radius of the site, and generally at depths of greater than 6m. Thus, the probability of humans (both residents and/or workers) having exposure to abstracted groundwater via dermal contact or ingestion is low.

On 4 June 2020, WSP conducted a desktop survey and walkover of areas surrounding the site for evidence of unregistered bores and the use of those bores. The survey and did not identify any unregistered bores. However, this doesn't rule out the potential for unregistered bores to exist nearby.

Groundwater is not abstracted at the service station site or surrounding properties for any other purpose than clean up/recovery and monitoring, and the depth to groundwater (approximately 6 metres deep at its shallowest in the study area) indicates that the probability of incidental intersection of the impacted groundwater during routine intrusive maintenance works is considered minimal. Where workers are potentially in contact with the water or are performing the clean up and groundwater monitoring activities, those workers follow the appropriate WHS guidelines to mitigate their exposure risks.

The risk of exposure to hydrocarbons in groundwater by on-site and off-site workers, including intrusive (trench) maintenance workers by means of vapour inhalation, dermal contact and ingestion is unlikely. Firstly, vapour intrusion into the sales building and workshop was assessed and deemed acceptable (WSP, March 2020). Secondly, utility pits surrounding the site have been routinely monitored with a photo-ionisation detector (PID) since the project commenced and vapour concentrations have always been below 1 ppm_v. Soil vapour testing in the previous works showed that concentrations were less than health screening level criteria (CRC Care Technical Report No 10) for maintenance workers' vapour exposure in shallow trenches. This risk-receptor pathway of vapour intrusion is therefore considered incomplete.

A further possible exposure pathway is the intrusion of vapours arising from hydrocarbon impacted groundwater and the smear zone created by fluctuations in levels of impacted groundwater. The receptors are the occupants of the buildings on three nominated properties (Zara Gardens, Scott Chambers Building and Raiders Belconnen) determined from earlier screening level assessments of soil vapour, to be potentially exposed to VOC vapours from the migration pathways. The receptors include any person occupying a building for any length of time. The Vapour Risk Assessment (off-site) (WSP October 2020) and subsequent Summertime Vapour Sampling (WSP, May 2021) concluded that the pathway of vapour intrusion into buildings off site has an acceptable risk levels for building occupants. Therefore, the risk-receptor pathway is considered incomplete.

A summary of potential risk pathways and receptors is presented in Table 6.1.

Table 6.1 Risk level assessment for relevant source-pathway-receptor linkages

Potential Receptor	Potential Exposure Pathway	Risk from Exposure Through the Pathway (Is the Linkage Complete & is there a Risk?)
Ecological: Surface water bodies	Discharge of groundwater into surface water bodies – stormwater channel or Ginninderra Creek to the north-west	Considered to be an incomplete pathway as groundwater impacts were not identified in the perimeter wells of the current investigation area approximately 120 m from the source location; therefore, no unacceptable risk.

Potential Receptor	Potential Exposure Pathway	Risk from Exposure Through the Pathway (Is the Linkage Complete & is there a Risk?)
Users of groundwater bores registered for water supply	Abstraction of groundwater for beneficial purpose	There are currently no known users of groundwater within 500 m of the service station. Possible exposure pathways if water is accessed and used are: ingestion; dermal contact; contamination of soil if groundwater is used for irrigation. There are currently no known groundwater extraction bores, with irrigation of the playing fields in Block 47 Section 53 and the Raiders Club utilising mains water. Thus, the risk pathways are believed to be currently incomplete.
Residents and occupiers of commercial buildings	Vapour intrusion	The pathway of vapour intrusion into buildings on and off the site has assessed to result in acceptable risk levels for building occupants. Accordingly, this pathway can be considered incomplete.
Human receptors on open space land	Vapour inhalation	Due to considerable atmospheric dispersion above unconfined open space (the car parking area to the west of the site, and open fields to the north east and east), the level of risk has been shown to be acceptable. The pathway can thus be considered incomplete.
Sub-surface maintenance workers (intrusive trench workers)	Inhalation of vapour in shallow excavation trenches	Soil vapour testing in the earlier environmental site assessment works showed that concentrations were less than screening level criteria (CRC Care Technical Report No 10) for workers' vapour exposure in shallow trenches. This risk-receptor pathway is therefore considered incomplete.
Sub-surface maintenance workers (intrusive trench workers)	Ingestion and direct contact with impacted groundwater or soil	Considered an incomplete pathway. The groundwater is too deep for excavation workers to come into contact with and potential soil contamination is believed to be confined to the service station.

6.6 LNAPL CONCEPTUAL SITE MODEL

In response to the requirements of ACT EPA (2019) *Information Sheet 9* and considering the presence of LNAPL detected at a thickness greater than 3 mm at the site (and also off-site), an LNAPL CSM (LCSM) is required to be developed and presented as part of the site assessment process.

6.6.1 LNAPL CHEMICAL PROPERTIES

LNAPL was found to have a chromatographic profile typical of a slightly degraded Vortex 98 unleaded petrol product. Based on the absence of groundwater impacts in September 2019, and the understanding that the leak possibly commenced in late 2019 (detected in early February 2020), it is estimated that the age of the LNAPL is approximately 15-18 months at the time of writing.

A compositional analysis of the BTEXN component of the LNAPL was also undertaken. The BTEXN component of the LNAPL was identified to make up 18.2% to 34.2 % of the total product across the analysed samples; with the latter more typical of petrol composition. The percentage of benzene was consistent across all samples, which was close to 1%, which meets the Australian regulation of benzene content of petrol of 1%.

6.6.2 LNAPL MOBILITY AND BODY STABILITY

The groundwater monitoring event of 22-24 February 2021 identified LNAPL in wells MW15 and MW16 with measured thicknesses of 0.065 m and 0.071 m respectively. Since the commencement of the works program at the site, regular gauging of the groundwater monitoring well network have been undertaken. Over the course of the 2020-2021 works, the measured LNAPL thickness measured in wells appear to be generally declining across the monitoring well network. The declining thicknesses of LNAPL on-site are at least partially due to the ongoing product recovery measures and / or the rise in groundwater levels across the general area encompassing the well network.

An assessment of LNAPL transmissivity was performed by means of a bail down test on the 21 May 2020. The off-site and downgradient well MW15 was selected for the assessment due to its proximity to sensitive receptors (Zara Gardens residents). Initial gauging of well MW15 prior to undertaking the bail down test showed an apparent LNAPL thickness of 0.663 m. LNAPL transmissivity was estimated at 0.076 m^2/day and indicates that the LNAPL may be recoverable (i.e. is greater than LNAPL transmissivity range of 0.009–0.07 m^2/day (ITRC, 2009)). However, recent attempts during the September 2020 pilot trials to conduct LNAPL transmissivity testing were not be possible due to the reduced LNAPL thicknesses.

As the contamination to groundwater is a recent occurrence, not enough time has passed the for biodegradation of natural attenuation parameters to occur and therefore produce a meaningful result, and the is only limited data collected to date. However, geochemical indicators of microbial activity, and thereby potential natural attenuation processes, were noted by the reduction of pH and DO when comparing the results between the GMEs undertaken in Stage 1 and Stage 2 ESA works.

6.6.3 LNAPL SOURCE – PATHWAYS – RECEPTORS

A summary of the potential receptors of the LNAPL impact detected on and off-site, the potential exposure pathways and an assessment of the likelihood of risk from exposure to the LNAPL through the potential pathway is presented in Table 6.2.

Table 6.2 Source-pathway-receptor linkages related to LNAPL

Potential Receptor	Potential Exposure Pathway	Risk from Exposure Through the Pathway (is the linkage complete & is there a risk?)
Ecological: Surface water bodies	Discharge of LNAPL into surface water bodies – stormwater channel or Ginninderra Creek to the north-west	Considered to be an incomplete pathway as LNAPL was not identified in the perimeter wells of the investigation area approximately 120 m from the source location; therefore, no unacceptable risk.
Users of groundwater bores registered for water supply	Abstraction of groundwater impacted with LNAPL for beneficial purpose	There are currently no known registered users of groundwater within 500 m of the service station. Possible exposure pathways if water is accessed and used are: ingestion; dermal contact; contamination of soil if groundwater is used for irrigation. There are currently no known groundwater extraction bores, with irrigation of the playing fields in Block 47 Section 53 and the Raiders Club utilising mains water. Thus, the exposure pathway associated with groundwater abstraction is incomplete.
Residents and occupiers of commercial buildings	Vapour arising from the LNAPL intrudes and accumulates in buildings	The pathway of vapour intrusion into buildings on and off the site was assessed to result in acceptable risk levels for building occupants. Accordingly, this pathway can be considered incomplete.

Potential Receptor	Potential Exposure Pathway	Risk from Exposure Through the Pathway (is the linkage complete & is there a risk?)
Human receptors on open space land	Vapour arising from the LNAPL is inhaled	Due to considerable atmospheric dispersion above unconfined open space (the car parking area to the west of the site, and open fields to the north east and east), the level of risk has been shown to be acceptable. The pathway can thus be considered incomplete.
Sub-surface maintenance workers (intrusive trench workers)	Vapour arising from the LNAPL enters shallow excavation trenches and is then inhaled	Soil vapour testing in the earlier environmental site assessment works showed that concentrations were less than health screening level criteria (CRC Care Technical Report No 10) for workers' vapour exposure in shallow trenches. This risk-receptor pathway is therefore considered incomplete.
Sub-surface maintenance workers (intrusive trench workers)	Ingestion and direct contact with LNAPL impacted groundwater or soil	The groundwater is too deep (>4m) for excavation workers to come into contact with and potential soil contamination is believed to be confined to the service station. This risk-receptor pathway is therefore considered incomplete.

7 CLEAN UP GOALS

The assessment works conducted to date have determined that there are no unacceptable vapour inhalation risks to existing receptors, specifically the on-site commercial workers, and the commercial and residential receptors located adjacent to the site (i.e. residents in Zara Gardens and the commercial occupants of the Raiders Sports Club and the Scott Chambers Building). In addition to the vapour risks being low and acceptable to on- and off-site receptors, the plume has been delineated in all directions, and is not impacting any surface water receptor or the users of a groundwater bore.

While the risks to receptors are low and acceptable, LNAPL at a thickness of more than 3mm has been identified at site and in the immediate off site areas during all gauging events since February 2020, and thus in accordance with ACT *Contaminated Sites Information Sheet 9: Management of groundwater impacted by light non-aqueous phase liquids (LNAPL)* (dated April 2019) (Information Sheet 9) ongoing management of the LNAPL and the associated dissolved phase plume is required. Information Sheet 9 states that:

> *"Where LNAPL has been identified at* ***3mm*** *or greater at a site a follow-up gauging event must be performed within three (3) months of its original detection. Where LNAPL is again detected at* ***3mm*** *or greater active remediation or ongoing management of the LNAPL is required."*

Information Sheet 9 also states:

> *"Any remedial action must demonstrate that there are no unacceptable risks to human health, the environment and the beneficial uses of the groundwater.*
>
> *The results of the risk assessment will guide the level of LNAPL clean-up that is required. LNAPL needs to be cleaned up to such an extent that further removal or treatment of LNAPL no longer reduces the level of risk. 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."*

Therefore, given the absence of unacceptable risks to receptors, and taking the regulatory guidance from Information Sheet 9 into consideration, the clean up goals for the site are to:

- Remove all observable LNAPL contamination[2] from the groundwater on and off the site such that the LNAPL thicknesses are <3mm for at least three consecutive months; and
- Reduce the dissolved phase hydrocarbons to the maximum extent practicable, ensuring that there remains no unacceptable risk to human health and the environment and the beneficial uses of the groundwater; and
- Ensure that the LNAPL and dissolved phase plumes are not spreading.

The overall clean up end-points for operation of the chosen clean up strategy correspond to these clean up goals. However, it is acknowledged that to remove the residual hydrocarbon impacts from soil and groundwater (such that the LNAPL thickness in all wells remain less than 3mm for three consecutive months) may require active clean up for many years.

Given that the LNAPL removal may not be achieved via active clean up within a reasonable timeframe, a review of the clean up outcomes at an appropriate point in time may be required. This will enable an assessment of practicability of ongoing clean up.

While Information Sheet 9 acknowledges that the level of clean up will be guided by risks, and the nature of the LNAPL and / or dissolved phase plumes (e.g. expanding, stable or contracting), there is no guidance on when clean up has been conducted to the "*extent practicable*" (or similar). In lieu of such guidance in the ACT, it is proposed that the Environment Protection Authority Victoria (EPA Victoria) Publication 840.2 "*The Clean Up and Management of Polluted Groundwaters*" (April 2016) (Publication 840.2) is used as the basis for determining the practicable limit of

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2 As per the LNAPL definition in Information Sheet 9

groundwater clean up (Publication 840.2 is included as Appendix H in the attached RAP (Appendix A). This document recognises the impracticability in some cases of full clean up, to the point where groundwater contamination no longer compromises any potential beneficial uses. In this case, the option is available for clean up to be carried out (to the extent practicable), and for this to be demonstrated to EPA Victoria in a formal submission (which in this case would be ACT EPA via the Site Auditor).

Only where the Site Auditor and ACT EPA agrees that clean up has been conducted to the extent practicable, will it be acceptable for further clean up efforts to be ceased. Cessation of clean up works under a '*clean up to the extent practicable*' (CUTEP) scenario would then be subject to ongoing groundwater management (via a long term management plan), including any measures required to ensure the risks remain low and acceptable, monitoring (i.e. a Monitored Natural Attenuation (MNA) Strategy, as per Information Sheet 9), and contingency measures should conditions worsen. It is also subject to periodic EPA review that may determine that clean up efforts need to be revisited.

In the event LNAPL removal (such that the LNAPL thickness in all wells remain less than 3mm for three consecutive months) cannot be achieved, and WSP considers clean up has been conducted to the 'extent practicable', a review of the practicability of further clean up using the current clean up approach or additional clean up measures will be undertaken in consultation with the Auditor. Where further clean up works are considered impracticable, with agreement from the Auditor and ACT EPA, the residual impacts would be assessed, and management measures implemented where required. A cessation of clean up submission would then be prepared for determination from EPA (See Section 10 for further details on the clean up validation protocols / end points).

8 CLEAN UP OPTIONS & STRATEGY

8.1 REMEDIAL OPTIONS ASSESSMENT

In September 2020, WSP conducted a desktop assessment of the options for the clean up and management of the gross impacts sourced from the site. A wide range of clean up technologies were assessed taking into consideration factors such as the reasons for the clean up work and any constraints on it, risk management, technical suitability and feasibility, stakeholders' views, cost/benefit ratio and wider environmental, social and economic impacts (i.e. waste generation, sustainable development, etc.).

Based on the nature and extent of impacts, the geology / hydrogeology, site setting, and the ability for the clean up technologies to remove / reduce / transform contaminant mass, costs and treatment time of implementation, the initial remediation screening process prepared for the site showed that the clean up technologies that are retained for further consideration are:

- SVE (with / without pumping);
- MPVE;
- ISCO; and
- (Continued) pumping.

The Remediation Options Assessment is attached in full in Appendix D. Based on the Remediation Options Assessment remediation trials were conducted for SVE, SVE + Pumping, MPVE and ISCO. As outlined within Section 4.2.3 and in Appendix D, it was considered that each technology could be effectively applied at the site. The pneumatic and hydraulic radius of influence for technologies was at least 10 m, and the hydrocarbon mass removal rate (based on carbon tube results) was well above 1 kg/hr.

Although the extractive clean up technologies trialled use very similar techniques to recover/destroy the hydrocarbon impact, the MPVE approach utilises greater applied wellhead vacuum, which can result in greater hydrocarbon mass removal rates.

Generally, the main advantage of MPVE over the concurrent down-hole pumping and SVE approach is that a higher vacuum is able to be applied to the extraction points via MPVE, and consequently it is more suited to relatively impermeable formations, such as clays and fractured rock.

However, an advantage of the concurrent down-hole pumping and SVE approach over MPVE is that generally the transfer of fluids (liquids and vapour) is more efficient. The concurrent down-hole pumping and SVE approach transfers the liquids and vapour separately back to the remediation compound, which requires less energy than transferring the liquids and vapour together (as per a MPVE system) from the extraction points to the remediation plant.

Additionally, greater hydraulic control of the plume is able to be maintained through the application of down-hole pumping and SVE. However, the volume of water able to be pumped, and therefore the hydraulic control of the plume, may be limited by the maximum volume of water able to be discharged under a (likely) trade waste agreement.

It is considered that SVE + Pumping can achieve similar mass recovery and ROI as MPVE, with lower applied vacuum (and accordingly lower energy requirements), and with more efficient transfer and treatment of fluids. Additionally, the current power supply at the site is insufficient to run MPVE (with water treatment) or SVE + Pumping (with water treatment) at any one time, however there is sufficient electrical supply to run SVE at night with groundwater pumping (no water treatment), and / or pumping (with water treatment, but no SVE) during the day. Therefore SVE + Pumping is considered to be most appropriate and flexible extraction clean up technology for the on-site areas.

While SVE + pumping could transfer fluids back to the site efficiently, access restrictions (particularly the road crossing of Hardwick Crescent), and the presence of trees and numerous underground services on the northern side of Hardwick

Crescent is a limitation of the expansion of the on-site SVE + pumping system to the north (across Hardwick Crescent). Therefore, to address the (LNAPL) impacts on the northern side of Hardwick Crescent (e.g. MW15 – MW17), a series of mobile MPVE events is considered to be most appropriate extraction clean up technology for these off-site areas.

In regard to ISCO injection at the site, the remediation trial results suggest that there is sufficient connectivity to ensure chemical injection will be an effective clean up technique where impacts are present (e.g. IW1 and IW2). However, given the likely chemical oxidant demand (typically 20:1), it is considered that chemical injection will be more suitable once the bulk of the hydrocarbon removal has been conducted through the chosen active extraction method, i.e. SVE + Pumping). This would mean that less chemicals would be required for injection, which would save on costs of chemical product, less infrastructure requirements (pumps, mixing containers, dosing equipment) and minimise the storage of potentially hazardous chemicals on the site.

8.2 PROPOSED (ON-SITE) CLEAN UP METHOD

SVE + Pumping was selected as the most appropriate clean up method to address the bulk LNAPL/hydrocarbon contamination on site in a timely, cost efficient and sustainable manner. The proposed system will be installed and operated to remove adsorbed, vapor-phase and dissolved phase hydrocarbons from subsurface soil and groundwater. Once the majority of the hydrocarbon/LNAPL mass has been removed and the clean up system is observing diminishing returns (and mothballing of the system does not result in significant rebound), ISCO will be considered to remove the residual dissolved phase hydrocarbons remaining, as required.

The active system can be broken down into two main parts, the SVE extraction and treatment component and the groundwater pumping and treatment component. The SVE extracts and treats the contamination that is able to be volatilised within the soil and groundwater, and the liquid pumping component extracts and treats the contaminated groundwater and LNAPL. The concurrent dewatering aims to ensure that the smear zone is further exposed, which enables a larger effective ROI and more efficient hydrocarbon removal. Figure 1 below presents conceptual remediation model proposed for the site.

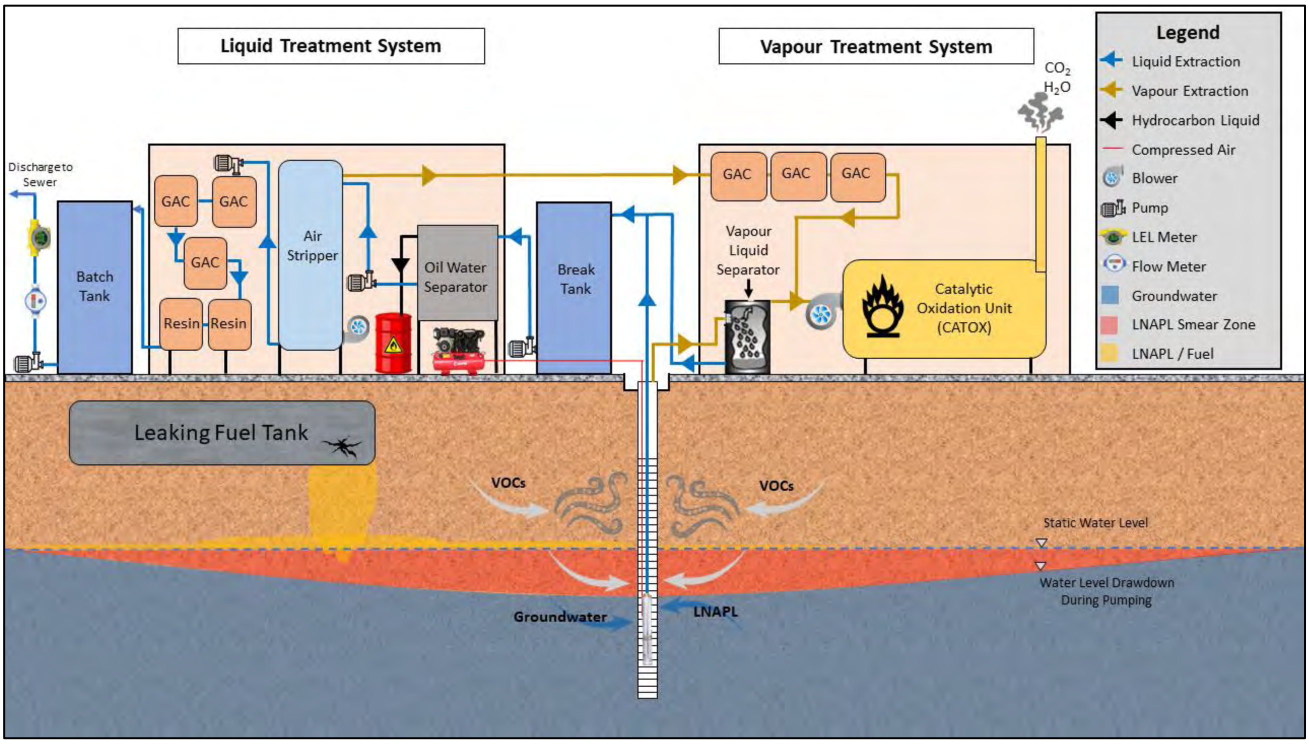


Figure 1 Conceptual remediation model for the site showing both the proposed liquid and vapour treatment components.

The remediation contractors detailed schematic design drawings are presented in Appendix G.

We note that unless the existing power supply to the site can be upgraded in cost and time effective manner, the system will be designed and operated such that the SVE component of the system operates during the night (when the store is closed), and the pumping and groundwater treatment component of system operates during the day (while the store is open). The pumps will continue to extract liquids during the night, however the water treatment system will not operate. The system will be configured so that pumping will cease once the initial break tank high switch is triggered, but SVE will continue to operate.

8.2.1 EXTRACTION WELLS & PIPE NETWORK

To ensure that the clean up approach has sufficient coverage of the site, several extraction wells will need to be installed across the site. The remediation trial at the site conservatively assumes that the ROI that will be achievable at the site to be 10-15 m. Considering this expected ROI, the extent of contamination, and groundwater flow, it is proposed that a total of nine extraction wells are used within the on-site system. Figures 6a and 6b (Appendix A) presents the proposed extraction well and associated pipe work layout. It should be noted that this system layout is subject to change, due to factors such as the location and depth of underground services, and where future UPSS may be located if they were to be replaced at the site.

Each of the extraction wells will be 100 mm diameter wells and screened appropriately to ensure that enough of the screened section is below the SWL. This will allow for installation of the groundwater pump at a suitable level for groundwater drawdown. There should also be sufficient screen above the SWL to ensure that sufficient soil vapours can be extracted from the target smear zone. Due to the potentially long-term duration of the clean up works, seasonal changes in water levels will be considered when installing the extraction wells.

The design of the extraction well heads will allow for the connection of both the vapour extraction pipeline, as well as the pneumatic pumps compressed air feed line and pumps outlet liquid flow line (three separate connections to each wellhead). Each of the lines (vapour outlet, compressed air inlet and pump liquid outlet) will have a valve close to the well head to ensure that the flows can be easily adjusted or isolation of that specific extraction well.

The pipework will be located below ground (within trenches) to ensure that vehicle and pedestrian traffic is minimally affected by the operations.

The extraction wells will be connected to the containerised treatment components via the proposed pipe network. Each of the treatment components, the vapour treatment system and the liquids treatment system, are outlined in detailed below.

8.2.2 VAPOUR TREAMENT SYSTEM

The vapour treatment component will consist of a containerised system containing the following:

- Inlet manifold;
- Vapour / liquid separator.;
- Extraction blower; and
- Catalytic oxidation (CatOx) unit.

The system will be controlled by an automated control panel (programmable logic controller (PLC)), which uses several sensors to control the flow and combustion / reaction within the CatOx unit.

8.2.2.1 INLET MANIFOLD

The vapour extraction pipelines will enter the containerised treatment system through an inlet manifold. Each outlet from the manifold will have valves installed in order to regulates the vacuum flow from each extraction well. The inlet manifold will enter, through a single pipe, to the vapour / liquid separator.

8.2.2.2 VAPOUR / LIQUID SEPARATOR

The vapour / liquid separator, also known as a "knock out pot", is used to separate out liquid that may be entrained with the extracted vapour stream. This protects the blower pump and vapour treatment system located downstream of the separator from potential damage from liquid ingress. Condensation of water vapour from the extracted vapour stream can be a significant issue in SVE systems, occurring when ambient temperatures are greater than the extracted vapour stream temperature. Condensation can occur with a decrease of temperature (e.g. during winter) or where a pressure reduction of the stream occurs. The separated liquid captured by the vapour / liquid separator is pumped over to the water treatment system for further removal of contaminants.

8.2.2.3 VAPOUR EXTRACTION BLOWER

The blower is located after the vapour liquid separator, and is used to produce the vacuum in the system that extracts the vapours from the extraction wells and transports it back to the treatment system.

8.2.2.4 CATOX UNIT

Catalytic oxidation, through the use heat and a catalyst, converts the extracted VOCs into carbon dioxide and water. This exhaust is then released to the atmosphere through an exhaust vent.

The heat for the oxidation of the contaminant comes initially from a supplemental heat source (electric heaters) and, once the system is running, by a combination of the supplemental heat and combustion of the contaminant itself (where there is sufficient calorific value in the extracted vapour stream).

The CatOx unit proposed for this site utilises a heat exchanger to capture the heat from the combustion process and then use this to pre-heat the vapour stream before it enters the system, increasing the efficiency of the system and reducing the need for the use of supplemental heat.

CatOx utilises a catalyst (in this case platinum and palladium coated ceramic beads) to destroy the VOCs at much lower temperatures (315 – 430°C). The lower temperature prevents the potential to form dioxins.

Figure 2 below presents the processes involved in treating VOCs using a CatOx system.

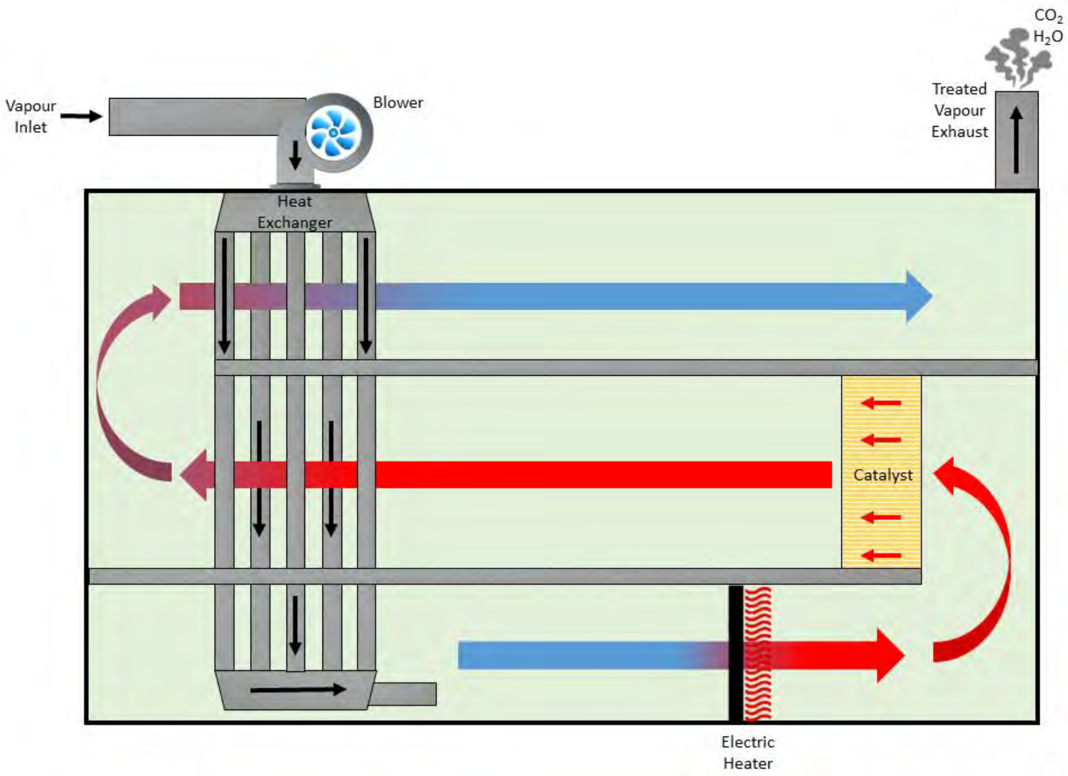


Figure 2 Example of a CatOx vapour treatment process for destroying VOCs.

8.2.3 WATER TREATMENT SYSTEM

The water treatment component will consist of a containerised system containing the following:

- Inlet manifold;
- Oil water separator;
- Air stripper; and
- GAC filter.
- Resin filter.

The system will be controlled by an automated control panel (programmable logic controller (PLC)), which uses several sensors to control the treatment process.

8.2.3.1 OIL WATER SEPARATOR

The extracted liquids are initially pumped to the Break Tank. The Break Tank allows the LNAPL (fuel) to rise to the surface of the liquid mixture, ultimately separating the water from the bulk of hydrocarbons (in the fuel) using their different specific gravities. The tank will be routinely monitored using an interface probe to detect any LNAPL (fuel) that can be routinely pumped out and trucked off site for disposal.

Separated water is then pumped from the bottom of the Break Tank to the oil/water separator, in this case a coalescing plate separator (CPS) – see Figure 3 below. Once the water enters the CPS unit, it flows laterally through the coalescing plates which aid the removal of any LNAPL (fuel) that managed to be drawn out of the Break Tank. The coalescing plates have a zero velocity boundary condition where LNAPL is able to move vertically up the plates to the surface and water continues to move over a weir to a back-end storage tank. Any LNAPL that has migrated to the surface of the CPS unit will be skimmed off by two conical lateral skimmers and stored in a 20L container. The treated water in the back-end of the CPS unit is then pumped into the air stripper.

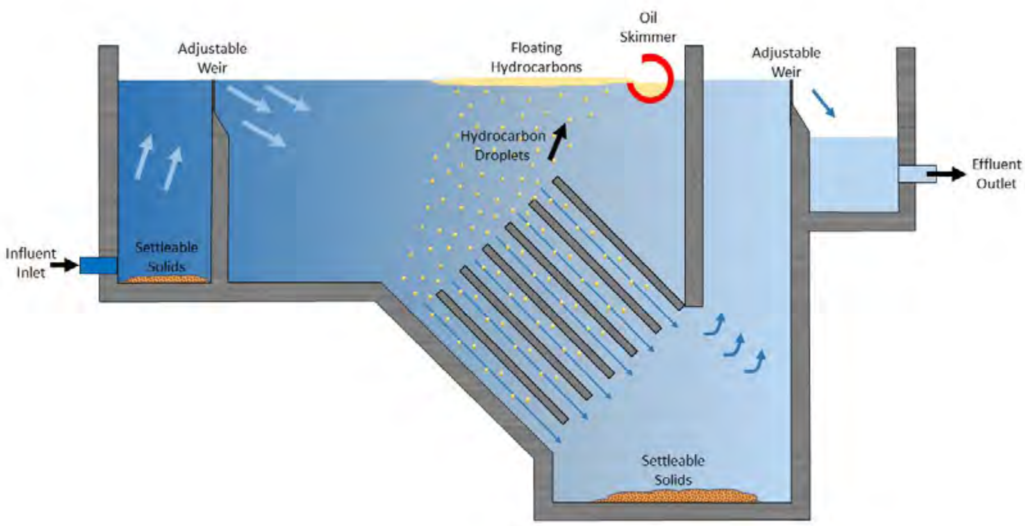


Figure 3 Example of an oil / water separator unit, showing the treatment processes.

8.2.3.2 AIR STRIPPER

Air stripping is the process of moving air through contaminated water to remove the volatile hydrocarbons dissolved within the wastewater stream. The influent water is distributed over a series of perforated trays, and as the liquid flows downward over the trays, a blower unit forces clean atmospheric air up in a counter flow direction to the water stream (see adjacent Figure 4).

The interface interaction between the downward moving contaminated water and the upward moving air stream induces the transfer of volatile hydrocarbons in the water into the air stream. The rising air and vapours accumulate at the top of the air stripper tank, where they are collected and transferred to a separate vapour treatment unit.

After the water has been pumped through the air stripper, the treated effluent is stored in a small holding tank at the bottom of air stripper prior to processing through three granular activated carbon (GAC) adsorption vessels.

Figure 4 Example of an air stripping unit.

8.2.3.3 GRANULAR ACTIVATED CARBON (GAC)

GAC treatment of wastewater involves passing the influent stream through a vessel filled with granulated activated carbon. GAC comprises of carbon-rich granular material such as charcoal, which has been processed so that it has an increased surface area upon which contaminants can adsorb from the extracted water stream or with which they can react chemically. GAC treatment will consist of three GAC vessels joined together in series.

Due to the process of adsorption, the GAC will eventually become saturated with contaminates. This will depend on the contaminant concentration of the influent stream, but when GAC media saturation occurs, the GAC will be replaced.

The water treated by the GAC vessels is pumped into resin filters for the final polishing step to remove PFAS.

8.2.3.4 RESIN FILTRATION

Resin filtration treatment of wastewater involves passing the influent stream through a vessel filled with ion exchange resin. Ion exchange resins are made up of highly porous, polymeric material that is acid, base, and water insoluble. Positively charged anion exchange resins (AER) are effective for removing negatively charged contaminants (like PFAS), as the negatively charged ions of PFAS are attracted to the positively charged anion resins.

The resin filtration is the final polishing step that has been included to ensure the PFAS in the recovered groundwater is removed to comply with the Icon Water requirements for the trade waste discharge. The resin filtration treatment consists of two resin filters joined together in series immediately following the GAC vessels. Like GAC, the resin will eventually become saturated with PFAS, and when the resin media saturation occurs, it will be replaced.

The water treated by the GAC and resin filters is then pumped into a 5kL Treated Water Batch Tank for storage before the treated water is discharged through an approved Water Flow Meter (FMOL) and LEL Meter (LEL). The discharge water will also have to be sampled as per the ICON trade waste agreement in order to ensure the water quality meets the discharge criteria.

8.2.4 ELECTRICAL CONNECTION

A data logger was installed at the site to monitor the power consumption during the day. Based on the outcomes of the assessment of the current site electrical usage, the existing electrical supply to the site (80 amps) has sufficient capacity to operate the pumping and water treatment components of the system while the site is operational (7:00am to 9:00pm). However, there is insufficient power supply to the site to run the SVE component of the system while the site is operational.

Therefore, unless the existing power supply to the site can be upgraded in cost and time effective manner, the system will be designed and operated such that the SVE component of the system operates during the night (when the store is closed, and there is less power consumption), and the pumping and groundwater treatment component of system operates during the day (while the store is open). The pumps will continue to extract liquids when the store is closed, however the water treatment components of the system will not operate. The system will be configured so that pumping will cease once the initial break tank fills and the high switch is triggered, but SVE system will continue to operate.

8.2.5 CLEAN UP SYSTEM PERMITS

8.2.5.1 DEVELOPMENT APPLICATION

Initial discussions / enquires with the ACT Government regarding the proposed clean up works at the site has indicated that a Development Application (DA) will be required.

As part of the DA process, we will be required to obtain an Environmental Significance Opinion (ESO) that will need to be approved by EPA. The ESO seeks an opinion that the site development is not likely to have a significant adverse environmental or heritage impact. If an opinion is given to that effect, the proposal is taken out of the impact track, unless other reasons apply. A merit track development application can then be submitted. It is anticipated that this RAP (in particular the environmental management components outlined in Section 13) will constitute a large component of the ESO that would be submitted for review and approval by EPA. Once approved, the ESO will then need to make up a component of the DA submission.

With respect to the timeframes for the ESO and DA process are as follows:

- ESO approval: 30 working days from submission; and
- (Merit Track) DA approval: 30-45 working days from submission (noting that the submission can only occur after the ESO has been approved).

8.2.5.2 EFFLUENT DISPOSAL (WASTE MANAGEMENT)

It is proposed to discharge the treated wastewater to sewer under a Trade Waste permit. The issuing of this permit may be a limiting factor for the implementation of an SVE + Pumping system. Preliminary discussions with the water authority (Icon Water) have indicated that they do not normally accept groundwater within trade waste. Discussions are ongoing and a trade waste application has been resubmitted (following the PFAS sampling results), and we expect that they will accept the treated water as trade waste if we can demonstrate that there is no other viable option and appropriate reduction in contaminants within the effluent water can be achieved.

8.3 PROPOSED (OFF-SITE) CLEAN UP METHOD

A series of mobile MPVE events was selected as the most appropriate clean up method to address the bulk LNAPL/hydrocarbon contamination off site to the north (across Hardwick Crescent) in a timely, cost efficient, sustainable and safe manner.

The MPVE events will be conducted monthly to remove adsorbed, vapor-phase and dissolved phase hydrocarbons from subsurface soil and groundwater.

8.3.1 EXTRACTION WELLS & PIPE NETWORK

To ensure that the clean up approach has sufficient coverage of the impacted areas to the north of the site, four extraction wells will be installed on the northern side of Hardwick Crescent. The remediation trial at the site conservatively assumes that the ROI that will be achievable at the site to be 10-15 m. Considering this expected ROI, the extent of contamination, groundwater flow, and location of underground services and existing trees, it is proposed that a total of four off-site extraction wells are used for the mobile MPVE events, as shown in Figure 6a (Appendix A).

Each of the extraction wells will be 100 mm diameter wells and screened appropriately to ensure that enough of the screened section is below the SWL, to account for fluctuations in the top of fluids, and to ensure there is sufficient screen above the SWL to ensure that soil vapours can be extracted from the target smear zone.

8.3.2 MPVE EVENTS

The MPVE events will consist of the following:

- 12 MPVE events (assumed three days each) to be conducted (nominally) monthly over the course of a 12-month period. Each MPVE event will be supervised by experienced WSP field staff. Based on the previous MPVE events we have assumed extraction and disposal of up to 1500 L impacted groundwater per day.
- MPVE was conducted at the site using the trailer-mounted MPVE system that utilises GAC to treat the recovered hydrocarbons in vapour.
- The inlet of the drop tube (stinger) will be placed at the approximate depth of the LNAPL / groundwater interface, with the depth modified at times in an attempt to maximise hydrocarbon removal.
- During the application of MPVE, vacuum gauges will be attached to observation wells (e.g. MW15 – MW17) to detect the pneumatic response and gauging will be conducted to measure changes in SWL.
- The air flow rates, temperatures, fuel consumption, applied vacuum, hydrocarbon concentrations in the vapour in the extracted air will be measured using the MPVE unit.
- The recovered vapour from the extraction event will be treated by activated carbon canisters to adsorb the volatile organic compounds (VOCs) from the recovered vapour. The recovered liquids were stored within the (dangerous goods rated) truck for off-site disposal.

- To monitoring the changes in LNAPL and hydrocarbon impacts in groundwater, gauging will be conducted monthly as part of the MPVE works (prior to, during and immediately after each MPVE event), and GMEs will be conducted six-monthly (at a minimum).

9 CLEAN UP MONITORING PLAN

9.1 CLEAN UP SYSTEM MONITORING

Regular monitoring and maintenance of the on-site clean up system will be conducted throughout the operational period. Operation and maintenance (O&M) monitoring will be undertaken as follows.

- Daily monitoring of the system via telemetry; and
- Regular (at least monthly) O&M site visits.

O&M activities will include monitoring of the following:

- Groundwater gauging of key monitoring wells (See Section 9.2);
- Fluid flow monitoring, checks on the water treatment system operation;
- Sampling and laboratory testing of treated fluids;
- Adjustment of fluid flows from individual wells as a result of interpretation of system operation, gauging and vapouring monitoring during site visits;
- General checks on equipment condition and operation, including operation of the vacuum blower and pumps;
- Checks of operation of all level switches and critical safety devices;
- Off-site disposal of LNAPL; and
- Issue of a biannual progress report.

9.2 SAMPLE DESIGN AND RATIONALE

In order to assess the effectiveness of the clean up strategy during and post clean up, systematic groundwater and soil vapour monitoring will be undertaken. The sampling events will be undertaken to provide data on the temporal distribution and migration of the LNAPL, dissolved phase plume, vapour phase impacts, and to what extent the concentrations of hydrocarbons are reduced (or not).

The locations and the rationale of the monitoring events are presented in Table 9.1, and plans of the following groundwater monitoring locations is presented in Appendix A:

- Figure 7a: Monthly gauging wells
- Figure 7b: Quarterly groundwater sampling wells
- Figure 7c: Biannual groundwater sampling wells
- Figure 7d: Monitored natural attenuation (MNA) parameter wells.
- Figure 7e: Biannual soil vapouring locations

Table 9.1 Proposed assessment locations and rationale

ASSESSMENT METHOD/MODE	LOCATION	MATRIX	PARAMETER MEASURED	RATIONALE
Monthly Gauging (Attachment A – Figure 7a)	MW01 MW24 MW02 PMW1 MW04 PMW2 MW05 PMW4 MW06 PEW1 MW07 IW01 MW09 IW02 MW10 IW03 MW11 EW01 MW12 EW02 MW15 EW03 MW16 S2-P2 MW17	Groundwater LNAPL	- LNAPL Presence/Absence - LNAPL Thickness - Groundwater Level	- The purpose of these GMEs is to the monitor trends in LNAPL thickness in key selected wells. - These wells have been selected due to the historical presence of LNAPL, as well as providing good coverage of the site.
Quarterly Groundwater Sampling (Attachment A – Figure 7b)	MW01 MW16 MW02 MW17 MW04 MW24 MW05 PMW1 MW06 PMW3 MW07 IW01 MW10 EW01 MW15 S2-P2	Groundwater LNAPL	- LNAPL Presence/Absence - LNAPL Thickness - Groundwater Level - Hydrocarbons (TPH & BTEXN)	- The purpose of these GMEs is to the monitor trends in LNAPL thickness and hydrocarbon concentrations in key selected wells. - If no LNAPL is present, then the groundwater will be sampled and analysed for dissolved phase hydrocarbons. - These wells have been selected due to the historical presence of LNAPL, as well as providing good coverage of the site.
Bi-annual Groundwater Sampling (Attachment A – Figures 7c and 7d)	All wells, with selected wells for Monitored Natural Attenuation (MNA) related parameters (attachment A – Figure 7c)	Groundwater LNAPL	- LNAPL Presence/Absence - LNAPL Thickness - Groundwater Level - Hydrocarbons (TPH & BTEXN) - Selected wells for MNA[1,2] related parameters	- The purpose of these GMEs is to the monitor trends in LNAPL thickness and hydrocarbon concentrations in all wells. - If no LNAPL is present, then the groundwater will be sampled and analysed for dissolved phase hydrocarbons - MNA related parameters in selected wells will be analysed to assist with the long-term assessment of MNA.
Bi-annual Soil Vapour Sampling (Attachment A – Figure 7e)	SV01S SS1 SV02S SS2 SV02D SS3 SV03S SVB1Z SV03D SVB2Z SV04S SS2SC SV04D SV05S SV05D SV06S	Soil vapour	Samples are to be analysed for a broad range of volatile petroleum hydrocarbons from C_5 to C_{15} (including BTEXN and NEPM fractions F1 and F2).	- The purpose of the vapour sampling is to the monitor trends in soil vapour in soil vapour bores and sub-slab pins on- and off-site (and largely within the assumed influence of the remediation system), and to monitor the risk of exposure of the off-site receptors (e.g. Zara Gardens residents) to soil vapours.

1 – MNA Parameters = nitrite, nitrate, sulphate, ferrous iron, dissolved methane & alkalinity as bicarbonate.

2 – Selected wells include MW01, MW02, MW04 – MW07, MW10, MW15 – MW17, MW24, PMW1, PMW3, IW01, EW01, S2-P2, S2-P5, S2-P6, S2-C5 and S2-C10 (these additional wells are outlined within Appendix A – Figure 7c).

The SAQP for the groundwater monitoring and soil vapour monitoring works is attached in Appendix I.

9.3 DATA QUALITY PLANNING

9.3.1 DATA QUALITY OBJECTIVES

The initial, fundamental and prerequisite step in quality assurance for the monitoring of the clean up works is to choose sampling and analytical methods that can provide the data that are necessary to meet the project's objective. A second and equally critical prerequisite is to design a sampling pattern that enable the data to be interpreted, such that the question to be answered can be addressed (i.e. to investigate the effectiveness of the clean up strategy).

Schedule B2 of the NEPM 2013 presents guidance on certain aspects of quality assurance planning and recommends that a systematic planning process is used to ensure the quality of data collected for site assessments. The NEPM 2013 states:

> "*In its simplest form, the planning process should consider:*
>
> - *the overall objective of the site assessment;*
> - *the decision(s) to be made on the basis of the site assessment findings;*
> - *the constraints on the assessment (financial, time and logistical); and*
> - *the degree of flexibility to conduct follow-up investigations."*

The intent of a data quality planning process is to identify the sampling design and methodologies needed to undertake measurements that are sufficient to meet the study objectives. A second aspect of data quality control is the process of assuring the quality of the data collected which in turn involves the controls on how data / samples are collected. A third aspect is how the reliability of the data / analytical results is determined.

For the current project, the practical considerations for data quality planning are to design a monitoring program that enables or ensures:

- Contaminants can be detected if present at concentrations exceeding background levels;
- The collection of sufficient data to enable the project objectives to be met;
- The selection of sampling locations that were relevant to the project objectives;
- The use of appropriate sampling methodologies applying standard documented operating procedures;
- Sufficient duplication to provide confidence in the precision of the data;
- Careful sample handling and transport; and
- Use of an analytical laboratory that is expert in the analytical methods required by the sampling.

9.3.2 STATEMENT OF DATA QUALITY OBJECTIVES

The NSW EPA's '*Guidelines for the NSW Site Auditor Scheme (3rd edition)*', 2017, requires that, when undertaking an environmental assessment or clean up program, the consultant has properly addressed and adopted data quality objectives (DQOs) for the investigation or validation program and that the consultant's report includes the following:

- A statement of pre-determined DQOs for field and laboratory procedures, including quantitative DQOs;
- A plan to achieve pre-determined DQOs; and
- Procedures to be undertaken if the data do not meet the expected DQOs.

The US EPA has produced a document describing a process for quality assurance planning for projects and identifies seven steps and considerations in describing data quality objectives. The document, USEPA 2000, *Guidance for the Data Objective Process and Data Quality Objectives Process for Hazardous Waste Site Investigations* specifies that the Data

Quality Objectives process is a seven-step planning approach to develop sampling designs for data collection activities that support decision making.

For the proposed investigation WSP has adapted the US EPA's seven step DQO process to the project objectives. A description of the process is given below in Table 9.2.

Table 9.2 Data Quality Objectives

ITEM	METHODOLOGY
State the Problem	This step involves clarifying the issue to be resolved – i.e. the problem that initiated the study. In this case, the problem is to produce reliable data that accurately demonstrate the recovery rates of the clean up system, and characterise and determine trends of the LNAPL and concentrations of hydrocarbon contaminants in groundwater so that the effectiveness of the clean up strategy can be assessed.
Identify the Decision	The decision to be made is whether the data, when compared to relevant assessment criteria and clean up goals, demonstrate decreasing contamination trends and the acceptable contaminant conditions with respect to site suitability. More specifically for this site, the decisions to be made are: — Has the nature and extent of the groundwater / soil vapour contamination in and beyond the site boundary been adequately characterised and suitably remediated? — Has the nature and extent of the LNAPL present in and beyond the site boundary been assessed and suitably remediated? — Have the clean up system hydrocarbon recovery rates decreased and reached an asymptote? — Is there a statistically significant decreasing trend in hydrocarbon concentrations in groundwater and / or soil vapour? — Does the contamination pose an unacceptable risk to the off-site human and/or ecological receptors?
Identify the Inputs to the Decision	This process identifies the information that is needed to resolve the problem and make a decision. This involves: acceptance of the data collection, investigation, sampling and analytical methods and acceptance of the quality of the data and its completeness. If sufficient data of suitable quality are not collected, plans for the collection of additional quality data would be needed. The clean up system recovery data collected daily via the programmable logic controller will be evaluated for completeness and quality. The gauging and analytical data from the sampling of groundwater and soil vapour collected during the site works, will be evaluated for completeness and quality. National and ACT government endorsed criteria for assessing the results will be the basis of decisions on data completeness and quality.

ITEM	METHODOLOGY
Define the Study Boundaries	The boundaries of the investigation are: — **Spatial boundaries:** the spatial boundary of the clean up area is defined as likely radius of influence of the active clean up system (see Figures 6a and 6b (Appendix A)). The spatial boundary of the assessment area extends beyond the clean up area, and is the geographical extent of all wells extending in all directions from the site (see Figure 7c (Appendix A)). — **Vertical boundaries:** the vertical boundaries correspond to the depths of the bases of the clean up and monitoring wells — **Temporal boundaries:** the date of the project inception to the completion of the clean up works under this RAP, and prior to the implementation of the post-clean up management plan (if required).
Develop a Decision Rule	These steps involve the choosing of parameters and action levels on which to base a decision. Published values for acceptable exposure levels and risk levels will be used as the basis of the decision. The parameters of interest are clean up system hydrocarbon recovery rates (as both vapour and liquid), and the listed contaminants of concern, and the concentrations thereof, in groundwater and soil vapour. An assessment of the concentrations of the contaminants of concern in the sampling locations tested will be undertaken to ensure that the data gaps have been adequately investigated. Groundwater and soil vapour results would be compared to a range of assessment criteria for different receptor endpoints to determine the potential exposure routes.
Specify Tolerable Limits on Decision Errors	This step concerns the interpretation of the data – whether the data indicates a problem exists or does not exist. In the case of this project, the decision to be made is whether the site has been suitably remediated, considering the clean up goals outlined within the RAP. The consequences of a false negative decision (no risk indicated, stable or reducing plume, limited mass recovery) is more serious than a false positive decision. Therefore, the limit for the false negative decision will be set at a low detection level (of contamination) and low hydrocarbon recovery rates.
Optimise the Design	This step involves processes and considerations for designing a resource effective operations and maintenance (O&M), sampling and analysis program. The clean up monitoring has been designed considering knowledge of the leak, information from previous assessment works, and the clean up system outputs. The resource effective data collection design that is expected to satisfy the DQOs is described in detail above.

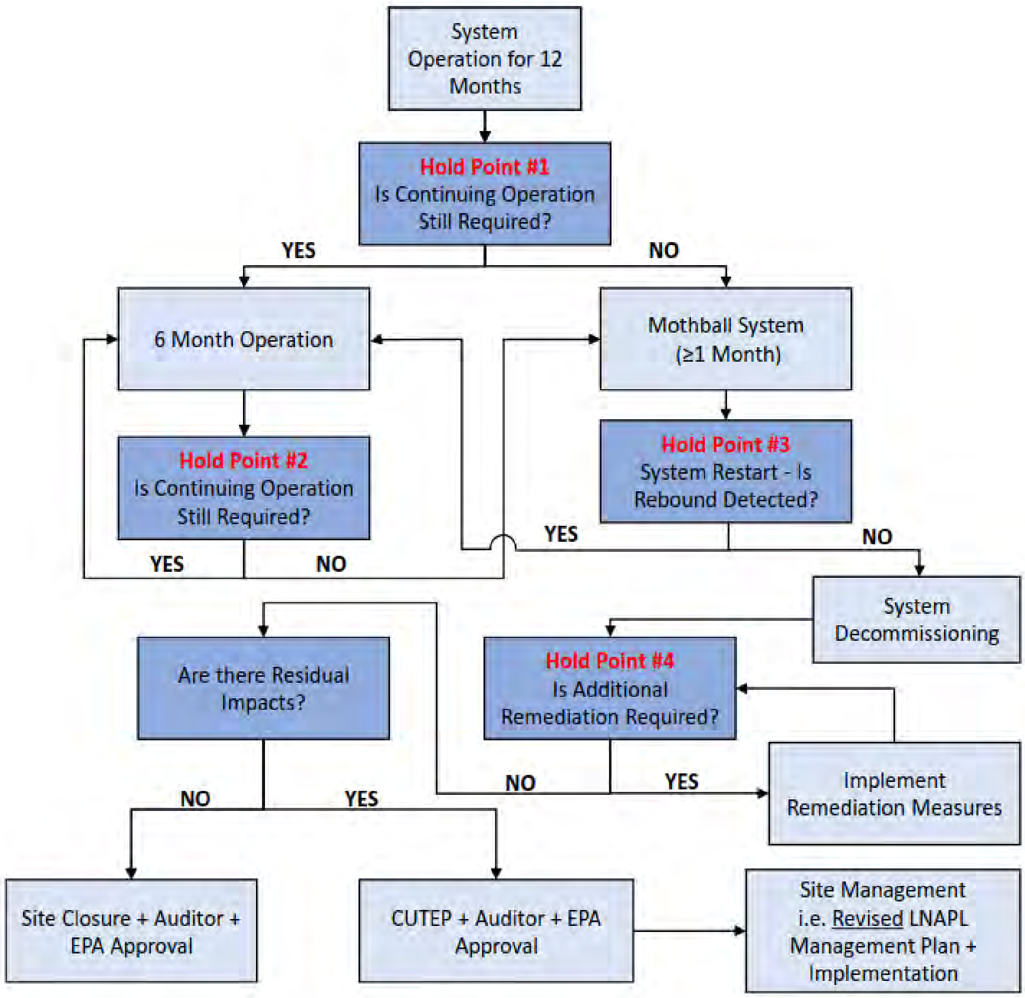
9.3.3 DATA QUALITY PROTOCOLS

A summary of the quality assurance and quality control (QA/QC) protocols to be followed for collecting and analysing the groundwater monitoring and soil vapour works are presented in the SAQP (Appendix I).

10 VALIDATION PLAN / END POINTS

Following operation of the clean up system, it will be necessary to validate that the clean up has achieved the clean up goals (as outlined in Section 7). In this context, site validation is defined as the methodology by which the remedial goals are proven to have been achieved.

Experience in clean up of LNAPL indicates that frequently the achievement of dissolved phase remedial goals / targets is typically not practicably achievable, while still captured as a possibility (and ideal objective) in the validation approach. In these circumstances a strategy that assesses the practicability of ongoing clean up is often adopted. The following validation process is therefore proposed (also shown in Flow Chart 1 below).



Flow Chart 1: Pathway to Closure

i. The gauging / sampling of all wells proves that the effective LNAPL[3] residual mass has been removed; OR

ii. In the event that validation protocol (i) is not achieved after 12 months of system operation, a review of the clean up to assess the effectiveness of the clean up and status of the LNAPL impacts will be conducted as part of the biannual (6-monthly report) that this to be reviewed by the Site Auditor (**Hold Point #1**).

[3] LNAPL as defined in Information Sheet 9

Factors that will be considered in the review include:

- Review of the extent and thicknesses of LNAPL, and whether the LNAPL is increasing, stable or decreasing. The groundwater levels will be taken in consideration, as the depth to water can affect the presence / thickness of LNAPL that can be detected in wells.
- Statistical analysis (Mann Kendall) of the groundwater concentrations, and an assessment of whether the groundwater plume is expanding, stable or reducing.
- Review of the soil vapour concentrations.
- Review of the hydrocarbon recovery rates of the clean up system.
- Potential health risks from LNAPL and hydrocarbon dissolved phase remain low and acceptable.
- Costs and sustainability of continued operation (e.g. financial costs, energy use, waste generation, carbon footprint, etc.)

Where it is determined that the operation of the clean up system should continue (based on validation protocols (i) and (ii)), the clean up system shall operate for a further six months, after which this review process will be repeated. Six monthly reviews (**Hold Point #2**) of the system operation will be conducted in consultation with the Auditor until such time as it is determined that that is no overall net benefit to the community for continued operation of the system (in the balance of the benefits of hydrocarbon reduction, risk profile changes, versus the costs of energy consumption / carbon footprint, waste generation, and costs).

iii. In the event that the validation protocol (ii) determines that clean up should cease, the system will be mothballed for at least one month. Following a period of at least one month, groundwater gauging and sampling would be conducted and then the system restarted an operated for a further period of at least one month, and the hydrocarbon recovery rates and groundwater conditions reviewed (**Hold Point #3**). In the event that LNAPL or hydrocarbon recovery rates rebound[4], the system will again continue operate, and another review (as per validation protocol (ii)) will be conducted after up to six months operation.

iv. In the event that the mothballing (validation protocol (iii)) does not detect any rebound, the clean up system will be decommissioned, and a review of alternative clean up technologies (e.g. oxidant injection) would be undertaken to assess their potential to achieve (practicably) the complete removal of LNAPL and / or decrease to target concentrations in groundwater for the contaminants of potential concern (**Hold Point #4**). If additional clean up is determined to be necessary (in consultation with the Auditor), the clean up measures will be implemented, followed by further reviews (as per validation protocol (ii)) to determine the requirement for further clean up (in consultation with the Site Auditor)[5]. The cycle of implementation of clean up measures followed by review will continue until clean up has been extended to the maximum extent practicable, in consideration of the technical, logistical and financial considerations outlined in EPA Victoria's Publication 840.2 (Appendix H).

v. If it is considered (by validation protocols (ii) to (iv)) that clean up has been extended to the maximum extent practicable, a Site Validation / Clean up Cessation report will be issued to the Auditor and EPA for review, verification and approval. The Site Validation / Clean up Cessation report will be prepared in general accordance with Appendix 2 (CUTEP Information guide) of EPA Victoria's Publication 840.2 (Appendix H)

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[4] Rebound will be determined by a statistically significant increase in groundwater concentrations or LNAPL thickness, and / or an increase of more than 50% in the hydrocarbon recovery rate (e.g. in kg/hr) that was recorded during the last 3 months of operation immediately prior to system mothballing.

[5] If additional remediation measures are to be implemented (e.g. oxidant injection), a work plan will be prepared to outline the remediation approach, new well locations, monitoring requirements, validation protocols / end points, management / environmental controls, etc. of the works, that would be reviewed and approved by the Auditor prior to implementation.

and ACT EPA Information Sheet 9 (which references CRC Care Technical Report No. 34, noting Table 7 in Step 5 of this CRC Care document provides guidance for LNAPL clean up closeout reporting).

If residual impacts are present following clean up (e.g. LNAPL is present (as per the definition in Information Sheet 9)), the LNAPL management plan for the site will be updated and implemented to monitor and manage residual contamination following the completion of the clean up works. The LNAPL management plan (if required) will be updated in accordance with ACT EPA Information Sheet 9 and ACT EPA "*Environmental guidelines for preparation of an Environment Management Plan*" and will be issued to the Site Auditor and ACT EPA for review and approval.

Additionally, groundwater restrictions may need to be imposed on the site and surrounds by the ACT EPA in accordance with Part 9, Section 71 of the *Water Resources Act 2007.* Implementation of the following measures is proposed to prevent polluted groundwater being extracted for any other use other than clean up or monitoring:

- Formal communication of the groundwater impacts to the affected off-site properties. This has been conducted previously, with a number of letters and direct communications with the neighbouring stakeholders conducted in months from July to October 2020 notifying them of the groundwater impacts; and
- Inclusion of the affected area within the Dial Before You Dig registry service so that Ampol is notified whenever a person requests plans for works conducted within the affected area. Ampol can then determine if these subsurface works include any potential for groundwater extraction.

The extent of the proposed area of groundwater restrictions is shown on Figure 8 of Appendix A. The extent of the proposed area for groundwater usage restriction takes into account current and possible future migration of the plume. The extent of this restricted use zone will be decided on in consultation with the Auditor and EPA at the time of implementing the post-clean up Management Plan. This restricted use zone will again be communicated to the affected stakeholders during the process.

While the current risk to receptors has been determined to be low and acceptable, this is based on the current land use, and thus would need to be reassessed if the affected blocks were to be redeveloped to include basements. We note that some of the blocks in the vicinity of the site are included in the "Kippax Group Centre Master Plan" that has been prepared by the ACT Government to set out "*a vision, planning principles, spatial framework and planning strategies to guide growth and development in the centre over time*".

The following Blocks and Sections, that are earmarked in the Kippax Master Plan for potential redevelopment, may potentially have been impacted by the fuel release at Caltex Holt:

- Blocks 2 and 5, Section 53 – Vacant land and carpark to the north west of the site
- Block 26, Section 51 – Scott Chambers Building
- Blocks 34, 35 and 47, Section 51 – Open space parkland north of Scott Chambers and Zara Gardens

The locations of these blocks are also shown in Figure 8 (Appendix A).

While the Kippax Masterplan indicates that the only development in the southern area of the open space / parkland on Blocks 34, 35 and 47, Section 51 (nearer to the groundwater plume) is the construction of a skate park to the north of Zara Gardens (i.e. no basements), Blocks 2 and 5, Section 53 and Block 26, Section 51 are earmarked for mixed use, and are likely to include basement carparks. Such redevelopment of these areas will require a variation to the Territory Plan, and we would expect will likely trigger a contaminated land assessment by the ACT EPA. In the event that a potential vapour risk is identified at both or either sites by a future contaminated land assessment (based on the proposed future development), vapour barriers would likely need to be implemented as part of the development to mitigate the potential health risks.

11 CONTINGENCY MEASURES

Measures to overcome unexpected issues that could arise during site work are detailed in Table 11.1.

Table 11.1 Remedial contingencies

POTENTIAL ISSUES	PROPOSED CORRECTIVE ACTIONS	RESPONSIBLE PERSON	COMMUNICATION AND ADDITIONAL SAMPLING/ MONITORING
The clean up system is unable to be installed due to permitting or power supply issues	In the event that the remedial approach is unable to be installed / operated due to the DA not being approved or there being insufficient power supply, the remedial strategy will need to be revised in consultation with Ampol and the Site Auditor.	Consultant	Ampol and the appointed Site Auditor are to be consulted on the most appropriate remedial strategy moving forward and ultimately will need to be agreed upon.
The clean up strategy failing, e.g. little / no hydrocarbon mass removal, expansion of the hydrocarbon impacts in groundwater.	In the event that the remedial approach is ineffective, the entire remedial strategy will need to be revised. The only foreseeable way this may happen is if soil vapour is unable to be physically removed from the proposed extraction wells in sufficient volumes. In the event that this occurred, all works are to cease at the site until a revised comprehensive and considered remedial approach has been determined, based on all the data collected to that point.	Consultant	Ampol and the appointed Site Auditor are to be consulted on the most appropriate remedial strategy moving forward and ultimately will need to be agreed upon.
Treated effluent cannot be disposed of to sewer under a Trade Waste agreement	In the event that the treated groundwater is not accepted for disposal to the sewer one or more of the following actions may be required: — Look into other disposal options (transport off site in tankers, reinjection etc.) — Consider no groundwater extraction (i.e. SVE only) — Further treatment on-site in order to satisfy the water companies requirements for discharge to sewer. — Revisit the remedial strategy to an approach that does not require waste water disposal (in consultation with Ampol and the Site Auditor)	Consultant	Ampol and the appointed Site Auditor are to be consulted on the most appropriate remedial strategy moving forward and ultimately will need to be agreed upon.

POTENTIAL ISSUES	PROPOSED CORRECTIVE ACTIONS	RESPONSIBLE PERSON	COMMUNICATION AND ADDITIONAL SAMPLING/ MONITORING
The presence of detectable LNAPL in any of the groundwater monitoring wells where LNAPL has not previously been detected. Or a statistically significant increase in hydrocarbon concentrations in any of the groundwater monitoring wells. (i.e. potential migration of the plume)	Confirm the presence (or absence) of measurable LNAPL (statistically significant increase in hydrocarbon concentration by way of Mann-Kendall analysis) at another gauging (or sampling) event conducted one month after the initial event. If LNAPL (or the concentration increase(s)) is not present, then revert to original groundwater monitoring frequency. If the LNAPL (or the concentration increase(s)) is present in groundwater wells then the relevance of the issue and the likely source of the impacts will be discussed with EPA and / or an Auditor, and recommendations for appropriate additional clean up, monitoring and / or management will be prepared for comment from, and endorsement by, the Auditor.	Consultant	Ampol and the appointed Site Auditor are to be consulted on the most appropriate remedial strategy moving forward and ultimately will need to be agreed upon.
Excessive dust during drilling works or excavation works	Use water sprays; stop dust-generating activity until better dust control can be achieved. Stop work in high wind conditions.	Remediation / drilling contractor.	Breaches are to be recorded in the daily site log and provided to Ampol and the environmental consultant within 24 hours of breach occurring. No additional monitoring/sampling required.
Heavy rain	Ensure sediment and surface water controls are operating correctly. If possible divert surface water away from active work areas or excavations.	Remediation contractor.	None.
Equipment failures	Maintain spare equipment or parts close to site; keep rental options available, shut down affected operations until repairs are made. Develop and implement routine operation and maintenance checks on equipment, service checks etc. Clean up any equipment or plant spills (i.e. hydraulic or fuel releases) with absorbent material.	Remediation contractor.	Breaches are to be recorded in the daily site log and provided to Ampol and the environmental consultant within 24 hours of breach occurring. Sample any impacted materials that have resulted from equipment failures and determine appropriate disposal/treatment option based on an assessment of analytical results.
Complaints are received relating to the works undertaken	Stop works and implement control measures to address complaint (if possible). Advise and consult with Ampol.	Remediation contractor.	Notify relevant Project Managers following complaint. Report complaint as per Ampol's management procedures.

POTENTIAL ISSUES	PROPOSED CORRECTIVE ACTIONS	RESPONSIBLE PERSON	COMMUNICATION AND ADDITIONAL SAMPLING/ MONITORING
Potential risk to receptors confirmed by the soil vapour assessment.	If a potential risk to receptors is confirmed by the soil vapour assessment, the impacts will be discussed with EPA and / or an Auditor, and recommendations for appropriate additional clean up, monitoring and / or management will be prepared for comment from, and endorsement by, the Auditor – see Section		

11.1 VAPOUR RISK MANAGEMENT OPTIONS

In the event that unacceptable vapour intrusion risks are identified within commercial properties and / or inside the residential dwellings, there are a number of different options available that could be utilised to mitigate the risks.

For pollution to pose an actual risk, a complete source-pathway-receptor (SPR) linkage must be present, and breaking any one of these linkages will mitigate the risk. Therefore, the potential options for mitigation of the potential risks can be broken down into dealing with each component of the SPR linkages.

Depending on the outcomes of the soil vapour assessments (e.g. if an actual risk is identified), one or more of the following measures outlined Table 11.2 overleaf may be implemented to mitigate the risks.

Table 11.2 Vapour mitigation options

LINKAGE	CLEAN UP OBJECTIVE	OPTIONS	COMMENTS / ISSUES
Source	Reduction / Removal of the source (such that the residual mass no longer represents a vapour inhalation risk)	— Extraction / removal (e.g. pumping, SVE, MPVE, etc.) — In-situ reduction / transformation (e.g. chemical oxidation / enhanced bioremediation)	— Effectiveness is unlikely to achieve a significant change in hydrocarbon mass (and thus risk profile) in the short to medium term – i.e. unlikely to achieve the objectives — Difficult to access all contaminated zones (due to limitations associated with buildings, etc.) — Costly — Ongoing maintenance required (e.g. equipment servicing)
Pathway	Interruption of the (vapour) pathway	— Sub-slab depressurisation - Depressurisation of the sub slab beneath the building slab by way of fans connected to external or interior sumps / bores) — Soil vapour extraction of soil vapours from beneath slab using blowers and vertical / angled / horizontal bores — Active pressurisation of the house / ventilation of indoor air — Indoor air treatment by activated carbon — Sealing of cracks / penetrations — Impermeable vapour lining between the slab and the flooring	— Interior works (e.g. sumps, air treatment, pressurisation, etc.) will be disruptive and not aesthetically pleasing. — Possibly costly (e.g. horizontal bores) — Effectiveness is difficult to predict (or in some cases unlikely to be adequate) — Ongoing maintenance required (equipment servicing, carbon replacement, etc.) — Slab construction (e.g. raft slabs) for sub-slab options (e.g. depressurisation, SVE) needs to be considered to ensure all zones are able to be adequately addressed.
Receptor	Removal or management of the receptor(s)	— Temporary or permanent removal of the affected residents / commercial occupants to new residential / commercial properties — Caltex to lease properties	— Costly — Significant reputational and / or legal implications (e.g. media exposure, etc.) — Not all receptors may be amenable to moving

In the event that unacceptable vapour intrusion risks are identified within commercial properties and / or inside the residential dwellings, the approach that is likely to be implemented (as it is considered to be the easiest to implement and with the least ongoing maintenance), is the following:

- Temporary relocation of the occupiers for a period of 6-12 months
- Removal of the existing floor coverings
- Sealing of any cracks / penetrations through the slab
- Installation of an impermeable vapour lining.
- Reinstatement of flooring
- Validation / verification that the vapour barrier has sufficiently reduced the flux of vapours into the units.

As noted above, the works would only be conducted if an actual unacceptable risk was identified, and furthermore, the approach outlined above is subject to change following consultation with the unit owner(s) and occupier(s) / resident(s), as each individual stakeholder may have different requirements that need to be considered.

12 SITE SAFETY PLAN

12.1 PRELIMINARIES

Appropriate Work Health and Safety (WH&S) measures would be established by the contractor for the personnel involved in remedial works at the site. This will involve the finalisation of a detailed WH&S Plan by the contractor. The WH&S plan will be prepared prior to performing on-site works associated with this RAP. The plan will address the health and safety of residents, site users and workers in the surrounding area and will be subject to review by the appointed Site Auditor. As a minimum, it will consider:

- Site security;
- Potential exposure to contamination;
- Excavation / drill hole safety;
- Vibration;
- Noise;
- Odour; and
- Dust.

Work associated with the clean up of the site will conform, at a minimum, to WorkSafe ACT requirements and associated Regulations. Typically, the WH&S plan will address the following issues:

- Regulatory requirements;
- Responsibilities;
- Hazard identification and control;
- Chemical hazard control;
- Sample and chemical handling procedures;
- Personal protective equipment;
- Work zones;
- Decontamination procedures;
- Emergency response plans;
- Contingency plans; and
- Incident reporting.

Site safety and environmental management plans will be prepared to ensure that potential hazards related to the work are identified and control measures are implemented. Job safety analyses (JSA) or safe work method statements (SWMS) will be prepared for all tasks required to be undertaken by any of the key stakeholders and their contractors.

13 SITE MANAGEMENT PLAN

13.1 HOURS OF OPERATION

It is planned to have the SVE + Pumping clean up system operating (in at least some form, e.g. SVE and / or pumping) at all times during the clean up phase of the works. The only times it will not be operating will be during maintenance of the system, which will be during the following times:

- Monday to Friday: 7:00 am to 6:00 pm
- Saturday: 8:00 am to 1:00 pm
- Sunday or Public holidays: No work permitted

Emergency work is permitted outside these hours.

Similarly the operation of the off-site MPVE events will only occur on Monday to Friday between 7:00 am to 6:00 pm.

13.2 SITE SIGNAGE AND CONTACTS

Signage at the main access point to the fenced of remediation equipment compound (north-west potion of the site) will include afterhours contact details of the remediation contractor and site manager.

13.3 SITE ACCESS

Due to site being an operating service station, transport of materials to and from site will need to consider traffic management options which take into account public vehicle and pedestrian movements on and around the service station forecourt.

There is an equipment laydown area already established at the site, on the north-western portion of the forecourt area, which will be used to establish the treatment system. This area has a perimeter fence erected to restrict public access and only authorised personnel are permitted into this area.

Periodically during operation, wastewater collection from the above ground storage tank will need to take place. During these operations traffic cones, barricades and suitable signage will be erected around the trucks working area to ensure only authorised personnel are within the area.

13.4 AIR QUALITY

13.4.1 DUST CONTROL

The greatest potential for dust generation may occur during the drilling of extraction wells on and around the site and during excavation / trenching works. Control procedures that will be put into place during these works include:

- Installation of a “dust hood” around the compressed air dust outlet of the drill rig;
- During the earthworks, dust will be visually monitored. If excessive dust is being generated, areas of earthworks will be sprayed with water to reduce dust levels. Soil to be stockpiled should be covered or wetted down to minimise dust generation;
- Being aware of prevailing wind direction when carrying out the potential dust generating works to ensure that any dust produced is not creating problems with nearby receptors; and

- During excavation and transport of any soil off-site, truck wheels should be cleaned or driven through a constructed wash bay or similar control (e.g. rumble grid) to prevent potentially contaminated soil from being transported onto local roads.

13.4.2 ODOUR AND VAPOURS

Due to the nature of vapour extraction, there is a potential for nuisance odours and/or vapours to be released into the atmosphere outside the treatment system(s).

The following measures are used to monitor and mitigate odours/vapours, if generated:

- Monitor and maintain the system critical safety devices to ensure no potentially hazardous vapours are being released / leaking, i.e. PID and LEL meters;
- Ensure that the treatment systems are operating at its optimal capacity, e.g. the CatOx unit is operating at the correct temperature to ensure the destruction of VOC's;
- Be aware of prevailing wind direction when carrying out works that have the potential for creating nuisance odours and/or vapours;
- The excavation / trenching works may result in vapours and odours being released into the atmosphere, particularly when excavation of potentially contaminated soil on site is carried out. At these times, consideration will be given to prevailing weather conditions and if distinct odours are detected, site works will cease work until the odours can be reduced or controlled;
- The site supervisor shall monitor all open excavations stockpiled soils with a photoionisation detector (PID) to ensure ambient air concentrations are within the acceptable work safe limits. Concentrations of PID monitoring shall be recorded by field staff and submitted for review on a daily basis. If ambient air concentrations of VOCs exceed 15 ppm for over 30 minutes based on short term exposure limit of 15 ppm for benzene (NOHSC, 1995), work should cease until levels drop; and
- A complaints log is maintained, to ensure any nuisance odours or vapours highlighted by the public or neighbouring property occupants is recorded and acted on promptly.

13.5 NOISE

Increased noise levels may result from the use of certain components of the treatment system, such as blowers and pumps, as well during the drilling and installation of system components (e.g. extraction well drilling, trenching etc.).

To mitigate any noise which may arise as a result of works, all mobile MPVE and construction / installation works will be carried out during normal working hours and in accordance with ACT regulations on this matter.

Noise control measures to be implemented during the clean up works will include:

- Significant noise generating activities on the site that may constitute a complaint will be restricted to the hours of 07:00 to 18:00 weekdays and 09:00 to 13:00 Saturdays;
- Machinery on site to have appropriate mufflers fitted and maintained in good condition;
- Where required the remediation plant equipment will be noise attenuated;
- Particularly noisy operations where practical will be enclosed;
- Deliveries and collections to the site are to be scheduled for 7:00 to 18:00 weekdays;
- Vehicle speeds on site restricted to less than 20 km per hour; and
- Suitable construction techniques and methodologies and use of quieter plant equipment where possible.

All practical measures will be taken to minimise generation of noise and contact information for enquires or complaints will be posted on the site entrance gate.

13.6 WATER AND SEDIMENT MANAGEMENT

Surface water / sediment may be produced during the following activities of the clean up works:

- Drilling works associated with the installation of the extraction wells; or
- If there is a leak within the groundwater extraction or treatment system.

To mitigate the potential for the groundwater extraction and treatment system to leak, several mitigation measures will be employed, including:

- Regular maintenance inspections will be carried out by the remediation contractor to ensure that all equipment is functioning as it should be. Maintenance logs will be kept documenting any issues identified with the system;
- The groundwater treatment system will be self-bunded, and have emergency shutoff components installed to ensure that any leakage / failure is detected, and the system operation is shut down until the leak is fixed and
- Emergency contact details will be posted on signage around the clean up system in case an issue is identified by site users.

Potentially contaminated waters generated during the clean up activities will be treated on-site via the water treatment plant and disposed of to sewer under a trade waste agreement. Other generated contaminated waters associated with other site works will be contained in drums prior to determining disposal options. Where possible waters generated during sampling activities will be processed through the water treatment plant.

13.7 EQUIPMENT AND PERSONNEL CLEANING PROCEDURES

Throughout the clean up works, controls will be placed on the decontamination of equipment and personnel to prevent the possibility of cross contamination. General procedures that will be implemented include:

- Personal decontamination must be undertaken each time workers leave any contamination work area and at the completion of contamination removal work. Personal decontamination should be undertaken within the nominated decontamination area. The extent of decontamination required is dependent upon the type of contaminant;
- mechanical equipment will be washed in an environmentally sound manner prior to leaving the site; and
- no trucks or equipment carrying contaminated soils should be allowed to move across unsealed ground surfaces, except across designated transport corridors.

All contaminated soil requiring off-site disposal will be transported to an appropriate landfill facility. All transport trucks loaded with contaminated soil for off-site disposal should be sealed and the load completely/securely covered to prevent wind-blown emissions or spillages and covers should be maintained until unloading. All truck tailgates should be securely fixed prior to loading and immediately after unloading soils and all vehicles are to be operated in a manner so as to prevent loss of soils during loading, transport and unloading activities.

13.8 GENERAL WASTE MANAGEMENT

The site works will implement a two-tiered waste management policy. The policy will implement, in order of preference, the following hierarchy:

- Waste minimisation / avoidance; and

- Waste disposal.

To manage general wastes, which includes all wastes other than contaminated materials generated on site, one or more of the following may be implemented:

- Appropriate receptacles provided in suitable locations on site to enable the segregation and storage of wastes generated on site;
- Undertake regular housekeeping to keep the site tidy and have rubbish removed;
- Where possible, contractors are used to remove wastes for reuse, recycling or disposal; and
- Staff on site informed of the waste management policy and encouraged to participate in reducing waste materials generated.

14 STAKEHOLDER ENGAGEMENT

Stakeholder engagement has been undertaken throughout the investigation and clean up works conducted to date, and will continue to be undertaken throughout the future clean up / monitoring phases of work. A Stakeholder Engagement Plan has been developed to provide a framework for ongoing communications with key stakeholders.

While the results have indicated that there is not an unacceptable risk to human health, it is considered important that stakeholders are kept informed about the results and ongoing monitoring and clean up activities and have a consistent contact into the project should questions or concerns arise in the near to medium future.

The key objectives of this plan were to:

— Maintain open and positive relationships with stakeholders;

— Minimise the risk of issue escalation outside the project, negative media attention and reputational damage; and

— Minimise the risk of misinformation.

Where access has been required for assessment works to date, a number of access letters and summaries of results / outcomes have been provided to the affected parties.

Table 14.1 and Table 14.2 below summaries the key stakeholders and ongoing communications with these stakeholders.

Table 14.1 Stakeholder analysis

STAKEHOLDER GROUPS	AREAS OF INTEREST	PROPOSED ENGAGEMENT TOOLS	LEAD RESPONSIBILITY
Residential occupants	— Ongoing impacts on health, property and the environment — Completed and future investigations and monitoring — Compensation	— Door knock — Face to face meetings — Letters — Works notifications — Internal and external FAQs — Telephone — Emails	WSP
Residential owners — Zara Gardens - Strata Committee / Strata Manager — ACT Housing	— Ongoing impacts on health, property and the environment — Completed and future investigations and monitoring — Compensation — Property values	— Door knock — Face to face meetings — Letters — Works notifications — Internal and external FAQs — Telephone — Emails	WSP

STAKEHOLDER GROUPS	AREAS OF INTEREST	PROPOSED ENGAGEMENT TOOLS	LEAD RESPONSIBILITY
Commercial occupants — Scott Chambers	— Ongoing impacts on health, property and the environment — Completed and future investigations and monitoring — Compensation — Impacts on business	— Drop in visits — Letters — Works notifications — Telephone — Emails	WSP
Commercial owners — Scott Chambers — Property Manager	— Ongoing impacts on health, property and the environment — Completed and future investigations and monitoring — Compensation — Property values — Impacts on business	— Drop in visits — Letters — Works notifications — Telephone — Emails	WSP
Raiders Belconnen	— Ongoing impacts on health, property and the environment — Completed and future investigations and monitoring — Compensation — Property values — Impacts on business	— Drop in visits — Letters — Works notifications — Telephone — Emails	WSP
Utilities, including: — Water — Sewer — Electricity — Gas — Telecommunications	— Ongoing impacts on groundwater and/or soil — Ongoing impacts on services, their continuity and planned/unplanned outages — Potential health and safety issues	— Letters — Telephone — Emails	WSP

STAKEHOLDER GROUPS	AREAS OF INTEREST	PROPOSED ENGAGEMENT TOOLS	LEAD RESPONSIBILITY
ACT Government, including EPA Site Auditor	— Impact of contamination on human health and the environment — Impact of mitigation, management and clean up on human health and the environment — Compliance with EPO 50048 and audit requirements — Approach to, and effectiveness of, stakeholder and community communications and engagement	— Letters — Telephone — Emails — Meetings — Reports	Ampol
Media (if required)	— Impacts on health, property and the environment — Completed and future investigations	— Media Release or Holding Statement	Ampol
Local MPs	— Impacts on health, property and the environment — Engagement with stakeholders — Completed and future investigations	— Briefings — Telephone — Letters — Emails	Ampol

Table 14.2 Ongoing Communications Action Plan

MILESTONES	DESCRIPTION	STAKEHOLDERS	TOOLS
Investigations and monitoring works	— Works that are likely to be overtly visible and / or impactful — Works that require access to private commercial or residential properties	— Residential and commercial owners — Residential and commercial tenants — Strata committee — Property manager — Media — Utilities — Government — MPs	— Works notifications — Media Holding Statement — Emails — Telephone

MILESTONES	DESCRIPTION	STAKEHOLDERS	TOOLS
Cessation of investigative and monitoring works	— Final communications closing off project and providing ongoing contact details if further questions and /or concerns arise — Communicate appreciation and apologise for any inconvenience that may have been caused by investigations and monitoring activities	— Residential and commercial owners — Residential and commercial tenants — Strata committee — Property manager — Media — Utilities — Government — MPs	— Door knock — Drop in visits — Face to face meetings — Briefings — Tailored letters — Emails — Media Holding Statement
Clean up works	— Works that are likely to be overtly visible and / or impactful — Works that require access to common areas of the residential property (Zara Gardens)	— Residential owners and tenants — Strata committee — Property manager — Media — Utilities — Government — MPs	— Works notifications — Media Holding Statement — Emails — Telephone

15 TIMING

The following timing is proposed for the works outlined in the RAP.

15.1 OFF-SITE MPVE EVENTS

There are no major restrictions on the commencement of the off-site extraction well installation and subsequent MPVE events, as temporary traffic management (TTM) plans can be typically be approved within 1 – 4 weeks. The only foreseeable limitation is the availability of contractors (drillers and MPVE contractors).

On the basis that this RAP is reviewed and approved in May 2021 and contractors are available, it is envisaged that the well installation can be conducted in June 2021, with the MPVE events to commence in late June or early July. It is envisage that up to 12 monthly MPVE events will be conducted, however this will be reviewed in consultation with Ampol and the Auditor.

15.2 ON-SITE CLEAN UP SYSTEM INSTALLATION AND OPERATION

Given the works are subject to a DA, a process which could take approximately six months to complete, it is likely that the system installation and commissioning works will be completed in Quarter 3-4 of 2021.

Once commissioned it is expected that the system will operate for at least 12 to 24 months to ensure that the system has operated during the seasonal variations (e.g. high and low groundwater levels).

When regular monitoring of the hydrocarbon recovery proves asymptotic conditions (e.g. after say 12 months operation), the system will be subject to a "mothballing" for a period of at least one month to allow for sub-surface equilibrium to be restored.

In the case where significant rebound in LNAPL or contamination recovery is observed following the mothball period, or during the subsequent gauging / sampling event, the clean up system operation will be recommenced.

If no significant LNAPL and VOC recovery rebound occurs following the mothball period, the permanent termination of active clean up would be considered in accordance with the validation protocols details in Section 10.

15.3 POST-CLEAN UP MANAGEMENT PLAN

In the case no rebound is observed following the mothball period, it is proposed that a Site Validation / Clean up Cessation report will be submitted to the Auditor and EPA for review, verification and approval. The Site Validation / Clean up Cessation report will be prepared in general accordance with Appendix 2 (CUTEP Information guide) of EPA Victoria's Publication 840.2 (Appendix H) and ACT EPA Information Sheet 9 (which references CRC Care Technical Report No. 34, noting Table 7 in Step 5 of this CRC Care document provides guidance for LNAPL clean up closeout reporting).

Following acceptance of the clean up cessation with the Auditor and EPA, a post-clean up Management Plan will be implemented (if required) to monitor and manage residual contamination (if any) following the completion of the clean up works (in agreeance with the Auditor and ACT EPA).

It is envisaged that the cessation of clean up and the commencement of the implementation of the Management Plan (if required) will occur at some point in 2022 or 2023.

16 CONCLUSIONS

This RAP has been prepared to provide the Auditor and the EPA with an understanding of the strategy to address the contamination on and off site to date and in the future. This RAP provides a clean up strategy based on the available information and an objective screening approach, and information on how clean up is being implemented at the site, criteria for assessing the success of clean up and the general procedures for the management of potential impacts during the clean up works.

Based on the outcomes of the pilot trials, the extent of impacts, the logistics of installation, SVE + Pumping (in-situ system) was selected as the most appropriate clean up method to address the bulk LNAPL/hydrocarbon contamination in the on-site areas and a series of MPVE events was selected as the most appropriate clean up method to address the bulk LNAPL/hydrocarbon contamination in the off site areas.

A suitable location for the installation of an on-site clean up system is identified in the north-western portion of the site, where the current groundwater/LNAPL collection tank is located. The absence of residential properties immediately adjacent to the clean up system should minimise potential issues related to the operation of an on-site clean up system at the site (e.g. noise). Similarly, the off-site MPVE events will only be conducted during working hours (i.e. Monday to Friday, 7:00am to 6:00pm).

A monitoring plan is outlined for the proposed active clean up works and includes monthly well gauging and quarterly groundwater sampling from selected wells, and a bi-annual (6-monthly) groundwater sampling campaign covering all groundwater wells, on and off the site.

Following validation that the clean up has achieved the clean up goals (in agreeance with the Site Auditor and ACT EPA), a post-clean up Management Plan will be implemented (if required) to monitor and manage residual contamination (if any). The management plan (if required) will be prepared and implemented in accordance with ACT EPA Information Sheet 9 and ACT EPA "*Environmental guidelines for preparation of an Environment Management Plan*".

Updating and review of this RAP will be undertaken regularly to ensure changes to operations are incorporated or as further or updated site information becomes available.

17 REFERENCES

- ACT EPA 2017, *Contaminated Sites Environment Protection Policy.*
- ACT EPA 2017, *Environmental authorisation no. 0749*.
- ACT EPA 2019, *Environmental Guidelines for Petroleum Storage in the ACT.*
- ACT EPA 2019, Information Sheet 8 – *Requirements for the Classification and Reuse of Drilling Mud Waste in the ACT.*
- ACT EPA 2019, Information Sheet 9 – *Management of groundwater impacted by light non-aqueous phase liquids (LNAPL).*
- ACT EPA 2020, Information Sheet 11 – *Environment Protection Authority Report Submission Requirements.*
- AECOM 2011, *Groundwater Monitoring Well Report, Caltex Holt (22546), Corner Hardwick Crescent and Flack Street, Holt, ACT.*
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- *Environmental Protection Regulation 2005.*
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- WSP 2018, *Caltex Kippax Holt service station (Site ID: 22546), 1 Hardwick Crescent, Holt ACT 2615: Groundwater monitoring event*;
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LIMITATIONS

1. This Report has been prepared by WSP Pty Limited ("WSP") for the benefit of Caltex Australia Petroleum Pty Ltd ("Caltex"), the registered proprietor or tenant of the site requested to be investigated by WSP ("Site") under its agreement with Caltex dated 21 March 2018 ("Agreement").
2. The nature and extent of the environmental consulting and remediation works at the Site detailed in the Report reflects the scope of the Services set out in the Request for Proposal under the Agreement and the Scope of Works set out in Schedule 1 of the Agreement ("Scope of Works").
3. A potential purchaser (but not including a purchaser's successor in title) of the Site may rely on the findings contained in the Report for the purpose of considering the possible (but not actual) level of contamination of or at that Site at the time of the contamination assessment of the Site was undertaken ("Permitted Purpose").
4. The registered proprietor of the land to which the report relates at the time of writing the report (but not including any proprietor's successor in title) may rely on the findings contained in the Report for the purpose of assessing the possible level of contamination of that Site ("Permitted Purpose") and subject to the limitations set out in the Scope of Works.
5. The findings contained in the Report are subject to the qualifications, assumptions and limitations set out in the Report or otherwise communicated to, or by, Caltex. To the extent of any inconsistency between this Limitation Statement and the qualifications, assumptions and limitations in the Report, this Limitation Statement shall prevail.
6. The Report may contain information provided by others. Except as otherwise stated in the Report, WSP has not verified the accuracy or completeness of this information. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the Report ("Conclusions") are based in whole or in part on this information, those Conclusions are contingent upon the accuracy and completeness of that information. WSP accepts no responsibility for the reliability, accuracy, completeness or adequacy of information provided by others.
7. WSP has prepared the Report without regard to any special or particular interest of any person (including that of a potential purchaser), other than Caltex when undertaking the Services or setting out its findings in the Report.
8. The Report can only be relied upon for the Permitted Purpose and may not be relied upon for any other purpose and does not purport to recommend or induce a decision to make (or not make) any purchase, disposal, investment, divestment, financial commitment or otherwise in relation to the Site ("Investment Decision").
9. Matters material to a potential purchaser, may have been omitted from the Report, or may not have been investigated because of the scope of the Services. It follows that a potential purchaser should be cognisant of the restrictions inherent in or otherwise set out in the Report and should commission the preparation of a contamination assessment of the Site that caters for its own interests and scope of services, and which will provide findings in relation to the level of contamination of or at the Site at the time the potential purchaser is making an Investment Decision.
10. The Report has not and will not be updated for events occurring after the date of the Report or any other matter which may have a material effect on its contents which come to light after the date of the Report. WSP will not be obliged to inform a potential purchaser of any matter arising or coming to its attention after the date of the Report, which may affect or qualify the Report.
11. WSP is not liable to a potential purchaser in respect of errors or omissions in the Report which a potential purchaser knows of, or ought to be aware of, from:
    - **a** its own actual knowledge and inquiries
    - **b** inquiries made by its advisers; or
    - **c** matters which a potential purchaser should have been aware of by making reasonable inquiry (including the inquiries recommended at Item 9 above).
12. To the fullest extent permitted at law, WSP, its related bodies corporate, its officers, employees and agents assume no liability and will not be liable to any potential purchaser for, or in relation to, any losses, damages or expenses (including any indirect, consequential or punitive losses or damages or any amounts for loss of income or profit, revenue or loss of opportunity to earn profit, loss of production, loss of contract, increased operational costs, loss of business opportunity, business interruption and pure economic loss) of any kind (and whether arising in contract, tort (including negligence), under statute, in equity or otherwise, suffered or incurred by a potential purchaser (or any other third party) arising out of or in connection with any matter outside the ambit of the Permitted Purpose in relation to the Report or findings expressed in the Report.

APPENDIX A

FIGURES & PLANS

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Figure prepared for WSP by InSite Remediation Services Pty Ltd

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CALTEX HOLT SERVICE STATION
1 HARDWICK CRESCENT
HOLT ACT

FIGURE 1
SITE LOCATION

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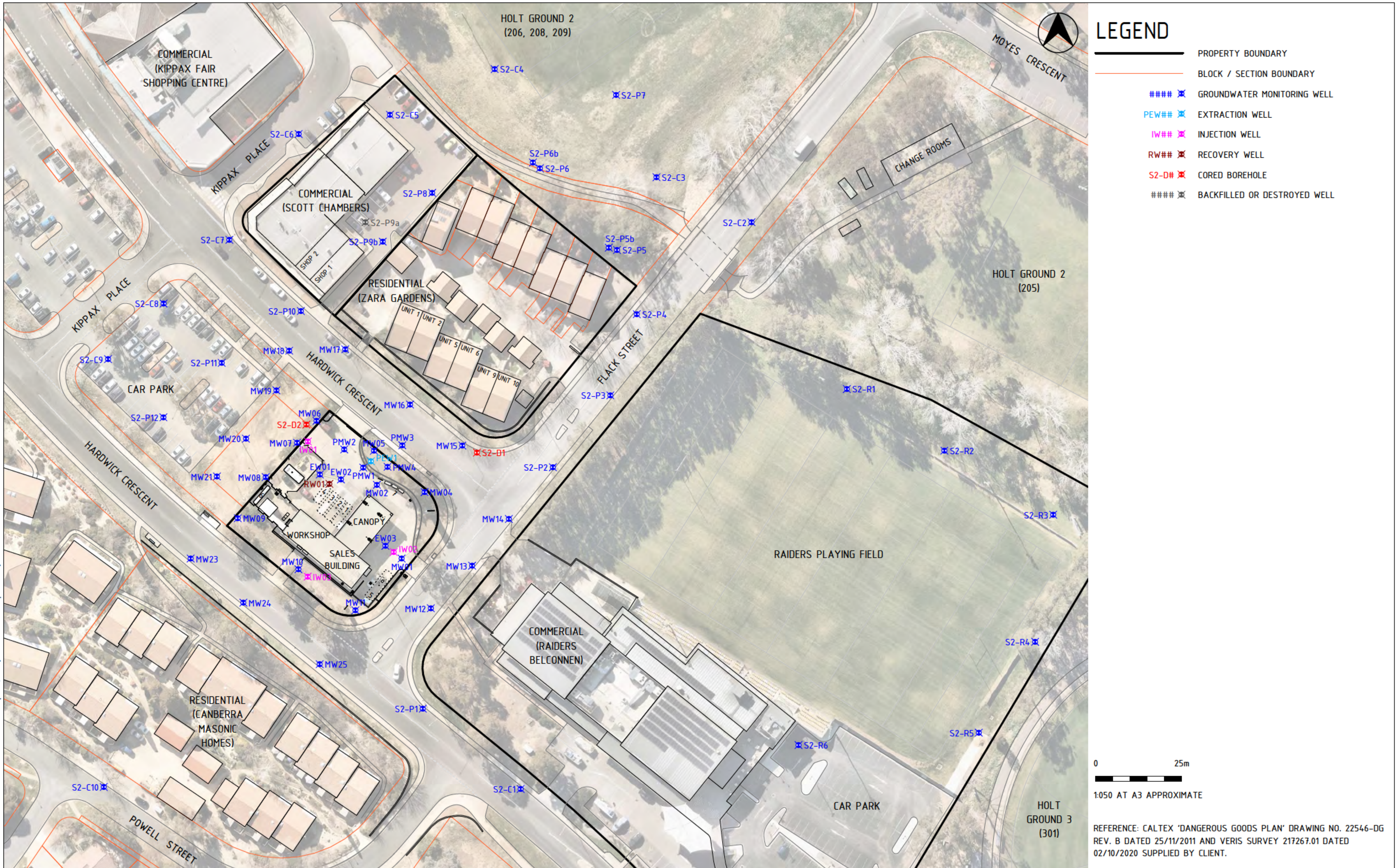

aerial image nearmap august 2020
block & section data from http://www.actmapi.act.gov.au

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CALTEX HOLT SERVICE STATION
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FIGURE 2
SITE LAYOUT & GROUNDWATER MONITORING LOCATION NETWORK