



Environmental Audit Report

35-37 Shannon Avenue, Manifold Heights, Victoria

Prepared for:

Caltex Australia Petroleum Pty Ltd

Level 24, 2 Market Street, Sydney, NSW 2000

20 June 2011





Distribution

Environmental Audit Report, 35-37 Shannon Avenue, Manifold Heights, Victoria

20 June 2011

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This Environmental Audit report is issued subject to the limitations noted in Section 12.

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Environmental Auditor

Appointed Pursuant to the Environment Protection Act 1970



Executive summary

An Environmental Audit was conducted regarding the risks to human health and the environment associated with the storage and handling of petroleum hydrocarbons from the Caltex service station premises situated at 35-37 Shannon Avenue, Victoria (the site). The Audit was completed in response to a request by Mr Simon Caples on behalf of Caltex Australia Petroleum Pty Ltd. The Environmental Audit was completed by Michael Rehfisch, an employee of Senversa Pty Ltd (Senversa), as a person appointed as an Environmental Auditor (Contaminated Land) under section 53S of the Environment Protection Act, 1970 (the Act). The Environmental Audit and this Audit report were completed in accordance with Section 53V of the Act.

This executive summary should be read in conjunction with the full Environmental Audit report 'Environmental Audit Report, 35-37 Shannon Avenue, Manifold Heights, Victoria'.

A summary of the Audit is outlined below.

Summary of Audit Information

EPA file reference no.	63348-1
Auditor	Michael Rehfisch
Name of person requesting audit	Formerly Elizabeth Townsend, then Simon Caples, now Belinda Patterson Caltex Australia Petroleum Pty Ltd
Relationship to premises/location	Owners Representative
Date of request	14 February 2008
Date EPA notified of audit	18 February 2008
Completion date of the audit	20 June 2011
Reason for audit	EPA s.62A Clean Up Notice No. 7206, served 9 July 2008, since lapsed
Description of activity	Storage and handling of petroleum hydrocarbons
EPA region	South West
Dominant – Lot on plan	Lot 1 LP55916
Additional – Lot on plan(s)	-
Site/premises name	Caltex Service Station
Building/complex sub-unit no.	-
Street/Lot – Lower No.	35
Street/Lot – Upper No.	37
Street Name	Shannon
Street type (road, court, etc)	Avenue
Suburb	Manifold Heights
Postcode	3218

Summary of Audit Information

GIS coordinates of site centroid Latitude (GDA94) Longitude (GDA94)	38.130880 144.337931
Members and categories of support team utilised	Ms Kristi Hanson – contaminant transport and assessment of exposure pathways and risk. Dr Bruce Anderson – remedial and geotechnologies (whilst Auditor employed at AECOM).
Other support staff used on Audit	Michael Charge
Outcome of Audit	Recommendations on measures to manage risk to an acceptable level
Further work or requirements	As detailed in Section 11 of this report.
Groundwater segment	C
Surrounding land use	North – roadway then low density residential South – medium density residential East – roadway then vacant land comprising former Mobil Oil service station West – commercial premises (Recreational and Educational Adult Program (REAP) Scope Centre)

Following the identification of polluted soil and groundwater at the site, EPA served a clean up notice under Section 62A of the Environment Protection Act, 1970 (the Act), requiring Caltex Australia Petroleum Pty Ltd (Caltex) to complete the following:

- Review underground petroleum storage system integrity.
- Delineate the extent of off-site groundwater contamination originating from the premises.
- Develop a clean up plan for the clean up of land on the premises and groundwater on and from the premises.
- Complete an Environmental Audit pursuant to section 53V of the Act.

The site has operated as a service station for 30 to 40 years and prior to 1987 the site was operated by Shell. Historically the site operations included a mechanical workshop, but currently the site only distributes fuel (i.e. operational service station). The site operates in a mixed residential and commercial area including a former Mobil Oil service station on the opposite south eastern corner of Shannon Avenue and Church Street.

Geo & Hydro Pty Ltd (1994), Handex (1999) and more recently URS (current assessment consultant) have completed various investigations that have identified the following contamination:

- Shallow soil impact limited to the area surrounding the former and current fill points on the western boundary of the site.
- Deeper soil impact associated with groundwater impacts at the water table at a depth of approximately 9 metres below ground surface, where a Light Non-Aqueous Phase Liquid (LNAPL) comprising petroleum hydrocarbons is present.
- Groundwater impacts on and from the site comprising LNAPL and dissolved phase hydrocarbons migrating off-site to the north east with groundwater flow.

In accordance with the State Environment Protection Policy (Groundwaters of Victoria) and EPA Publication 840 (EPA, 2002), where groundwater is polluted it should be cleaned up to restore beneficial uses (pollution is defined as exceedence of indicator objectives). Where this is not possible or feasible, groundwater must be cleaned up to the extent practicable (CUTEP). Based on the most

recent round of groundwater monitoring remediation is required. The proposed remediation strategy (in the context of ongoing service station operations) comprises:

- Replacement of failed underground petroleum storage system fuel distribution infrastructure (completed).
- Following review of hydrocarbon remedial technologies, URS proposes a strategy for the site comprising on-site shallow Soil Vapour Extraction (SVE) for unsaturated (soil) clean up and Multi Phase Extraction (MPE) to address LNAPL and dissolved phase impacts on and off-site.
- Ongoing environmental monitoring to assess the effectiveness of the strategy and to confirm the risk posed by soil, groundwater and vapour emissions at and from the site.

Based on the results of the Audit, the Auditor has prepared a number of management responses as detailed in **Section 11** of this report.



Contents

Executive summary	i
List of Acronyms.....	7
1.0 Introduction.....	1
1.1 Background.....	1
1.2 Audit Summary Information.....	1
1.3 Reason for the Environmental Audit	3
2.0 Audit Framework and Methodology	4
2.1 Environmental Audits.....	4
2.2 Clean Up Notice Requirements.....	4
2.3 Audit Objective	6
2.4 Audit Scope.....	6
2.4.1 Review of Activity Undertaken	6
2.4.2 Segment Considered.....	6
2.4.3 Elements Considered	6
2.5 Audit Criteria.....	7
2.5.1 Policies and Guidelines	7
2.6 Beneficial Uses Considered.....	7
2.6.1 Land.....	7
2.6.2 Groundwater	8
2.7 Audit Team and Expert Support	8
2.8 Audit Methodology	8
2.9 s.62A Notice Compliance Review	10
2.10 Audit Exclusions.....	11
2.11 Communications with EPA	11
3.0 Site Setting.....	12
3.1 Site and Surrounding Land Use.....	12
3.2 Topography and Drainage.....	12
3.3 Geological Setting	12
3.3.1 Regional Geology.....	12
3.3.2 Site-Specific Geology	13
3.4 Hydrogeological Setting.....	13
3.4.1 Regional Hydrogeological Setting.....	13
3.4.2 Regional Groundwater Use	14
3.4.3 Site Specific Hydrogeological Setting	14
3.5 Environmental Audits Completed in the Vicinity of the Site	15
4.0 Protected Beneficial Uses	16
4.1 Beneficial Uses of Land	16
4.1.1 Protected Beneficial Uses	16
4.1.2 Soil Quality Objectives	16
4.2 Beneficial Uses of Groundwater	17

4.2.1	Protected Beneficial Uses	17
4.2.2	Groundwater Quality Objectives	17
5.0	Assessment of Environmental Quality of the Site	19
5.1	Potential Sources of Petroleum Hydrocarbon Contamination.....	19
5.1.1	Service Station Site History	19
5.1.2	UPSS Infrastructure	19
5.1.3	Integrity of UPSS.....	19
5.2	Nature and Extent of Soil Contamination.....	20
5.2.1	Soil Investigations Undertaken	20
5.2.2	VOC Screening	21
5.2.3	Soil Contamination Present	21
5.2.4	Summary of Impact to Beneficial Uses	22
5.3	Nature and Extent of Groundwater Contamination	23
5.3.1	Groundwater Investigations Undertaken.....	23
5.3.2	LNAPL Contamination Distribution	25
5.3.3	Dissolved Phased Hydrocarbon Contamination Distribution	26
5.3.4	Contaminant Plume Movement over Time (Stability)	27
5.3.5	Biodegradation Attenuation Mechanisms.....	27
5.3.6	Summary of Impact to Beneficial Uses	28
5.4	Air Quality Review	28
5.4.1	Soil Vapour Investigations	29
5.4.2	Air Quality Monitoring	29
5.4.3	Utility Pit Monitoring.....	31
5.4.4	Quantitative Risk Assessment and Impact to Beneficial Uses.....	32
6.0	EPA Notice Compliance	34
6.1	Compliance with s.62A Clean Up Notice	34
7.0	Review of Data Quality	36
7.1	Vapour Risk Assessment.....	42
7.2	Overall Summary of Data Quality	43
8.0	Clean Up Measures.....	44
8.1	EPA Requirements	44
8.2	Clean Up Plan Measures Proposed	45
8.2.1	Clean Up Objectives.....	45
8.2.2	Clean Up Strategy	45
9.0	Assessment of Risk Posed by Site Conditions	47
9.1	Risk Management Methodology	47
9.2	Risk Communication and Consultation	47
9.3	Context Establishment	48
9.4	Risk Identification.....	48
9.4.1	Contamination Sources	48
9.4.2	Transport and Exposure Pathway Analysis – Human Receptors	49
9.4.3	Transport and Exposure Pathway Analysis – Ecological Receptors.....	49
9.4.4	Transport and Exposure Pathway Analysis – Other Receptors and/or Issues.....	50
9.5	Risk Analysis	51
9.5.1	Methodology	51

9.5.2	Results	52
9.6	Risk Evaluation	57
9.7	Risk Treatment	57
9.8	Adequacy of Existing Risk Mitigation Measures	57
9.8.1	EPA Requirements for the Restoration of Protected Beneficial Uses of Groundwater	57
9.8.2	Receptor Management - Risk Communication and Information	58
9.8.3	Primary Source Control Measures (Infrastructure)	58
9.8.4	Secondary Source (Soil and Groundwater) Control Measures (Proposed Remediation System)	58
10.0	Summary of Audit Findings	60
10.1	Land Pollution and Risk	60
10.2	Groundwater Pollution and Risk	60
10.3	Air Pollution and Risk	61
11.0	Recommended Measures	62
12.0	Report Limitations	64
13.0	References	65

Figures

Figure 1: Site Layout and Soil, Groundwater and Soil Vapour Bore Locations

Figure 2: Groundwater Contour Plan (July and November 2009)

Figure 3: Utility Pit Monitoring Locations and Results (July 2009)

Appendix 1: EPA Section 62A Clean Up Notice

Attachment 1: Assessment Consultant Reports (refer CD)



List of Acronyms

Acronym	Definition
AS	Australian Standard
ANZECC	Australian and New Zealand Environment and Conservation Council
BTEX	Benzene, toluene, ethyl benzene, xylenes
CCME	Canadian Council of Ministers for the Environment
CUTEP	Clean up to the extent practicable
DO	Dissolved oxygen
EC	Electrical conductivity
EIL	Ecological Investigation Level
ESA	Environmental Site Assessment
GME	Groundwater Monitoring Event
GMW	Groundwater Monitoring Well
EIL	Ecological Investigation Level
EPA	Victorian Environment Protection Authority
EW	Extraction Well
GQRUZ	Groundwater quality restricted use zone
GQMP	Groundwater Quality Management Plan
HIL	Health based investigation level, as defined under the NEPM
ISO	International Standards Organisation
ITRC	Interstate Technology and Regulatory Council
LEL	Lower explosive limit
LNAPL	Non aqueous phase liquids lighter than water. Also commonly termed PSH (phase separate hydrocarbon) where LNAPL is a known hydrocarbon.
m AHD	Elevation in metres relative to the Australian Height Datum



Acronym	Definition
m BTOC	Depth below top of well casing (in metres)
m bgl	Relative elevation in metres below ground level
MNA	Monitored natural attenuation
MoE	Maintenance of ecosystems
MPE	Multiphase extraction
MW	Monitoring well
NAPL	Non aqueous phase liquid
NATA	National Association of Testing Authorities
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NHMRC	National Health and Medical Research Council
NSW EPA	New South Wales Environment Protection Authority (now Department of Environment, Climate Change and Water)
PCR	Primary contact recreation
PSH	Phase separated hydrocarbons, more commonly known as light non-aqueous phase liquids (LNAPL), however referred to as PSH in most supporting reports
PID	Photo-ionisation detector
QA	Quality assurance
QC	Quality control
QRA	Quantitative risk assessment
RPD	Relative percentage difference
RSL	Regional screening level
SB	Soil bore
SEMP	Site Environmental Management Plan
SEPP (AQM)	State Environment Protection Policy (Air Quality Management)
SEPP (GoV)	State Environment Protection Policy (Groundwaters of Victoria)



Acronym	Definition
SEPP (PMCL)	State Environment Protection Policy (Prevention and Management of Contaminated Land)
SEPP (WoV)	State Environment Protection Policy (Waters of Victoria)
SIRA	Stock Inventory Reconciliation Analysis
SV	Soil vapour
SVE	Soil vapour extraction
SW	Stock watering
TDS	Total dissolved solids
TPH	Total petroleum hydrocarbons
UPSS	Underground petroleum storage systems
URS	URS Australia Pty Ltd
USEPA	United States Environmental Protection Agency
UST	Underground storage tank
VOC	Volatile organic compound
WHO	World Health Organization



1.0 Introduction

1.1 Background

An Environmental Audit was conducted regarding the risks to human health and the environment associated with the storage and handling of petroleum hydrocarbons from the operating Caltex service station premises situated at 35-37 Shannon Avenue, Victoria (the site). The Audit was completed in response to a request by Mr Simon Caples on behalf of Caltex Australia Petroleum Pty Ltd. The Environmental Audit was completed by Michael Rehfisch, an employee of Senversa Pty Ltd (Senversa), as a person appointed as an Environmental Auditor (Contaminated Land) under section 53S of the Environment Protection Act, 1970 (the Act).

The Audit was conducted in accordance with Section 53V, Part IXD, of the Act and in a manner consistent with relevant guidelines issued by Environment Protection Authority Victoria (EPA), in particular, the "Environmental Auditor Guidelines for the Preparation of Environmental Audit Reports on Risk to the Environment" (Publication 952.2, August 2007) and "Environmental Auditor Guidelines for Conducting Environmental Audits" (Publication 953.2, August 2007).

The location of the site is presented in the figure below.



1.2 Audit Summary Information

Details of the Audit process are presented in **Section 2.1** of this report. Information relating to the site and environment Audit process are summarised as follows:

Summary of Audit Information	Details
EPA file reference no.	63348-1



Summary of Audit Information	Details
Auditor	Michael Rehfisch
Name of person requesting audit	Formerly Elizabeth Townsend, then Simon Caples now Belinda Patterson, Caltex Australia Petroleum Pty Ltd
Relationship to premises/location	Owners Representative
Date of request	14 February 2008
Date EPA notified of audit	18 February 2008
Completion date of the audit	20 June 2011
Reason for audit	EPA s.62A Clean Up Notice No. 7206, served 9 July 2008, since lapsed
Description of activity	Storage and handling of petroleum hydrocarbons
EPA region	South West
Dominant – Lot on plan	Lot 1 LP55916
Additional – Lot on plan(s)	-
Site/premises name	Caltex Service Station
Building/complex sub-unit no.	-
Street/Lot – Lower No.	35
Street/Lot – Upper No.	37
Street Name	Shannon
Street type (road, court, etc)	Avenue
Suburb	Manifold Heights
Postcode	3218
GIS coordinates of site centroid	
Latitude (GDA94)	38.130880
Longitude (GDA94)	144.337931
Members and categories of support team utilised	Ms Kristi Hanson – contaminant transport and assessment of exposure pathways and risk. Dr Bruce Anderson – remedial and geotechnologies (whilst Auditor employed at AECOM).
Other support staff used on Audit	Michael Charge
Outcome of Audit	Recommendations on measures to manage risk to an acceptable level
Further work or requirements	As detailed in Section 11 of this report.
Groundwater segment	C
Surrounding land use	North – roadway then low density residential South – medium density residential East – roadway then vacant land comprising former Mobil Oil service station West – commercial premises (Recreational and Educational Adult Program (REAP) Scope Centre)



1.3 Reason for the Environmental Audit

EPA requested the Environmental Audit for the reasons described in the Clean Up Notice (s.62A Notice) served on Caltex Australia Petroleum Pty Ltd on 9 July 2008. The s.62A identified EPA's concerns on the nature and extent of dissolved phase and Non Aqueous Phase Liquid (NAPL) on and from the premises and the need for mitigation and clean up of pollution. The s.62A requirements are detailed in **Section 2.2**. A copy of the s.62A Notice is presented in **Appendix A**.



2.0 Audit Framework and Methodology

The process under which the Audit was undertaken is described in the following Sections.

2.1 Environmental Audits

As defined in the Act, an Environmental Audit is:

“a total assessment of the nature and extent of any harm or detriment caused to, or the risk of any possible harm or detriment which may be caused to, any beneficial use made of any segment of the environment by any industrial process of activity, waste, substance (including any chemical substance) or noise”.

The relevant segment of the environment for the purposes of this Environmental Audit is the land and water (groundwater) environment.

In accordance with Section 53V of the Act, an Environmental Audit report in relation to the risk of any possible harm or detriment to a segment of the environment caused by any industrial process or activity, waste, substance or noise must:

- specify the industrial process or activity, waste, substance or noise in respect of which the Environmental Audit was conducted;
- state the name of the person who has engaged the Environmental Auditor to conduct the Environmental Audit;
- be signed by the Environmental Auditor; and
- specify the results of the Environmental Audit.

As described in the guideline *Environmental Auditing in Victoria* (EPA Publication 902) the scope of an Environmental Audit may be narrowly defined for a small area of land focussing on a single segment of the environment such as in this case the land, groundwater and surface water segments. This is described further below.

2.2 Clean Up Notice Requirements

Caltex Australia Petroleum Pty Ltd (Caltex) commissioned the Environmental Audit in response to the requirements of an EPA Victoria s.62A Notice served to assess risk to the land and groundwater environment caused by past and current service station activities at the premises. A copy of the s.62A Notice is provided in **Appendix A**.

The s.62A Notice was served by EPA for the reasons outlined in Attachment A, *‘Reasons for which the Clean Up Notice is Served’* to the s.62A Notice an extract of which is reproduced below:

1. *EPA is satisfied that pollution has occurred on and from the premises.*
2. *EPA is satisfied that action is required to fully delineate the extent of dissolved phase and NAPL groundwater pollution on and from the premises.*
3. *EPA is satisfied that action is needed to mitigate and clean up the pollution.*
4. *A draft Clean Up Notice was issued on 21 December 2007 which requested the review of the operation and management of Underground Petroleum Storage System infrastructure, the characterisation of pollution from the premises, development of a clean up plan, engage an Environmental Auditor (appointed pursuant to the Environment Protection Act, 1970) to undertake 53V audit, provide a scope for the 53V audit and complete the 53V audit.*



5. On 18 February 2008 EPA received notification from Michael Rehfisch (Auditor) that he has been engaged to conduct an environmental audit pursuant to section 53V in relation to the risk of any possible harm or detriment to a segment of the environment caused by an activity.
6. On 18 February 2008, the Auditor provided EPA with a draft scope for the 53V audit. EPA's comments regarding the draft scope were sent to the Auditor on 4 June 2008.
7. On 14 May 2008 a tank integrity report for the premises infrastructure was provided to EPA. This report (UPSS Precision Test Report, Certified Report No. CA3047, MassTech Australia Pty Ltd, dated 14/4/08) concluded that all repairs, all tanks and lines have passed the tests and there were no further recommendations.
8. On 22 May 2008, the Auditor notified EPA of the presence of NAPL on and from the premises.

An extract of the requirements of the s.62A Notice, 'Attachment B', relating to the Environmental Audit are reproduced from Attachment B below:

1. By 15 August 2008, submit for review to the engaged Auditor (referred to in Item 5 of Attachment A) the results of the UPSS Precision Test Report, Certified Report No. CA3047, MassTech Australia Pty Ltd, dated 14 April 2008 with reference to the elements of EPA Publication 888 Guidelines on the Design, Installation, and Management Requirements for Underground Petroleum Storage Systems.
2. By 15 September 2008, the occupier must submit a report to EPA and the engaged Auditor that delineates the full extent of soil and groundwater contamination on and from the site caused by the premises former and current use.
This report must also quantify the risks associated with the contamination including any vapour risk.
3. By 30 September 2008, the occupier must submit a Clean Up Plan to EPA for the clean up of contaminated land upon the premises; and groundwater on and from the premises.
Refer to EPA detail on Clean up Plan requirements in **Section 8.0** of this report.
4. By 30 September 2008 submit to EPA a time-line and schedule of remediation works in accordance with the clean up plan referred to in Requirement 3.
5. By no later than 13 November 2008, the occupier must submit to EPA, an environmental audit report prepared by an environmental auditor appointed under the Environment Protection Act, 1970 in relation to any possible harm or detriment to the land and groundwater environment's caused by past and current service station activities at the premises, as determined by:
 - a. Review of the operations and management of Underground Petroleum Storage Systems infrastructure with reference to the elements of EPA Publication 888 [888.1] Guidelines on the Design, Installation, and Management Requirements for Underground Petroleum Storage Systems.
 - b. Review of the any systems, plans, procedures, monitoring programs including the clean up plan and proposed timeline, data, records, reports or other information relevant to the scope of the audit.
 - c. Inspection of any relevant activities, processes, plant and/or equipment on site.
 - d. Collection and/or modelling of any data as the auditor sees fit.
6. The environmental audit report referred to in Requirement 5 must:
 - a. Indicate if the activities conducted at the premises causes a risk of any possible harm or detriment to the land and groundwater environments as determined by an assessment of compliance with requirements of SEPP (PMCL), SEPP (GoV) and SEPP (WoV).
 - b. Where a risk of any possible harm or detriment to a segment of the environment has been determined in (a), recommend any measures necessary to reduce the risk to an acceptable level.
 - c. Where contamination of a segment of the environment has been determined, delineate the full extent of contamination/impact.



- d. *Where the risk of any possible harm or detriment to a segment of the environment cannot be determined, recommend any measures necessary to ensure that any risk to a segment of the environment will be able to be determined in the future.*
- e. *Comment on the adequacy of the clean up plan considered necessary to manage risk.*
- f. *Include recommendations for improving environmental performance, management systems, monitoring programs or other recommendations as the auditor sees fit including whether additional clean up measures are required.*

2.3 Audit Objective

The objectives of the Audit were based on the issues identified in the reasons for serving the s.62A Notice. The Audit has been completed to identify risks to the environment and to set a pathway forward for the management of the historical petroleum hydrocarbons at the premises.

Specifically, the objective of this Audit was to assess the risk of any possible harm or detriment to the land and groundwater environments caused by past and current service station activities at the premises. This included the following:

- Assessment of the risks to the land and groundwater environment at the site associated with the storage and handling of petroleum hydrocarbons.
- Where an unacceptable risk is identified or where the risk cannot be determined, recommend any measures necessary to identify and reduce the risk to an acceptable level.

2.4 Audit Scope

The Environmental Audit scope is defined by the description of the following components.

2.4.1 Review of Activity Undertaken

As indicated in EPA Publication 952.2 (EPA, 2007a), the term 'activity' means 'any industrial process or activity, waste, substance or noise' which can be focussed to a component of an activity. The activity for the purposes of this Audit is the release of petroleum hydrocarbons to the subsurface.

2.4.2 Segment Considered

The segment in the consideration of the Audit is 'the site'. This definition is taken from section 8.1 of EPA Publication 759.1 (EPA, 2007b). The site is defined in EPA publication 759.1 as a parcel of land and all other elements of the environment associated with the land within the boundary of the parcel of land. Elements to be audited are described below.

The geographical extent of the Audit comprises the land at 35-37 Shannon Avenue, Manifold Heights (refer **Figure 1**) and the surrounding environment potentially affected by petroleum hydrocarbons releases.

The timeframe to which the Audit applies was originally as described in the s.62A Notice requirements. Since then significant time has passed while the extent of the impacts were further assessed and reported to the Audit. The timeframes outlined in the s.62A Notice have since lapsed.

2.4.3 Elements Considered

The elements of the environment around the site that were considered by the Audit are land and water (groundwater), for which the beneficial uses described in **Section 2.6** were considered.



2.5 Audit Criteria

2.5.1 Policies and Guidelines

The selected criteria for this Audit have been identified by the following sources:

- The Environment Protection Act 1970.
- State environment protection policy (Prevention and Management of Contamination of Land) (SEPP (PMCL)).
- State environment protection policy (Groundwaters of Victoria) (SEPP (GoV)).
- State environment protection policy (Waters of Victoria (SEPP (WoV)).
- State environment protection policy (Air Quality Management) (SEPP (AQM)).
- Environment Protection (Industrial Waste Resource) Guidelines - 2009.
- EPA Publication 668, Hydrogeological Assessment (Water Quality) Guidelines (EPA, 2006).
- EPA Publication 669, Groundwater Sampling Guidelines (EPA, 2000).
- EPA Publication 840, The Clean Up and Management of Polluted Groundwater (EPA, 2002).
- EPA Publication 888.1, Guidelines on the Design, Installation and Management Requirements for Underground Petroleum Storage Systems (EPA, 2009).
- EPA Publication 952.2 – Environmental Auditor Guidelines for the Preparation of Environmental Audit Reports on Risk to the Environment, 2007 (EPA, 2007a).
- EPA Publication 953.2 - Environmental Auditor Guidelines for Conducting Environmental Audits, 2007 (EPA, 2007c).

2.6 Beneficial Uses Considered

The beneficial uses for the segments considered under this Audit are as identified in the SEPP (PMCL) and SEPP (GoV). The SEPP (WoV) was also considered for groundwater discharge to receiving waters.

2.6.1 Land

The SEPP (PMCL) sets out the regulatory framework for the prevention and management of contaminated land within the State of Victoria. The goal of the policy is:

“to maintain and where appropriate and practicable improve the condition of the land environment sufficient to protect current and future beneficial uses of land from the detrimental effects of contamination by:

- preventing contamination of land; and
- where pollution has occurred, adopting management practices that will ensure:
 - unacceptable risks to human health and the environment are prevented; and
 - pollution is cleaned up or otherwise managed to protect beneficial uses.”

The SEPP (PMCL) identifies land use categories and protected beneficial uses for each of these categories. Land (including soil, fill, sediment, rock and vapour within interstitial spaces) is considered polluted where current and/or future protected beneficial uses for the relevant land use categories are precluded.

The SEPP (PMCL) specifies that the following beneficial uses are protected for consideration of the ongoing commercial/industrial land use of the site:

- Maintenance of ecosystems (highly modified).



- Human health.
- Buildings and structures.
- Aesthetics.

2.6.2 Groundwater

The SEPP (GoV) applies to management of groundwater contamination issues in Victoria. The goal of the policy is:

“to maintain and where necessary improve groundwater quality sufficient to protect existing and potential beneficial uses of groundwaters throughout Victoria”.

The key policy objectives relevant to pollution of groundwater are defined in the Groundwater SEPP, and include the following:

- Environmental policy goals, including the principles of “polluter pays”, “intergenerational equity” and the “precautionary principle”.
- Definitions of beneficial uses of groundwater to be protected (based on background salinity or total dissolved solids (TDS)), groundwater quality indicators and objectives.
- The policy objective that non aqueous phase liquid must be removed unless the Authority (EPA) is satisfied that there is no unacceptable risk to posed to any beneficial use.
- The method by which the Authority identifies a groundwater quality restricted use zone.

Groundwater is considered polluted where the objectives for indicators of a beneficial use are exceeded, or where non-aqueous phase liquid is present. Where groundwater has been polluted it must be cleaned up such that the protection of beneficial uses is restored, or if this is not possible, groundwater must be cleaned up to the extent practicable.

The completion of site investigations indicates that the TDS concentration of groundwater at the site varies from 3,120 to 9,282 mg/L, as of July 2009, which classifies the groundwater as Segment C under the SEPP (GoV). The SEPP (GoV) specifies that Segment C groundwater (i.e. TDS of between 3,501 and 13,000 mg/L) is protected for the following beneficial uses:

- Maintenance of Ecosystems (marine at the point of discharge, considered to be Corio Bay).
- Stock watering.
- Industrial water use.
- Primary contact recreation (e.g. bathing, swimming).
- Buildings and structures.

2.7 Audit Team and Expert Support

In conducting this Audit, the Auditor has relied upon the following members of his expert support team:

- Ms Kristi Hanson – contaminant transport and assessment of exposure pathways and risk.
- Dr Bruce Anderson – remedial and geotechnologies (whilst Auditor employed at AECOM).

Assistance has also been provided by the following personnel:

- Michael Charge – Principal Scientist, Senversa Peer Review.

2.8 Audit Methodology

The methodology that has been undertaken to conduct the Audit consisted of the following:



- At the outset, the Auditor met with the Caltex's consultants, URS Corporation Pty Ltd (URS), to discuss knowledge at the time of the site and the proposed scope of investigations.
- An initial site inspection on 3 March 2008 to familiarise the Auditor with the site setting and surrounds and to gain an understanding of the scale of the activity.
- Preparation of an Audit scoping document and discussion of the Audit scope with EPA (meeting 3 March 2008). EPA provided comments on the Audit scope on 4 June 2008. EPA concurred with the Audit scope, indicating however, that as per the s.62A Notice, "groundwater pollution (i.e. LNAPL and dissolved phase) needs to be fully delineated if it hasn't already been determined and addressed in the Clean Up Plan and that a staged remediation approach is not appropriate".
- Review existing information relating to the premises presented by URS with reference to National and State guidelines for assessing contamination of land, and the requirements of EPA Publication 888 [888.1], Guidelines on the Design, Installation, and Management Requirements for Underground Petroleum Storage Systems. Review documents were limited to:
 - Final Report – Addendum to Clean Up Plan, Caltex Geelong West Service Station (37344) and Response to Auditor Comments, URS Corporation Pty Ltd, 17 June 2010 (URS, 2010a).
 - Revised Quantitative Risk Assessment, Geelong West Caltex Service Station (37344), 35-37 Shannon Ave, Manifold Heights, VIC. URS Corporation Pty Ltd, 17 June 2010 (URS, 2010b)
 - Clean Up Plan, Geelong West Service Station (37344), URS Corporation Pty Ltd, 1 July 2008 (URS, 2008a).
 - Response to Auditor Comments (23/5/08), URS Corporation Pty Ltd, 27 June 2008. Includes consideration of site underground petroleum storage systems (UPSS) requirements (URS, 2008b)
 - Response to Auditor Comments (20/3/08), URS Corporation Pty Ltd, 12 May 2008. Includes consideration of clean up plan modifications (URS, 2008c).
 - Volume 1 of 3 – Site Investigation, Further Post Phase 2 Investigation and Remediation Trials, Caltex Geelong West (37344), 35-37 Shannon Ave, Manifold Heights. URS Corporation Pty Ltd, 25 October 2007 (URS, 2007a).
 - Volume 2 of 3 – Quantitative Risk Assessment, Further Post Phase 2 Investigation and Remediation Trials, Caltex Geelong West (37344), 35-37 Shannon Ave, Manifold Heights. URS Corporation Pty Ltd, October 2007 (URS, 2007b).
 - Volume 3 of 3 – Remediation Pilot Trials, Further Post Phase 2 Investigation and Remediation Trials, Caltex Geelong West (37344), 35-37 Shannon Avenue, Manifold Heights. URS Corporation, 29 October 2007 (URS, 2007c).
 - Post Phase 2 Environmental Assessment Caltex Geelong West Service Station (Site ID 37344) Corner of Shannon Avenue and Church Street, Geelong West, Victoria, URS Corporation, 19 January 2007 (URS, 2007d).
 - Air Quality Sampling and Results – Scope Learning Centre, Geelong West. URS Corporation Pty Ltd, 17 January 2007 (URS, 2007e; note that this report forms Appendix L within URS, 2007d).
 - Soil Gas Results and Preliminary Quantitative Risk Assessment for Caltex Geelong West Service Station, cnr Shannon Ave and Church St., Geelong, Victoria. URS Corporation, 26 June 2006 (URS, 2006; note that this report forms Appendix K within URS, 2007d).
- Review and assessment of risk to the land and groundwater environment at the site due to the past and current service station activities.
- Identification of data gaps and, where present, additional investigations were recommended. This included the provision of queries to Caltex and their site assessor (URS Corporation Pty Ltd) on the initial information provided.



- Assessment of whether or not soil and groundwater at the site is polluted with respect to the objectives of the SEPP (PMCL), SEPP (GoV), SEPP (AQM) and SEPP (WoV) and whether or not on-Site and off-site groundwater, land and surface water are polluted as a result of handling, storage and distribution of petroleum related products.
- Review of proposed clean up responses to petroleum hydrocarbon risks and recommend measures to address immediate (short term) risks and set out a pathway forward for the longer term management strategy.
- Preparation of this Environmental Audit report in accordance with EPA Publication 952.2 (EPA, 2007a).

2.9 s.62A Notice Compliance Review

In developing the agreed scope for the Audit, the s.62A Notice served by EPA was reviewed to develop the following methodology for reviewing compliance with the requirements of the s.62A Notice as part of the Audit.

s.62A Notice Requirements

s.62A Notice Requirement	Audit Methodology
1. By 15 August 2008, submit for review to the engaged Auditor (referred to in Item 5 of Attachment A) the results of the UPSS Precision Test Report, Certified Report No. CA3047, MassTech Australia Pty Ltd, dated 14 April 2008 with reference to the elements of EPA Publication 888 Guidelines on the Design, Installation, and Management Requirements for Underground Petroleum Storage Systems	Review UPSS Precision Test Report, Certified Report No. CA3047, MassTech Australia Pty Ltd, dated 14 April 2008 and URS correspondence dated 27 June 2008 with reference to the UPSS guidelines. Refer to discussion presented in Section 5.1 of this report.
2. By 15 September 2008, the occupier must submit a report to EPA and the engaged Auditor that delineates the full extent of soil and groundwater contamination on and from the site caused by the premises former and current use.	Review delineation information presented in section 8 of URS (2010a) and discussion presented in Section 5.2 and 5.3 of this report.
2.1 This report must also quantify the risks associated with the contamination including any vapour risk.	Review the results of the vapour risk assessment associated with the contamination and discussed in Section 5.4 of this report. Appendix J of URS (2010a) presents the revised quantitative vapour risk assessment.
3. Clean Up Plan Requirements	Review the clean up measures presented in the URS Clean Up plan (2008a, amended as URS, 2010a) with comparison to the requirements outlined in Section 8.1 of this report.
4. By no later than 13 November 2008, the occupier must submit to EPA, an environmental audit report prepared by an environmental auditor appointed under the Environment Protection Act, 1970 in relation to any possible harm or detriment to the land and groundwater environment's caused by past and current service station activities at the premises, as determined by: • Review of the operations and management of Underground Petroleum Storage Systems infrastructure with reference to the elements of EPA Publication 888 Guidelines on the Design, Installation, and Management Requirements for Underground Petroleum Storage Systems. • Review of any systems, plans, procedures, monitoring programs including the clean up plan and proposed timeline, data, records, reports or other information relevant to the scope of the audit. • Inspection of any relevant activities, processes, plant and/or equipment on site.	This Audit report was prepared to meet this s.62A Notice requirement. The methodology included the following: • Review UPSS Precision Test Report, Certified Report No. CA3047, MassTech Australia Pty Ltd, dated 14 April 2008 and URS correspondence dated 27 June 2008 with reference to the UPSS guidelines. Refer to discussion presented in Section 5.1 of this report. • Review of soil and groundwater assessment works and the clean up plan prepared for the premises. Refer to discussion presented in Sections 5.0 and 8.0 of this report. • Auditor verification sampling and/or inspections were carried out during utility pit monitoring. Refer to detail presented in Section 7.0 of this report.



s.62A Notice Requirement

Audit Methodology

Collection and/or modelling of any data as the auditor sees fit.	Auditor verification sampling and/or inspections were carried out during utility pit monitoring. Refer to detail presented in Section 7.0 of this report.
5. The environmental audit report referred to in Requirement 5 must: - Indicate if the activities conducted at the premises cause a risk of any possible harm or detriment to the land and groundwater environments as determined by an assessment of compliance with requirements of SEPP (PMCL), SEPP (GoV) and SEPP (WoV). - Where a risk of any possible harm or detriment to a segment of the environment has been determined in (a), recommend any measures necessary to reduce the risk to an acceptable level. - Where contamination of a segment of the environment has been determined, delineate the full extent of contamination/impact. - Where the risk of any possible harm or detriment to a segment of the environment cannot be determined, recommend any measures necessary to ensure that any risk to a segment of the environment will be able to be determined in the future. - Comment on the adequacy of the clean up plan considered necessary to manage risk. - Include recommendations for improving environmental performance, management systems, monitoring programs or other recommendations as the auditor sees fit including whether additional clean up measures are required.	The methodology comprised the following: - Comparison of soil, soil vapour and groundwater analytical results and modelling to relevant State environment protection policy criteria. Refer to discussion on impacts in Sections 5.2.4, 5.3.6, 5.4.4 of this report and risk assessment presented in Section 9.0 of this report. - Review plans for clean up (refer Section 8.0) and recommend any additional measures (refer Section 11.0). - Review delineation information presented in section 8 of URS (2010a) and discussion presented in Section 5.2 and 0 of this report. - Review adequacy of investigations to assess nature and extent of petroleum hydrocarbon impacts (refer above and Section 11.0 of this report). - Review plans for clean up and recommend any additional measures (if required) Review plans for clean up (refer Section 8.0) and recommend any additional measures (refer Section 11.0). - Assess the need for additional monitoring or clean up than that proposed (refer Section 11.0).

2.10 Audit Exclusions

Specific exclusions from the Audit scope include, but are not limited to:

- Assessment of contaminants of concern other than those derived from petroleum hydrocarbons.

2.11 Communications with EPA

During the conduct of the Audit, the Auditor advised EPA of the following:

- On 27 May 2008 – the presence of light non-aqueous phase liquid (LNAPL) at and beyond the boundary of the premises.
- On 8 August 2008 – correspondence with Environmental Performance Unit and Geelong Office regarding potential imminent environmental hazard associated with elevated Lower Explosive Limit (LEL) detections from utility pit monitoring conducted in the vicinity of the site (in particular on Church Street adjacent the former Mobil service station).
- On 15 August 2008 - email correspondence outlining a summary of results of utility pit monitoring and information provided by URS Corporation Pty Ltd on the risk to utilities.
- On 13 September 2010 – Clarification on the process and timeframe for completing the Audit.



3.0 Site Setting

3.1 Site and Surrounding Land Use

The site is an operating commercial service station. The surrounding area comprises mixed commercial and residential land uses as follows:

- North – roadway then low density residential.
- South – medium density residential.
- East – roadway then vacant land comprising former Mobil Oil service station.
- West – commercial premises (Recreational and Educational Adult Program (REAP) Scope Centre, formerly the Spastic Children's Society of Victoria (Scope Centre)).

3.2 Topography and Drainage

The Post Phase 2 Assessment Report (URS, 2008d) discusses the topography and drainage of the site. The elevation of the site is approximately 29 mAHD and is located near Corio Bay, with the slope at the site grading north-northeast towards Shannon Avenue. The surface drainage is likely to run off the site to the northeast boundary, into the kerb channel / open drain, into stormwater drains and ultimately into the Corio Bay which is located 1.5 km to the east of the site (also considered to be the nearest groundwater discharge receiving water).

3.3 Geological Setting

3.3.1 Regional Geology

The 1:63,360 scale geological series map (Geelong series map, Geological Survey of Victoria) indicates the site to be on the outcrop margin between the Quaternary aged Newer Volcanics and the Tertiary aged Moorabool Viaduct Formation which consists of various sands, clays and gravels. This is shown in the figure below.





3.3.2 Site-Specific Geology

Based on soil borelogs provided in the URS (2007a) report, geological conditions encountered during site assessment works were generally consistent with these descriptions with soils typically recorded as comprising of sandy or silty clays with traces of gravels and the occasional basalt boulders.

Hydrocarbon odours were recorded by URS during the advancement of soil bores, particularly within the clay layer between 7 and 12 m bgl.

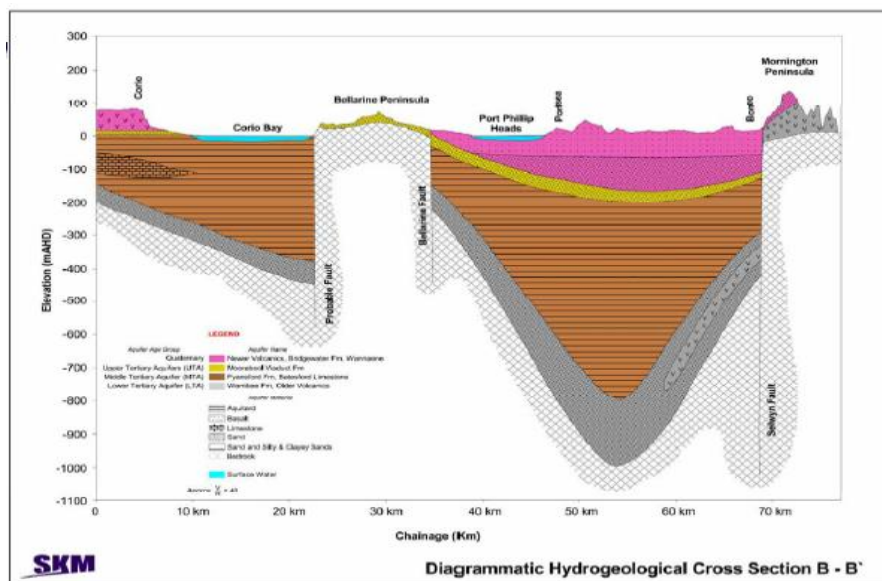
Based on the drilling conducted by URS, the local geology encountered at the site is summarised in the following table:

Minimum Depth (m bgl)	Maximum Depth (m bgl)	Description
0	0.25	Concrete
0.2	1.2	Fill: comprising dark brown clay, sand and gravel
0.5	10	Natural (Moorabool Viaduct Formation): Silty/sandy clay comprising grey to white/cream becoming green/brown at depth, very stiff. Bands of fragmented basalt within a clay matrix were encountered between 1.0 and 2.5 m bgl

3.4 Hydrogeological Setting

3.4.1 Regional Hydrogeological Setting

The uppermost regional aquifer within the Manifold Heights area comprises the Upper Tertiary Aged Moorabool Viaduct Formation which occurs in the Bellarine-Geelong region and comprises an aquifer which consists of marine and terrestrial sand, gravel and silt (URS, 2008a). The figure below (SKM, 2006) identifies Tertiary aged Newer Volcanics overlying Moorabool Viaduct Formation, Fyansford Formation, Werribee Formation and basement bedrock.





A review of the Melbourne Groundwater Map (SKM, 2002) indicates that the watertable depth is between 5 and 10 m, which is consistent with results of previous groundwater studies on the site.

TDS concentrations typically range from 7,001 – 13,000 mg/L (SKM, 2002) which is characterised as Segment C groundwater (i.e. TDS of between 3,501 and 13,000 mg/L). The quality of groundwater, assessed by URS (2010a) has identified TDS levels of the surface aquifer to range from 3,120 to 9,282 mg/L, based upon on-site readings. Regional groundwater flow is expected to be towards Corio Bay, which is located 1.5 km east of the site.

Based on the summary aquifer information presented in SKM (2006) the Moorabool Viaduct Formation is considered to have a saturated thickness of 10 – 15 metres, has a low transmissivity ($< 50 \text{ m}^2/\text{day}$) and low specific yield (~ 0.05). This information does not suggest the usage potential of the formation to be high.

3.4.2 Regional Groundwater Use

A review conducted by Senversa of licensed water bore data provided by the Victorian Water Resources Data Warehouse indicated that there are seven licensed groundwater monitoring bores within a 1 km radius of the site, all registered for investigation purposes only. A summary of licensed information is provided in the following table:

Well ID	Well Use	Distance and Direction from Site	Total Depth (m)	Lithology
140646	Investigation	1999 investigation well at site	9	Alluvial deposits
140647	Investigation	1999 investigation well at site	9	Alluvial deposits
140648	Investigation	1999 investigation well at site	9	Alluvial deposits
140649	Investigation	1999 investigation well at site	9	Alluvial deposits
142460	Investigation	<1 km east	10	Alluvial deposits
142462	Investigation	<1 km north east	12	Alluvial deposits
142643	Investigation	<1 km north east	12	Alluvial deposits

3.4.3 Site Specific Hydrogeological Setting

Based upon the data provided by URS (2010a), directly below the site is a shallow unconfined aquifer approximately 8.5 m bgl within the silty sandy clay which is consistent with the Moorabool Viaduct Formation. All groundwater monitoring bores have been completed in the shallow water table aquifer at the site.

The most recent gauging undertaken in November 2009 indicates that the standing water level in the shallow aquifer lies between 7.97 m below top of casing (mBTC) (MW22) and 9.76 mBTC (MW23). Localised SWL elevations suggest a groundwater flow direction to the northeast towards the Corio Bay at a rate between 2 and 40 m per year (refer **Figure 2**). The inferred hydraulic gradient on the site ranges from 0.003 to 0.01. The hydraulic conductivity from rising head tests conducted by URS (2010a) was calculated to be between 0.4 and 2.0 m/day. URS calculated a groundwater seepage velocity (assuming 20% effective porosity for silty/sandy clay) of the order of 2 to 40 m/year.



3.5 Environmental Audits Completed in the Vicinity of the Site

The Auditor is not aware of any Audits completed in the vicinity of the site. It is understood from review of the list of notified Audits (a list available to appointed Auditors) that there is an Audit in progress at the former Mobil Service Station on the corner of Shannon Avenue and Church Street to the east of the site (EPA Reference 53793-1). This Audit is being completed by Patrick Clarke of Senversa, a colleague of the Auditor. It is understood that this Audit has been underway for some time, but is currently inactive.



4.0 Protected Beneficial Uses

4.1 Beneficial Uses of Land

4.1.1 Protected Beneficial Uses

Further to the information provided in Section 2.6.1, the SEPP (PMCL) specifies that the following beneficial uses are protected throughout the State of Victoria for consideration of the proposed commercial/industrial land use of the site:

- Maintenance of highly modified ecosystems.
- Human health.
- Buildings and structures.
- Aesthetics.

4.1.2 Soil Quality Objectives

In accordance with SEPP (PMCL), soil quality objectives for the beneficial uses are primarily sourced from the National Environment Protection (Assessment of Site Contamination) Measure (NEPC, 1999) ('the NEPM'), specifically those provided in Schedule B(1) of the NEPM, Guideline on the Investigation Levels for Soil and Groundwater. The specific objectives used for each protected beneficial use identified are described in the following table.

Beneficial Use	Adopted Guideline Source
Maintenance of Ecosystems	Schedule B(1) of the NEPM provides a range of investigation levels for the protection of ecosystems, referred to as Ecologically-Based Investigation Levels (EILs). The following should be noted: • A limited range of EILs are provided, and only for metals/metalloids (no regional-based EILs are currently available). These values are based on consideration of phytotoxicity, 'ANZECC B' levels (ANZECC/NHMRC, 1992) and soil survey data from urban residential properties in four Australian capital cities. • The EILs do not currently discern between natural, modified and highly modified ecosystems, as defined in the SEPP (PMCL). For the consideration of petroleum hydrocarbons and benzene, toluene, ethylbenzene and xylenes (BTEX), the NSW EPA Service station guidelines (NSW EPA, 1994) have been considered EILs have been used to assess on-site environmental impacts, by direct comparison with soil concentrations found at each sampling location.
Human Health	Schedule B (1) of the NEPM provides a range of investigation levels for the protection of human health, referred to as Health Investigation Levels (HILs). HILs are provided for four exposure settings based on land use. These are: • Setting A - 'Standard' residential with garden/accessible soil (home-grown produce contributing less than 10% of vegetable and fruit intake; no poultry). This category includes children's day-care centres, kindergartens, preschools and primary schools. • Setting D – Residential with minimal opportunities for soil access. Includes dwellings with fully and permanently paved yard space such as high-rise apartments and flats. • Setting E – Parks, recreational open space and playing fields. Includes secondary schools. • Setting F – Commercial/industrial. Includes premises such as shops and offices as well as factories and industrial sites. It is emphasised within the NEPM that HILs are not intended for use as default remediation trigger criteria, but are intended to prompt an appropriate site-specific assessment when they are exceeded. For the purposes of this environmental Audit the Setting F HILs have been used for comparison with actual soil conditions at the site, consistent with the current and intended future use of the



Beneficial Use	Adopted Guideline Source
	site. Where soil quality objectives were not available within the NEPM, or alternative Australian guidelines were not available, additional sources of information were used. These include guideline values sourced from the following: - USEPA (2010) Regional Screening Levels (formerly known as Preliminary Remediation Goals). This included most other organic compounds such as BTEX. - Canadian Council of Ministers for the Environment (CCME, 2008), used as an investigation level for total petroleum hydrocarbons (TPH) in soils and supplementing the existing objectives for aliphatic/aromatic ranges defined in the National Environment Protection Measure. The values adopted were the lowest of the range of human health based levels or management limits for Commercial or Industrial use of land, as specified in the CCME (2008) technical supplement.
Buildings and Structures	The Land SEPP states, "Contamination must not cause the land to be corrosive to or adversely affect the integrity of structures or building materials". The potential for the condition of soils at the site to adversely impact upon buildings includes: - Elevated sulphate concentrations or acidic (low pH) soil conditions which are detrimental to some concrete structures - Ingress of contaminants into subterranean service lines (such as ingress into water supply pipelines). Australian Standard 2159 – Piling Design and Installation (Standards Australia, 2009a) has also been considered in assessing this beneficial use. The potential for the condition of soils at the site to adversely impact upon buildings and structures is discussed in Section 5.2.4.
Aesthetics	The SEPP (PMCL) states that contamination must not cause the land to be offensive to the senses of human beings. . The potential for the condition of soils at the site to adversely impact upon aesthetics is discussed in Section 5.2.4.

4.2 Beneficial Uses of Groundwater

4.2.1 Protected Beneficial Uses

Groundwater sampling indicates that the TDS concentration of groundwater at the site varies from 3,120 to 9,282 mg/L, as of July 2009. The SEPP (GoV) specifies that Segment C groundwater (i.e. TDS of between 3,501 and 13,000 mg/L) is protected for the following beneficial uses:

- Maintenance of Ecosystems (at point of discharge).
- Stock watering.
- Industrial water use.
- Primary contact recreation (e.g. bathing, swimming).
- Buildings and structures.

4.2.2 Groundwater Quality Objectives

In accordance with the SEPP (GoV), groundwater quality objectives for beneficial uses are primarily sourced from the Australian Water Quality Guidelines for Fresh and Marine Waters, published by the Australian and New Zealand Environment and Conservation Council (ANZECC, 1992 and ANZECC/ARMCANZ, 2000). Given that shallow groundwater at the site, as defined under the SEPP (GoV), has been assessed as Segment C, and considering the beneficial uses listed in the above sections, the Auditor has referenced the following groundwater quality objectives in order to assess impact to potential groundwater beneficial uses:

Beneficial Use	Adopted Guideline Source
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Beneficial Use	Adopted Guideline Source
Maintenance of Ecosystems	For maintenance of ecosystems, the State Environment Protection Policy (Waters of Victoria) (SEPP (WoV)) and its schedules apply. The SEPP (WoV) adopts surface water objectives from Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000). Corio Bay to the east of the site falls within Schedule F6, Waters of Port Phillip Bay (1997), and is described as a 'Highly Modified ecosystem with some habitat values' and in accordance with SEPP (WoV), a 90% protection level has been adopted. For particular chemicals where high and moderate reliability trigger values are not published by ANZECC/ARMCANZ (2000), low reliability trigger values have been used for comparison with concentrations of contaminants. Where low reliability trigger values have been adopted, these have been used as an indicative interim working level only, in accordance with ANZECC/ARMCANZ (2000).
Stockwatering	For stock watering, the SEPP (GoV) and its schedules apply. The SEPP (GoV) specifies indicators and investigation levels from ANZECC (1992). As the ANZECC (1992) guidance has been superseded by ANZECC/ARMCANZ (2000), the more recent guidelines have been referenced in the first instance as follows: 1. ANZECC/ARMCANZ, 2000. Primary Industries – Livestock Drinking Water Quality. For contaminants for which no livestock drinking water quality criteria are provided, ANZECC/ARMCANZ (2000) recommends that drinking water guidelines for human health be adopted. Drinking water guidelines to supplement the above values were adopted from the following sources (in order of preference): 2. NHMRC, 2004. Australian Drinking Water Guidelines – Health. 3. WHO, 2008. Guidelines for Drinking Water Quality. 4. USEPA, 2010. Regional Screening Levels – Tap Water.
Industrial Water Use	No guidelines have been adopted based on the wide range of possible industrial uses of water. This beneficial use is generally assessed when an existing, proposed or likely industrial use is known. As such this beneficial use is not considered further.
Primary Contact Recreation	For primary contact recreation, the SEPP (GoV) and its schedules apply. The SEPP (GoV) specifies indicators and investigation levels from ANZECC (1992). As the ANZECC (1992) guidance has been superseded by ANZECC/ARMCANZ (2000), the more recent guidelines have been referenced in the first instance, as follows: 1. ANZECC/ARMCANZ, 2000. Guidelines for Recreational Water and Aesthetics. For contaminants for which no primary contact recreation guidelines are provided, ANZECC (2000) recommends that drinking water guidelines for human health be adopted. Drinking water guidelines to supplement the above values were adopted from the following sources (in order of preference): 2. NHMRC, 2004. Australian Drinking Water Guidelines – Health and Aesthetics. 3. WHO, 2008. Guidelines for Drinking Water Quality. 4. USEPA, 2010. Regional Screening Levels – Tap Water.
Buildings and Structures	Specific guidelines for buildings and structures are not available, however Australian Standard (AS2159-2009) – Piling – Design and Installation was referred to for the protection of building and structures. In particular, the effects of pH, sulphate and redox need to be considered.

A groundwater quality objective for TPH in groundwater is not available from the above references. Petroleum hydrocarbon mixtures are typically made up of numerous individual hydrocarbons with varying physical, environmental and toxicological properties. The Auditor has adopted an investigation value developed by the Netherlands Ministry of Housing, Spatial Planning and the Environment Intervention Values for "mineral oil" (VROM 2008). This value (600 µg/L) has been applied as a TPH guideline in the Tasmanian Underground Storage Tank Decommissioning Guidelines (Tasmania Department of Tourism, Arts and the Environment, August 2006).



5.0 Assessment of Environmental Quality of the Site

5.1 Potential Sources of Petroleum Hydrocarbon Contamination

5.1.1 Service Station Site History

From information provided by URS (July 2008a), the service station has operated for 30 to 40 years and prior to 1987 the site was operated by Shell. In 1994, Geo & Hydro Pty Ltd completed assessment works for Ampol Petroleum (Vic) Pty Ltd and the site was an operating Solo service station. Historically the site operations included a mechanical workshop, the location of which is unknown. A search of Council planning and building permit records may yield additional information and should be completed.

5.1.2 UPSS Infrastructure

Based on information provided to the Auditor, the site is subject to soil and groundwater contamination that has resulted from the storage and handling of petroleum hydrocarbons. The tank locations are not well documented. Geo & Hydro Pty Ltd (1994) believe there were originally six operational and three abandoned USTs, which is different from the current number of tanks on-site. This has been noted to be either an error, or an indication of tank replacements at some stage.

Geo & Hydro Pty Ltd (1994) outlines reports of leakage from a pipeline which resulted in the north-east pump (supplying super and unleaded petrol) to become non-operational in 1992. This report also outlined stock discrepancies including 500 litre losses over a three to four month period in early 1994. It is understood that an active LNAPL skimmer system operated within three groundwater monitoring bores at the site. Details regarding the operation and product recovery of the system were not available (URS, 2008a). It is also understood that underground storage tank (UST) remote fill points have been replaced by Caltex.

Based on information provided to URS by Caltex, there are currently seven identified Underground Petroleum Storage Systems (UPSS) present, all with steel construction. The following UPSSs are present at the site:

- 2 Unleaded Petrol (ULP) storage systems both of which are 27,000 L capacity.
- 2 Premium Unleaded Petrol (PULP) storage systems 16,000L and 27,000 L capacity.
- 1 Diesel UST, capacity 16,000 L.
- 1 possibly decommissioned storage system with nominal 27,000L capacity (decommissioning status unknown, however appears to be concreted over and is indicated on Figure 3 within URS, 2007d to be decommissioned).
- 1 unknown UST of unknown capacity.

5.1.3 Integrity of UPSS

EPA Publication 888.1 (EPA, 2009), Guidelines on the Design, Installation and Management Requirements for Underground Petroleum Storage Systems establishes the minimum requirements for the management of UPSS for the protection of people, property and the environment from product release. In summary, the key requirements for UPSS include:

- In the event of installing a new UPSS, the design must be in accordance to equipment selection measure requirements for tanks, piping and other infrastructure as per standard 888.1.
 - As a minimum requirement, tanks are to be non-corrodible and have provision for secondary containment of spills / leaks and leak detection systems.



- Piping infrastructure should be non-corrodible, have provision for secondary containment for products, fill point requirements, leak detection systems and vapour recovery on delivery for UPSS with existing infrastructure.
- Groundwater monitoring bore installation at sensitive sites before operation begins, tank pit observation bores, overfill protection, earthing of UPSS and dispenser sumps area also required .
- Installation of UPSSs needs to be conducted in accordance with a quality assurance system and regular maintenance needs to be conducted in accordance with the manufacturer's recommendations.
- All practicable measures to detect leakage of any product from a UPSS are required to ensure it does not cause an environmental hazard. As a default minimum, the leak detection system needs to be rated to detect a release of 0.76 L/hour with greater than 95% confidence and be reported not less than monthly.
- Owner / operators who are made aware of a leak or spill from a UPSS must first verify, report it to the appropriate authorities and then mitigate the threat to people, properties and the environment by taking all practicable measures to clean up any UPSS leakage. Determination of what caused the leak, measures to ensure it does not reoccur and repair and / or upgrade of the UPSS will then be required.
- Disused UPSSs are required to be removed wherever practicable and any associated pollution cleaned up to the extent practicable.
- Where removal of a UPSS is not practicable (e.g. where removal will cause serious risk to adjoining structures) the disused UPSS is required to be emptied and decommissioned.

Information on the integrity of the UPSS is provided in URS information provided to the Auditor dated 27 June 2008 (URS, 2008b). It is understood that the tanks are in excess of 20 years old and Caltex does not have any documentation on the design and installation details of the UPSS. Caltex has completed the following UPSS management:

- It is understood that Stock Inventory Reconciliation Analysis (SIRA) has been completed since 2004 and all tanks are dipped daily to record product volume. If SIRA identifies a potential loss, a staged Caltex leak investigation process is followed.
- The premium unleaded petrol suction line to pumps 3/4 and 7/8 was replaced in October 2006 following line failure noted during integrity testing in August 2006.
- In February 2008, MassTech Australia Pty Ltd (MassTech) was contracted to complete tank and line integrity testing. The testing indicated failed diesel and unleaded petrol UPSS components. The failed components were successfully repaired as reported by MassTech in April 2008 (refer **Attachment 1**).

5.2 Nature and Extent of Soil Contamination

5.2.1 Soil Investigations Undertaken

Soil investigations have been completed at the site over a number of phases since 1994 as follows:

- Geo & Hydro Pty Ltd (1994): Twenty soil bores were drilled across the site to a maximum depth of 1.5 m bgl (refer Figure 2 of that report). These works comprised a preliminary site investigation.
- Handex (1999): Four soil bores were installed at the site by Mobil Oil as part of investigations on the adjoining service station to the east of Shannon Avenue (refer Figure 2 of that report).
- URS (2007d): A total of 15 soil boreholes were drilled in May and August 2006. Ten soil boreholes (MW1, MW2, MW3a, MW4a, MW5 and MW8 to MW12) were installed to a depth of 10



m bgl. One bore (MW6) was drilled to a depth of 9.6 m bgl. Four bores (SV1 to SV3 and MW7) were drilled to a maximum depth of 1.2 m bgl. These works comprised a more detailed site investigation than the Geo & Hydro and Handex work.

- URS (2007a): A total of 13 soil boreholes were drilled in April and May 2007. Six soil bores (SB13/MW13, SB14a/EW1, SB15/EW2, SB16/MW14, SB17/MW15 and SVE03) were drilled to depths ranging between 9.7 and 12.2 m bgl. Three bores (SVE01b, SVE02a and SVE4b) were drilled to a depth of 5 m bgl. Four off-site soil vapour monitoring bores (SV4-SV7) were drilled to a maximum depth of 1.2 to 1.3 mbgl. Only soil samples from SB13 to SB17 were submitted for laboratory analysis. These works comprised a more detailed assessment to include vapour risk assessment.
- URS (2010a): A total of 18 soil boreholes were drilled in November and December 2009. Six soil boreholes were drilled to a depth of 11 m and were then converted into groundwater monitoring bores (MW18-MW19 and MW21-MW24). Nine bores were installed and drilled to a depth of 12.1 m bgl and were converted to multiphase extraction wells (MPE01, MPE02, MPE05, MPE06, MPE07, MPE08, MPE09, MPE10 and MPE11). Two soil bores (SB18, SB19) were drilled to a maximum depth of 10.2 m bgl. One bore was installed and drilled to a depth of 4 m bgl and then converted to a soil vapour extraction well (SVE05). These works were commissioned to further delineate the extent of the hydrocarbon impact identified at the site and to establish a network of extraction bores.

5.2.2 VOC Screening

During the URS investigations (2007 – 2010), samples were screened in the field for volatile compounds (VOCs) via use of a photo ionisation detector (PID) and were present in concentrations ranging from 0.0 ppm to 3,800 ppm (MW8_8.0-8.1). URS indicated that soils that recorded PID concentrations greater than 10 ppm also exhibited hydrocarbon odours. Elevated PID results were recorded for samples up to 10 m bgl. Impact occurred either from throughout the soil profile to depth or in some cases only at the groundwater table interface, apparently associated with smear zone LNAPL impacts.

5.2.3 Soil Contamination Present

A summary of chemical concentrations in soil exceeding the adopted soil criteria for the site is provided in the following table:

Analyte	Sample ID	Sample Depth (m bgl)	Concentrations (mg/kg)	Guideline(s) Exceeded	Guideline Concentration (mg/kg)
Benzene	MPE02	6.0-6.1	8.2	USEPA (2010)	5.4
	SB14a, SB15	7.0-7.2 – 8.0-8.2	9-22.3		
	MW8	8.0-8.1	284	USEPA (2010)	5.4
	MW8	8.0-8.1	1707	USEPA (2010)	630
TPH (C ₆ -C ₉)	MPE11	6.0-6.1	342	CCME (2008)	320
	MW8	8.0-8.1	3800		
	SB14a, SB15	7.0-7.2 – 8.0-8.2	360-725		
TPH (C ₁₅ -C ₃₆)	SV2	0.2-0.3	3940	CCME (2008)	3,500



Analyte	Sample ID	Sample Depth (m bgl)	Concentrations (mg/kg)	Guideline(s) Exceeded	Guideline Concentration (mg/kg)
Nickel	MPE06, SVE05	1.0-1.2	62-87	NEPM HIL 'F'	60

Note: Unformatted exceedences denote sampling from November/December 2009 (reported by URS, 2010a), exceedences in **red** denote sampling from May/August 2006 investigation works (reported in URS, 2007d), and exceedences in **bold** denote sampling from May 2007 investigation works (reported in URS, 2007a).

In addition, odorous soils were encountered at a number of locations, generally corresponding to elevated PID readings.

The inferred extent of petroleum hydrocarbon soil impacts as described by URS and presented in Figures 3a and 3b of URS (2010a) can be summarised as follows:

- Principal soil impact is in the vicinity of the UST fill points near the western boundary (refer to Figure 5 of URS 2007d). Soil impact west of the boundary was not delineated due to access restrictions. The extent of shallow soil impact was assessed to be limited north of SV2 and MPE01 suggesting the risk of migration to stormwater drainage and related utilities to be low.
- Soil impact near the western boundary extends to the water table (e.g. sample location MPE01, 6.0 m bgl, 26 mg/kg benzene).
- Deeper soil impact in other areas of the site to depths of 8 and 9 m bgl appears to be related to smear zone impact associated with LNAPL present on the water table. This impact is intermittently present along the northern half of the site extending east to Shannon Avenue.

5.2.4 Summary of Impact to Beneficial Uses

Based on the SEPP (PMCL) and results of environmental investigations, the impacts on the beneficial uses of land at the site are detailed in the table below:

Beneficial Use	Beneficial Use Potentially Precluded	Comment/Rationale
Maintenance of Ecosystems	Yes	Petroleum hydrocarbon impacts have been identified in concentrations exceeding the threshold concentrations for sensitive use (which considers terrestrial ecosystem protection) outlined in the NSW EPA (1994) service station guidelines.
Human Health	Yes	Petroleum hydrocarbon impacts have been identified at concentrations exceeding the health investigation levels adopted from USEPA (2010) and CCME (2008).
Buildings and Structures	No	Shallow petroleum hydrocarbon soil impacts may corrode or adversely impact (e.g. permeate) non-metal underground services, however this is more likely if shallow soil LNAPL is encountered. No shallow soil LNAPL has been encountered at the site.
Aesthetics	Yes	Petroleum hydrocarbon odorous soils have been encountered principally throughout the soil profile in the western area of the site and are considered to preclude this beneficial use.



5.3 Nature and Extent of Groundwater Contamination

5.3.1 Groundwater Investigations Undertaken

Groundwater investigations have been completed at the site over a number of phases since 1999 as follows (refer URS, 2010a for detail):

- Handex, 1999 – four groundwater monitoring bores were installed GMW1 through GMW4. MW17 was installed at the site by Mobil Oil as part of investigations on the adjoining service station to the east of Shannon Avenue.
- URS, 2006 – 2010 as follows:
 - May 2006 – Installation of four groundwater monitoring bores (MW1, MW2, MW3a and MW4a) (reported in URS, 2007d).
 - August 2006 - Installation of seven groundwater monitoring bores (MW5, MW6, MW8, MW9, MW10, MW11 and MW12) (reported in URS, 2007d).
 - May 2007 – Installation of three groundwater monitoring bores (MW13, MW14 and MW15) and two groundwater extraction bores (EW1 and EW2) (reported in URS, 2007a).
 - October 2009 - Installation of six groundwater monitoring bores (MW18, MW19, MW21, MW22, MW23 and MW24) (reported in URS, 2010a). During these works nine multiphase extraction wells (MPE01 through MPE09) were installed for future groundwater remediation activities. Note that no MW7 or MW20 was installed at the site.

The groundwater monitoring bore locations are shown in **Figure 1** (reproduced from URS, 2010a).

The majority of monitoring bores were screened from 6.0 to 9.0 m bgl (GMW1 through GMW4) or 7.0 to 10.0 m bgl (MW1 through MW4). Bores installed for remediation purposes were typically screened between 3.0 and 10.0 m bgl. The following table presents a summary of the monitoring bore construction details and depth to water from the most recent groundwater level gauging event (24 November 2009).

Bore ID	Screened Interval		Depth to Water (m bTOC)	Location
	Top (m bgl)	Base (m bgl)		
GMW1	6.0	9.0	8.80	On site
GMW2	6.0	9.0	8.76 (LNAPL)	On site
GMW3	6.0	9.0	8.64 (LNAPL)	On site
GMW4	6.0	9.0	8.90 (LNAPL)	On site
MW1	7.0	10.0	9.15	On site
MW2	7.0	10.0	8.87 (LNAPL)	On site
MW3a	7.0	10.0	9.44 (LNAPL)	On site
MW4a	7.0	10.0	8.97 (LNAPL)	Off-site
MW5	3.0	10.0	9.20 (LNAPL)	On site
MW6	3.4	9.3	8.85	On site



Bore ID	Screened Interval		Depth to Water	Location
MW8	4.0	10.0	8.38	Off-site
MW9	6.0	10.0	8.26	Off-site
MW10	4.0	10.0	8.81 (LNAPL)	Off-site
MW11	4.0	10.0	9.37 (LNAPL)	Off-site
MW12	4.0	10.0	8.19	Off-site
MW13	4.0	10.0	9.04 (LNAPL)	Off-site
MW14	6.0	10.0	9.09	Off-site
MW15	6.0	11.0	9.16	Off-site
MW17*	unknown	unknown	8.51	On site
MW18	7.0	11.0	8.69	On site
MW19	7.0	11.0	9.09	On site
MW21	8.0	11.0	8.24	Off-site
MW22	7.0	10.0	7.97	Off-site
MW23	8.0	11.0	9.76 (LNAPL)	On site
MW24	7.0	11.0	9.24 (LNAPL)	On site
EW1	7.5	12.0	9.53 (LNAPL)	On site
EW2	7.2	12.2	9.01 (LNAPL)	On site
MPE01	6.0	12.0	9.09 (LNAPL)	On site
MPE02	6.0	12.0	9.11	On site
MPE05	6.0	12.0	9.05 (LNAPL)	On site
MPE06	6.0	12.0	8.83 (LNAPL)	On site
MPE07	6.0	12.0	8.88	On site
MPE08	6.0	12.0	8.84	On site
MPE09	6.0	12.0	8.71 (LNAPL)	On site
MPE10	6.0	12.0	8.61	On site



Bore ID	Screened Interval		Depth to Water	Location
MPE11	6.0	12.0	8.66	On site
SVE1b	-	4.96	4.86	On site
SVE2a	-	4.94	4.85	On site
SVE3	5.0	10.0	8.84 (LNAPL)	On site
SVE4b	-	5.02	Screened above watertable	On site
SVE5	3.0	4.0	Screened above watertable	On site

* Details of this well are not available. According to Handex (1999), MW17 was installed by PPK Environmental and Infrastructure Pty Ltd (PPK) during decommissioning of the former Mobil service station located to the east of the site.

The sampling and analytical program included:

- Gauging of depth to water and LNAPL from all bores on up to 14 occasions.
- Sampling and analysis of groundwater from all bores on up to five occasions. Groundwater was not submitted for analysis for any bores reporting the presence of LNAPL. Groundwater was tested in the field for physicochemical parameters (electrical conductivity, dissolved oxygen, redox potential, pH and temperature) and analysed for TPH, BTEX and lead. Limited bores were analysed for polycyclic aromatic hydrocarbons and phenolic compounds (MW18, MW19, MW21 and MW22). Indicators of natural attenuation were analysed at bores MW6, MW9, MW12 and MW17 in May 2007 and at MW19 and MW21 in November 2009. The specific gravity (density) of LNAPL samples was measured for product obtained from bores MW23, MW24, MPE01, MPE05, MPE09 (November and December 2009) and bores GMW2, MW3a and MW4a (May 2006).
- Select samples of LNAPL were also submitted for qualitative chromatogram 'fingerprint' analysis by CSIRO (GMW2, GMW3, GMW4, MW2, MW3a and MW4a). The fingerprinting results indicated a petrol hydrocarbon range with trace diesel.

5.3.2 LNAPL Contamination Distribution

LNAPL has been identified in 17 onsite and offsite wells with apparent thicknesses ranging from 0.01 to greater than 1.47 (GMW4 in November 1999). CSIRO fingerprinting of the product from several bores indicated the hydrocarbon to be a petrol range with traces of diesel. LNAPL varied slightly in colour from light yellow/brown to orange and red translucent product. LNAPL is currently, or has been recorded in the following bores:

- GMW2, GMW3, GMW4.
- MW1, MW2, MW3a, MW4a*, MW5, MW10*, MW11*, MW13*, MW17 (not present 29 November 2009), MW23, MW24.
- EW1, EW2.
- MPE01, MPE05, MPE06, MPE09.
- SVE3

Note: * denotes off-site bores.

The LNAPL distribution is described by URS (2010a) as being consistent with the previously identified extent of LNAPL and indicates the plume to be delineated to the south (MW6, MW18, MW19, GMW1), south east (MW17, MW18), north east (MW9, MW12) and north west (MW14, MW15).



URS (2010a) indicated that the LNAPL plume has not been delineated to the north west, due to access difficulties, presumably associated with the commercial development adjacent the western boundary of the site which covers that site.

LNAPL appeared for the first time in the July 2009 monitoring event in monitoring bores EW2, MW5 and MW13. The source of LNAPL in MW5 has not been identified.

5.3.3 Dissolved Phased Hydrocarbon Contamination Distribution

Dissolved phase hydrocarbon impact is located on and off-site with data indicating a hydrocarbon plume migrating to the north east from the site. Elevated dissolved phase concentrations are summarised in the following table:

Analyte	Beneficial Use and Guideline Value			Maximum On Site Concentration	Maximum Off-site Concentration
	MoE	PCR	SW		
Benzene	900	10	1	6,120	5,360
Toluene	180	25	800	15,200	14,600
Ethylbenzene	5	3	300	1,490	1,340
Xylenes (total)	450	20	600	10,360	9,950
TPH (C₆-C₉)	-	-	-	36,000	35,700
TPH (C₁₀-C₃₆)	600	600	600	3,800	33,660
Lead	6.6	50	100	42	12

NOTES:

All units µg/L unless otherwise stated.

MoE = Maintenance of Ecosystems

PCR = Primary Contact Recreation

SW = Stockwatering

The dissolved phase contaminant distribution is described by URS (2010a) as present across the site extending off-site to the east (MW8), north east (MW9, MW12, and MW21) and north (MW14). Two attempts have been made at delineating the extent of dissolved phase impact. As described for the LNAPL impacts, delineation is not complete to the immediate west of the site due to access restrictions (Scope Centre), and delineation to the east is complicated by the presence of the former Mobil Oil service station on the opposite street corner. URS also reported TPH and a non-petroleum hydrocarbon to be present in upgradient well MW19. This is discussed further in section 8.3 of URS (2010a).

Elevated concentrations of TPH, in particular benzene, were reported in wells MW9 and MW21 located down hydraulic gradient of the site. It is also noted that the reported benzene concentration in MW9 has increased from 2 µg/L (August 2006) to over 5,000 µg/L (July 2009) in the last three years, suggesting that the dissolved phase plume is expanding down-hydraulic gradient (to the north east) of the site.

The Auditor notes, as discussed in URS (2008a) section 5.4, that the vertical extent of dissolved phase impacts has not been delineated. It is understood that this will be incorporated into the drilling of additional remedial wells to be installed as part of the LNAPL recovery program.



5.3.4 Contaminant Plume Movement over Time (Stability)

Review of the LNAPL data over the period of groundwater monitoring suggests increasing apparent thicknesses of LNAPL in monitoring bore EW2. Other monitoring bores suggest stable or reducing apparent LNAPL trends. The Auditor notes that LNAPL thicknesses have been affected by the remediation pilot trial and product bailing at the site from time to time and water table fluctuations and may not be a reliable measure of the stability of the hydrocarbon impact at the site.

Plume stability has been assessed by comparison over time of the concentrations of key contaminants in bores across the site from presumed source areas through downstream dissolved phase plume areas to background or non-impacted wells. With consideration of the likely groundwater flow direction to the north east down gradient monitoring bores (namely MW9, MW21 and MW22) impacts suggest an expanding hydrocarbon plume. Significant BTEX and corresponding TPH concentrations was reported for the first time at monitoring bore MW9 during the July 2009 groundwater monitoring event (i.e. benzene concentration increased from 0.115 to 5.36 mg/L). The observed increase at MW9 has previously been indicated by URS (2008a) to be suggestive of the leading edge of the dissolved phase plume in the down gradient direction from the site. This is likely to be attributable to the recognised behaviour of benzene which will separate from the co-contaminant hydrocarbons mixture and move with groundwater flow and be less retarded by the aquifer matrix.

As noted by URS (2008a, 2010a) comparison of results over time for monitoring bores GMW1, MW9, MW12, MW14, MW15 and MW17 show a general increase in dissolved phase petroleum hydrocarbon concentrations over time indicating that the plume is not stable or shrinking.

Based on the groundwater seepage velocity range presented in **Section 3.4.3** and an assumed source release date of 1992 (as suggested in **Section 5.1**) any dissolved phase plume would be expected to have migrated between approximately 38 and 760 metres from the site, however this does not account for natural attenuation and/or sorption processes that may also reduce the lateral extent of impact. Based on the groundwater monitoring in the down hydraulic gradient direction from the site (i.e. MW9) and the appearance of benzene in recent times, the extent of the dissolved phase is expected to be within tens of metres, not hundreds of metres of the site.

5.3.5 Biodegradation Attenuation Mechanisms

URS (2010a) indicate in their assessment of natural attenuation parameters suggest some evidence of natural attenuation occurring however it does not appear from primary evidence that the plume is stable or shrinking, supported by observations at MW9 benzene concentrations in particular.

In the absence of available oxygen, alternative electron acceptors such as nitrate, ferric iron, manganese (IV) and sulphate can be used by micro-organisms for the mineralisation of hydrocarbons through to carbon dioxide (CO₂) and water, resulting in the depletion of nitrate and sulphate and the appearance of ferrous iron and manganese (II) in groundwater. At later stages, the CO₂ generated through the use of oxygen, nitrate, iron, manganese and sulphate can itself be used as an electron acceptor for the further oxidation of hydrocarbons, with the CO₂ being reduced to methane in the process (methanogenesis).

Increasing ratios of benzene to total BTEX concentrations (B/BTEX) are indicative of in situ conditions becoming unsuitable for degradation of benzene in comparison with the substituted monoaromatic contaminants (T, E, X), usually as a result of depletion of the higher order electron acceptors (oxygen, nitrate) needed for benzene degradation.

As a consequence of the expected minimal biological attenuation of benzene under anaerobic conditions (Saleem, 1999), the relative proportion of benzene to co-contaminants can increase even if the total hydrocarbon levels are diminishing, such that the leading edge of a migrating hydrocarbon contamination plume in groundwater can become predominantly benzene which will remain non-biodegradable unless more oxidative conditions are induced by remedial intervention, or arise as anaerobic groundwaters migrate and mix into more aerobic groundwater.

It is noted from the analytical data that the B/BTEX ratio in groundwater is varying across the site.



Collectively, the available data indicate that passive biodegradation in conjunction with the other attenuation processes is not sufficient to attenuate groundwater contamination at the site to prevent off-site migration without active remedial intervention.

5.3.6 Summary of Impact to Beneficial Uses

Based on the SEPP (GoV) and results of environmental investigations, the impacts on the beneficial uses of groundwater at the site are detailed in the table below:

Beneficial Use	Beneficial Use Potentially Precluded	Comment/Rationale and Relevance of Impact
Maintenance of Ecosystems	Yes (at the site)	Because the beneficial use maintenance of ecosystems applies at the point of (groundwater) discharge to surface water, in this case around 1.5 km from the site, this beneficial use is not currently considered to be precluded by groundwater contamination at the site. This is indicated by the north and north eastern extent of the plume generally being defined (or significantly reduced concentrations are reported in these areas) to within approximately 50 metres of the site boundary. .
Primary Contact Recreation	Yes	Whilst this beneficial use is potentially precluded, there are presently no registered wells located on the site or in the vicinity of the site that are known to be extracting groundwater for recreational water use (such as bathing or filling swimming pools). This beneficial use is also unlikely to be realised at the site in the future (and is therefore not relevant) in view of the ongoing likely ongoing on site commercial use. While considered unlikely, the potential for current unregistered and/or future off-site extraction bores in the vicinity of the site cannot be ruled out.
Stockwatering	Yes	Whilst this beneficial use is potentially precluded, there are presently no registered wells located on- or in the immediate vicinity of the site that are known to be extracting groundwater for stock water use. This beneficial use is also unlikely to be realised at or in the vicinity of the site in the future (and is therefore not relevant) in view of the likely ongoing on site commercial use and off-site commercial and residential use.
Buildings and Structures	Yes	Whilst this beneficial use is potentially precluded, present and likely structures, including building and utility services are unlikely to come into contact with groundwater in the water table aquifer of the Moorabool Viaduct Formation (encountered at > 8 m bgl).

5.4 Air Quality Review

The potential for petroleum hydrocarbon impacted soil and groundwater at the site to adversely impact on air quality was assessed on the basis of the following:

- Soil gas sampling and incorporation of soil gas data in a quantitative risk assessment (URS, 2010b and URS, 2006).
- Direct measurement of air quality within the Scope Centre located adjoining the western boundary of the site (URS, 2007e).
- Utility pit monitoring in 42 pits located within a 100 m radius of the site using a calibrated PID and landfill gas monitor.

The above activities are further detailed in the following sections.



5.4.1 Soil Vapour Investigations

URS undertook soil gas sampling and analysis from three on-site (SV01 to SV03) and four off-site (SV04 to SV07) dedicated soil gas bore locations on up to four occasions (31 May 2006, 15 May 2007, 5 July 2007 and 16 October 2008). Locations of these bores are shown in **Figure 1** (reproduced from URS, 2010a). Results of these investigations were reported within URS (2006), URS (2007b) and URS (2010b).

The maximum reported concentrations of volatile petroleum hydrocarbons in soil gas during the above investigations are summarised in the following table.

Analyte	Maximum Reported Concentration ($\mu\text{g}/\text{m}^3$)	
	On Site (SV01 to SV03)	Off-site (SV04 to SV07)
Benzene	1,268,000*	2.9
Toluene	1,643,000*	793
Ethylbenzene	167,000*	361
Xylenes	2,117,000*	96.8
Naphthalene	<833	6.1
C6-C9 fraction TPH	2,967,000 **	6,127
C10-C14 fraction TPH	<83,300	3,253

* Concentration may be underestimated due to overloading of sorbent tubes and associated breakthrough effects.

** Excludes BTEX

The Auditor notes that the maximum reported soil gas concentrations summarised by URS (2010b) contained some unit and data transcription errors and therefore differ from the above table. The data presented in the above table are based on the Auditor's review of results presented by URS (2006, 2007b, 2010b). Also note that the soil gas analytical summary table within URS (2007b) differs from soil gas concentration calculations undertaken within appendices to that report. Review of original laboratory reports and field sampling sheets by the Auditor indicated that concentrations reported within Appendix B of URS (2007b) were correct, while those summarised within the report body of URS (2007b) contained what appeared to be transcription errors.

The soil gas analytical results were incorporated in a number of quantitative risk assessments undertaken by URS, the most recent of which (URS, 2010b) evaluated all available soil vapour data. The quantitative risk assessment is further discussed in **Section 5.4.4**.

5.4.2 Air Quality Monitoring

Sampling and analysis of indoor, outdoor and crawlspace air was undertaken in September and October 2006 within and around the Scope Centre adjacent the west of the site at 163 Church Street, Manifold Heights, Victoria (URS, 2007e). The air sampling was recommended in light of elevated levels of volatile chemicals reported in on-site soil gas near the western site boundary adjacent to the Scope Centre.

Four rounds of sampling were undertaken (14, 20 and 26 September and 2 October, 2006). During each sampling round, eight-hour time averaged air samples were collected from two indoor locations (staff room and staff toilet), one outdoor location (the southwest corner of the Scope property) and in the crawlspace beneath the Scope building.



The ranges of reported VOC concentrations are summarised and compared to ambient air guidelines for protection of public health in the table below.

Analyte	Ambient Air Guideline ($\mu\text{g}/\text{m}^3$)	Maximum Reported Concentration ($\mu\text{g}/\text{m}^3$)		
		Indoor Air (staff room and toilet)	Crawlspace Air	Outdoor Ambient/Background Air
Benzene	9.6*	<2.1 - <3.7	<6.7 - <10	<2.4 - <2.7
Cyclohexane	6,300**	<2.3 - 5.0	<7.2 - <11	<2.6 - <2.9
Hexane	730**	<2.3 - 7.4	<7.4 - 36	<2.7 - <3.0
Toluene	380*	<2.5 - 32	61 - 3,500	<3.0 - 17
Ethylbenzene	22,000***	<2.9 - <5.1	<3.2 - <14	<3.0 - 5
Xylenes (total)	870*	<5.8 - <10.2	6.8 - <28	<6.6 - 24.2
1,2,4-Trimethylbenzene	7.3	<3.2 - <5.8	<3.7 - 26	<3.7 - 9.6

* NEPC (2004) annual average monitoring investigation levels. Values have been converted from ppm to $\mu\text{g}/\text{m}^3$ at 25° C and 1 atmosphere.

** USEPA Regional Screening Levels for Residential Air. Screening level table updated November 2010.

*** WHO (2000) Guidelines for Air Quality.

The air guideline values used to assess the air monitoring results in the above table were adopted from the following sources (in order of preference):

- National Environment Protection (Air Toxics) Measure, National Environment Protection Council, 3 December 2004.
- World Health Organization (WHO) Air Quality Guidelines published in the following:
 - Air Quality Guidelines for Europe, Second Edition, 2000
 - Guidelines for Air Quality, 2000
- USEPA Regional Screening Levels (RSLs) for residential air (<http://www.epa.gov/region9/superfund/prg/>). Values updated November 2010.

Volatile petroleum hydrocarbon concentrations were reported to be below adopted assessment criteria within the Scope Centre, however reported concentrations of toluene in crawlspace air beneath the building exceeded the adopted ambient air criterion in three of the four sampling events. The elevated toluene concentrations (relative to other hydrocarbons) in crawlspace air may indicate preferential volatilisation of toluene relative to other hydrocarbons and/or preferential degradation of other hydrocarbons relative to toluene within the vadose zone. It is noted that toluene concentrations reported in soil gas were generally higher than those of other BTEX compounds, particularly in off-site bores (see **Section 5.4.1** above). It is also possible that another source of toluene was present within the crawlspace (e.g. paint tins or other chemicals may have been stored), however this was not noted in the URS investigation report.

It is noted that the maximum reported background/ambient concentration of 1,2,4-trimethylbenzene ($9.6 \mu\text{g}/\text{m}^3$) marginally exceeded the adopted ambient air guideline of $7.3 \mu\text{g}/\text{m}^3$ for this compound. However, this compound is commonly reported at elevated concentrations in urban air (Environment Australia, 2001), and the reported range of concentrations is consistent with those reported in outdoor urban air in Brisbane (0.12 to 2.60 ppbv equivalent to approximately 1 to $14 \mu\text{g}/\text{m}^3$; Hawas et al. 2002) and Perth (0.10 to 5.02 ppbv equivalent to 0.5 to $26.5 \mu\text{g}/\text{m}^3$; WA DEP, 2000). The elevated 1,2,4-



trimethylbenzene concentrations are not considered likely to be indicate impacts to ambient air from the site.

Overall, the air monitoring results indicated that vapour migration from subsurface petroleum hydrocarbon sources (soil, groundwater and/or NAPL) to the Scope Centre crawlspace was occurring to a limited extent. However, dilution and attenuation processes between the subsurface and the crawlspace and between the crawlspace and indoor air appeared to be acting to reduce indoor air concentrations to below background levels and/or concentrations which may pose a risk to the health of Scope Centre occupants.

While the air monitoring results suggest that site related petroleum hydrocarbon contamination was not adversely impacting on air quality with the Scope Centre at the time of the sampling undertaken, it should be noted that the number and timing of air monitoring rounds do not meet the minimum requirements specified in the Air Toxics NEPM for assessment of seasonal and/or annual variation and further ongoing assessment is therefore warranted.

5.4.3 Utility Pit Monitoring

Utility pit monitoring was undertaken by URS (2010) (refer **Figure 3**, reproduced from URS, 2010a) on and in the vicinity of the site to assess whether site related petroleum hydrocarbon vapours may be entering and/or accumulating within subsurface utility pits.

Monitoring was undertaken in 38 accessible utility pits (note only 38 pits of 42 total pits were accessible) within a 100 m radius of the site using a calibrated PID and gas monitor with lower explosive limit (LEL) measurement as follows:

- 29 May 2008: Initial utility pit monitoring at 35 accessible locations (refer **Figure 3**, reproduced from URS, 2010a). Peak PID readings ranged from 0.2 to 2.2 ppm and Pit 28 (1.8 ppm PID reading) recorded a 100% LEL reading. LEL readings greater than 10% were also reported to the east of Shannon Avenue at the boundary with the former Mobil Oil service station. URS recommended further sampling and characterisation of the gases identified in some of the utility pits. These results led to a more detailed assessment of gas impacts from the site. The Auditor's representative was present during the URS utility pit monitoring.
- 7 August 2008: Utility pit monitoring was completed at 33 accessible locations. Only Pit 28 again reported an elevated LEL reading (44% of LEL). The Auditor advised EPA of the results and the further monitoring recommended.
- 11 August 2008: The Auditor was advised by URS that the relevant utility providers were contacted and were working with them to get the pits opened and vented. On 12 August, Telstra conducted their own utility pit monitoring and did not record any measurable results. Telstra also opened the pits for inspection.
- 13 August 2008: The Auditor's representative was present during URS utility pit monitoring to undertake verification monitoring. Results generally corresponded with the URS investigation results, however sampling methodology improvements were noted. The Auditor noted elevated LEL readings at Pit 22 (30% of LEL) and Pit 28 (5% of LEL).
- 13 August 2008: Based on utility pit monitoring on the day indicating elevated volatile hydrocarbons, Pit 23 was sampled using summa canisters to speciate the gases using US EPA total organics 12 and 15 screens. Detectable concentrations of a range of individual hydrocarbons were reported, including benzene, toluene, hexane and cyclohexane. However the concentrations were low (below ambient air guidelines for protection of human health). Total non-methane organic compounds were reported at a concentration of 57 ppmv. This concentration is below 10% of the LEL for petrol (assuming petrol LEL of 1.2% or 12,000 ppm).
- 30 and 31 July 2009: Monitoring of utility pits was undertaken using PID only. A maximum utility pit PID reading of 0.6 ppm was reported in Pit 28 (refer **Figure 3**, reproduced from URS, 2010a),



to the east of Shannon Avenue on the corner with Church Street adjacent the former Mobil service station.

Overall, the utility pit monitoring results indicated the following:

- VOC concentrations (based on PID measurements) were generally low (less than 2 ppm) within utility pits on and in the vicinity of the site at the time of the sampling undertaken.
- Elevated LEL readings were reported in some pits, predominantly to the east of the site along the boundaries of the former Mobil service station. However PID readings in pits with elevated LEL measurements were not higher than those reported elsewhere, suggesting that the source of the elevated LEL readings may not be due to elevated petroleum hydrocarbon concentrations. The elevated LEL readings were reported in pits located to the east of Shannon Avenue along the boundaries of the former Mobil service station (i.e. along the south side of Church Street). It is noted that a natural gas pipeline is also reported to run through these locations (see services locations on Figure 2a of URS, 2010a). The potential for this pipeline to have contributed to elevated LEL readings warrants further investigation.

It is noted that the PID and LEL meters were used as a qualitative measure only to assess the likely presence of generalised volatile organic compounds as an indication of petroleum ingress to underground services. Compositional analysis of the gases (USEPA TO-15 method) was also undertaken on one sample to more quantitatively assess petroleum hydrocarbon concentrations in Pit 23, to the east of the site, immediately north of the former Mobil Oil service station. The sum of individual hydrocarbons reported in Pit 23 (0.6 ppm) was generally consistent with the semi-quantitative PID results (<2 ppm).

5.4.4 Quantitative Risk Assessment and Impact to Beneficial Uses

URS (2010b) undertook a quantitative risk assessment (QRA) to estimate the extent to which petroleum hydrocarbon vapours reported in soil gas may pose a risk to human health via the vapour intrusion pathway.

The QRA considered potential risks to the following potential receptors:

- On-site workers employed at the service station.
- Off-site residents (adults and children) within dwellings overlying impacted groundwater.
- Intrusive workers conducting excavations in areas overlying impacted groundwater on and off-site.
- Visitors to the site and surrounds.

The QRA considered exposure by the above receptors to site related contaminants via the vapour inhalation pathway only, i.e. contaminant exposure via direct contact with soil and/or groundwater was not assessed.

The QRA did not consider potential vapour intrusion risks within the Scope Centre to the west of the site, since vapour risks to these receptors were subject to separate assessment based on direct air monitoring (see **Section 5.4.2**).

URS (2010b) concluded the following with respect to the receptor groups identified for the site:

- On-site workers – Risk to human health associated with the presence of petroleum hydrocarbons in groundwater were considered to be low and acceptable. The assessment does not replace occupational health and safety requirements.
- Intrusive worker - Risk to human health associated with the presence of petroleum hydrocarbons in groundwater were considered to be low and acceptable. The assessment does not replace occupational health and safety requirements.



- Off-site residents - Risk to human health associated with the presence of petroleum hydrocarbons in groundwater were considered to be low and acceptable for current residents (adults and children) in existing homes with a crawl space above groundwater impact. Possible future slab on grade construction was considered also using current results and reported a low and acceptable risk for residents. No assessment of basements structures was undertaken as it was considered unlikely by URS for this type of construction in the area.

The URS (2010b) quantitative risk assessment was undertaken in general accordance with nationally accepted and endorsed methodologies (enHealth, 2004; NEPC, 1999), and the majority of the adopted exposure and toxicity parameters are considered to be appropriate and/or sufficiently conservative for the purposes of the assessment. Data quality issues are discussed in **Section 7.2** of this report.

Overall, the Auditor is of the opinion that risks to human health associated with the migration of volatile contaminants to indoor or outdoor air are likely to be low and acceptable for the current land use conditions in both on-site and impacted off-site locations. However, the potential for vapour intrusion related health risks would require further assessment if the site is to be redeveloped and/or if a building with basement is constructed in off-site areas which are impacted by site-derived petroleum hydrocarbon contamination.



6.0 EPA Notice Compliance

6.1 Compliance with s.62A Clean Up Notice

The following assessment of compliance with the EPA PAN (provided in **Appendix A**) relates only to those items outlined in the objectives and scope of the Audit and is presented in the table below.

s.62A Notice Requirement	Compliance Review Comment
1. By 15 August 2008, submit for review to the engaged Auditor (referred to in Item 5 of Attachment A) the results of the UPSS Precision Test Report, Certified Report No. CA3047, MassTech Australia Pty Ltd, dated 14 April 2008 with reference to the elements of EPA Publication 888 Guidelines on the Design, Installation, and Management Requirements for Underground Petroleum Storage Systems	Review UPSS Precision Test Report, Certified Report No. CA3047, MassTech Australia Pty Ltd, dated 14 April 2008 and URS correspondence dated 27 June 2008 with reference to the UPSS guidelines. Based on limited data the site complies with the minimum requirements for secondary leak detection (use of SIRA package).
2. By 15 September 2008, the occupier must submit a report to EPA and the engaged Auditor that delineates the full extent of soil and groundwater contamination on and from the site caused by the premises former and current use.	Review delineation information presented in section 8 of URS (2010b) and discussion presented in Section 5.2 and Section 5.3 of this report. As described in Section 5.3 of this report, the full extent of soil and groundwater contamination has not been completed, in part due to access constraints.
2.1 This report must also quantify the risks associated with the contamination including any vapour risk.	The vapour risk has been quantified as discussed in Section 5.4 of this report.
3. Clean Up Plan Requirements	Review the clean up measures presented in the URS Clean Up plan (July 2008a, amended as URS, 2010a) with comparison to the requirements outlined in Section 8.1 of this report.
4. By no later than 13 November 2008, the occupier must submit to EPA, an environmental audit report prepared by an environmental auditor appointed under the Environment Protection Act, 1970 in relation to any possible harm or detriment to the land and groundwater environment's caused by past and current service station activities at the premises, as determined by: - Review of the operations and management of Underground Petroleum Storage Systems infrastructure with reference to the elements of EPA Publication 888 Guidelines on the Design, Installation, and Management Requirements for Underground Petroleum Storage Systems. - Review of any systems, plans, procedures, monitoring programs including the clean up plan and proposed timeline, data, records, reports or other information relevant to the scope of the audit. - Inspection of any relevant activities, processes, plant and/or equipment on site. - Collection and/or modelling of any data as the auditor sees fit.	This Audit report was prepared to meet this s.62A Notice requirement. The methodology was limited to the following: - Review of the UPSS Precision Test Report, Certified Report No. CA3047, MassTech Australia Pty Ltd, dated 14 April 2008 and URS correspondence (2008b) with reference to the UPSS guidelines. Based on limited data the site complies with the minimum requirements for secondary leak detection (use of SIRA package). - Review of soil and groundwater assessment works and the clean up plan prepared for the premises. Refer to Section 9.5.1 of this report for comment. - Auditor verification sampling and/or inspections were carried out during utility pit monitoring. Refer to detail presented in Section 7.0 of this report. - Auditor verification sampling and/or inspections were carried out during utility pit monitoring. The Auditor reran vapour intrusion risk models to assess vapour risk presented by URS. Refer to detail presented in Section 7.0 of this report.
5. The environmental audit report referred to in Requirement 5 must: Indicate if the activities conducted at the premises causes a risk of any possible harm or detriment to the land and groundwater environments as determined by an assessment of compliance with	The methodology was limited to the following: Comparison of soil, soil vapour and groundwater analytical results and modelling to relevant State environment protection policy criteria.



s.62A Notice Requirement

Compliance Review Comment

requirements of SEPP (PMCL), SEPP (GoV) and SEPP (WoV). - Where a risk of any possible harm or detriment to a segment of the environment has been determined in (a), recommend any measures necessary to reduce the risk to an acceptable level. - Where contamination of a segment of the environment has been determined, delineate the full extent of contamination/impact. - Where the risk of any possible harm or detriment to a segment of the environment cannot be determined, recommend any measures necessary to ensure that any risk to a segment of the environment will be able to be determined in the future. - Comment on the adequacy of the clean up plan considered necessary to manage risk. - Include recommendations for improving environmental performance, management systems, monitoring programs or other recommendations as the auditor sees fit including whether additional clean up measures are required.	- Review plans for clean up and recommend any additional measures (if required). Refer to Section 9.5.1 and 11.0 of this report for comment. - Review delineation information presented in URS (2010a). Refer to Section 5.2 and Section 5.3 of this report for comment. - Review adequacy of investigations to assess nature and extent of petroleum hydrocarbon impacts. Refer to Section 5.2 and 0 of this report for comment. - Review plans for clean up and recommend any additional measures (if required). Adequacy determined through comparison to SEPP (GoV) clauses and EPA Publication 840 <i>The Clean Up and Management of Polluted Groundwater</i>. Refer to Section 9.5.1 and 11.0 of this report for comment. - Assess the need for additional monitoring or clean up than that proposed. Refer to Section 9.5.1 and 11.0 of this report for comment.
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7.0 Review of Data Quality

This section reviews the quality assurance procedures and quality control results for soil, groundwater and soil gas monitoring.

7.1 Data Quality Indicators and Objectives

Guidance on undertaking laboratory analyses and interpreting quality control results for the purposes of undertaking an environmental assessment are provided in the following documents:

- Australia Standard (AS 4482.1) - Guide to the Investigation and Sampling of sites with Potentially Contaminated Soil Part 1: Non-volatile and semi-volatile compounds, (Standards Australia, 2005).
- Australia Standard (AS 4482.2) - Guide to the Sampling and Investigation Potentially Contaminated Soil Part 2: Volatile substances (Standards Australia, 1999).
- EPA Publication 668 - Hydrogeological Assessment (Groundwater Quality) Guidelines (EPA, 2006).
- EPA Publication 669 - Groundwater Sampling Guidelines (EPA, 2000).
- EPA Publication IWRG701 - Sampling and Analysis of Waters, Wastewaters, Soils and Wastes (EPA, 2009).
- State Environment Protection Policy (Prevention and Management of Contamination of Land).
- State Environment Protection Policy (Groundwaters of Victoria).
- National Environment Protection Council (NEPC) - National Environment Protection (Assessment of Site Contamination) Measure (NEPC, 1999), Schedule B(2): Guideline on Data Collection, Sample Design and Reporting.

Guidance specific to air and soil vapour sampling is not provided in the above documents, however many of the quality assurance and quality control procedures recommended in the above documents are relevant to air and soil vapour sampling. Additional guidance relevant to sampling design, sampling methodology and assessment of air and soil vapour data quality is provided in the following documents:

- NEPC, National Environment Protection (Air Toxics) Measure, 2004.
- Interstate Technology and Regulatory Council (ITRC), Vapor Intrusion Pathway: A Practical Guide 2007.
- USEPA, Soil Gas Sampling: SOP #2149 (within Compendium of ERT Groundwater Sampling Procedures, USEPA Office of Solid Waste and Emergency Response, EPA/540/P-91/007, January 1999).

Specific elements from the guidance publications that were checked are presented in the following table:

Component of Investigation and DQI ¹	Compliance Review Comment
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Soil Sampling coverage	The soil investigations including sampling coverage is discussed in Section 5.2.1 . The Auditor considers that the sampling coverage overall was sufficient for the
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¹ DQI refers to Data Quality Indicator that the auditor has assessed as part of the site assessor field and laboratory program



Component of Investigation and DQI¹ Compliance Review Comment

AS4482.1 and AS4482.2	Auditor to form an opinion of the contamination status of the site soils considering the operational nature of the premises. Soil impact has not been delineated to the west of the fill point area off-site due to the development adjoining the western boundary (Scope Centre). Additional soil investigation beneath UPSS infrastructure would enhance the understanding of soil conditions at the site, however the Auditor acknowledges that this would require UPSS removal from the site which is not planned as the site is operational.
Groundwater bore coverage and construction EPA 668 and EPA 759.1	Twenty five groundwater wells were installed both on and off-site (15 on-site and 10 off-site). The well monitoring network is illustrated in Figure 1. Wells were constructed in the shallow water table aquifer (Moorabool Viaduct Formation). Additionally, 11 multiphase extraction wells (installed in a similar fashion to monitoring wells) and 5 soil vapour extraction wells (shallow unsaturated zone bores) have been installed at the site, in preparation for the installation of the remedial system. The multiphase extraction wells provide additional groundwater quality information at the site. The well network provides reasonable spatial coverage across and beyond the site considering the historical groundwater concentrations and access restrictions. The Auditor notes that the plume(s) are not fully delineated due to the issues previously identified.
Soil vapour bore coverage and construction ITRC, 2007	Seven soil vapour monitoring bores were installed both on and off-site (3 on-site and 4 off-site). The locations are shown in Figure 1. The on-site soil vapour bores were targeted to the source area and to assess concentrations at the western site boundary (adjacent the SCOPE Centre to the west of the site). Off-site soil vapour bores were located along Church Street to the north of the site, between the site and down hydraulic gradient residential and commercial properties under which LNAPL and/or elevated dissolved phase hydrocarbon concentrations potentially extend. The soil vapour bore locations are considered generally appropriate for assessment of soil vapour concentrations which may be present in the vicinity of on-site and off-site receptors. Soil vapour borelogs were not provided within assessment reports, but URS (2006, 2007b, 2010b) reported that bores were installed to maximum depths of 1 to 1.2 m bgl, and comprised 10 cm of slotted screen at the base attached to standard PVC pipe which extended to the surface. Soil vapour implants were installed at the base of the bore within acid-washed sand, and the remainder of the bore was sealed with bentonite. The construction is considered appropriate, however the screen depths of the soil vapour bores are shallower than that recommended by international guidance (5 feet or approximately 1.5 m; ITRC, 2007) to minimise surface effects on soil vapour concentrations. The concentrations may therefore not be representative of those which may be present beneath buildings or other structures. However, the soil vapour bores were installed in areas underlying hardstand (asphalt or concrete) which is likely to minimise surface atmospheric effects, and the concentrations are therefore considered likely to be representative and/or conservative for assessment of the current small slab on grade buildings and/or current houses with crawlspaces.
Air monitoring locations and frequency NEPC, 2004	Air monitoring was undertaken within and in the vicinity of the Scope centre (to the west of the site) on four occasions in September and October 2006 (URS, 2007e). The air sampling locations comprised two locations inside the building (SM1 in the staff room and SM2 near staff toilet), one location within the crawl space beneath the building (SM3) and one in the south-west corner of the property (outdoors) to assessment ambient air concentrations from sources unrelated to the site. These locations are considered generally appropriate, however insufficient description of the building layout and construction details was provided by URS to justify the selection of sampling locations. The four air monitoring events were undertaken approximately weekly over a 3 week period. As noted by URS (2007e), this sampling frequency is below the minimum specified by NEPM (every six days for a year or 30 samples per season for 2 seasons per year). The results have been used to provide a preliminary assessment of air quality, however further sampling is likely to be required to assess seasonal/temporal variability in air quality.
Sample collection techniques EPA IWRG710, AS4482.1 and AS4482.2, EPA669 NEPC, 2004 (Air Toxics SEPP) ITRC, 2007	Soil sample collection techniques primarily comprised hand auger and push tube soil bores. Details are as follows: • Due to underground infrastructure concerns, on-site bores were drilled to 2.4 m bgl using hand auger, then advanced by push tube to depth • Samples were taken from a hand auger during the soil investigations. • Samples were taken from a solid stem auger upon refusal of push tube



Component of Investigation and DQI ¹	Compliance Review Comment
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	sampling. Low flow groundwater sampling techniques 'micro purge' were used for 2009 groundwater sampling, and bailers were used for the 2006 groundwater monitoring event. The Auditor notes that the more recent sampling is more consistent with sampling guidance. Soil vapour samples were collected by an active sampling method onto adsorbent material (thermal desorption and/or activated carbon tubes). The method used is considered to be generally appropriate for the contaminants of concern however the Auditor noted some potential deficiencies in the reported collection methodology and/or documentation. These include (i) bore leak testing was not conducted to assess the integrity of the bore and/or tubing seals, (ii) sampling pump calibration records were not provided or referred to in the soil gas investigation reports, (iii) bore purge volumes were low (only one volume) and (iv) field monitoring was not conducted to assess whether general gases (CO₂, O₂, CH₄, VOCs by PID) were at equilibrium prior to sampling. It is also noted that significant sample carry over was reported from the front to rear portions of carbon tubes used during the first round of on-site sampling, indicating potential sample loss and underestimation of soil gas concentrations. Air samples (in and around the Scope Centre) were collected by evacuated passive stainless steel canisters (Summa), with regulators to allow collection of an eight hour time averaged air sample. This is in accordance with NEPC (2004) guidance. Field procedures were not observed by the Auditor or his representative as part of this Audit report, however, it was noted that they were reported to be consistent with the referenced guidelines (other than where described above).
Sampling equipment decontamination AS4482.1, EPA669	Standard field decontamination procedures were used to clean equipment during the various phases of soil investigation. In general they consisted of washing sampling equipment with a phosphate free detergent before the commencement of the sampling program and between each sampling event. The low flow sampling technique uses dedicated tubing and bladders to minimise the potential for cross contamination. During the 2006 investigation dedicated disposable bailers were used. During the phases of groundwater investigation that URS completed, standard equipment decontamination procedures were used (i.e. washing of interface probe and low-flow pump equipment with phosphate free detergent). The Auditor notes that during the more recent sampling event (post 2007 reporting) low flow 'micro-purge' sampling has been used, which is more consistent with published guidance. The Auditor did not observe the assessor's decontamination techniques first-hand, however the procedures were noted to be consistent with the referenced guidelines.
Field measurements AS4482.2, EPA 668 and 669 ITRC, 2007	Soil field screening was completed with a PID and visual/olfactory observations were noted during each phase of soil investigation. Observations generally correlated with analytical results. There was no documentation to show the PID was calibrated during the 2006 soil investigations, however calibration certificates were sighted for the utility pit monitoring. A water quality meter was used to measure physiochemical water quality parameters during purging. For the 2006 investigation, however no documentation was provided to show the water quality meter was calibrated. With the exception of one of the utility pit monitoring events, field procedures were not observed as part of this Audit report. It was noted that field procedures were consistent with the referenced guidelines. Field measurements were not reported to have been undertaken during soil vapour or air monitoring activities.
Field documentation (i.e. field notes, bore logs and chain-of-custody records) AS4482.1, AS4482.2, NEPM B2, EPA 668 and 669	Field documentation including field notes, groundwater sampling forms and bore logs were generally completed to a satisfactory standard to enable the Auditor to interpret the soil and groundwater data. Field notes for some soil vapour sampling rounds were not provided and were blank. While the relevant data (e.g. sample volumes) were reported elsewhere in the report, it was not possible for the Auditor to verify how the sample volumes were determined in the field. Some chain of custody documents over various phases of investigations were not completely populated or there were issues with sample relinquishment (e.g. samples on 24 November 2009, did not contain adequate relinquishment dates and times, however the receiving laboratory did receive samples later the same day of



Component of Investigation and DQI¹ Compliance Review Comment

	sampling suggesting samples were received in good order). It is also noted that chain of custody and laboratory certificates of analysis for the groundwater sampling undertaken in May 2007 (URS, 2007a) was missing from the report. This can be rectified in subsequent monitoring proposed for the site. During the most recent sampling round (November, 2009; see URS, 2010a), minor stabilisation issues were noted during groundwater purging, particularly in regards to electrical conductivity and redox stability not being achieved within some monitoring bores. It was also noted that the redox potential values recorded on the well purging data sheets for MW18, MW19, MW21 and MW22 contained transcription errors. The Auditor considers that subsequent groundwater sampling events included detailed quality assurance procedures and improvements to rectify these issues.
Sample handling, preservation and storage AS4482.1, EPA669, IWRG701 and NEPM B2	During the URS phases of investigation, soil samples were collected in jars/bottles supplied by the laboratory and stored/transported in chilled eskies. The URS reports and chain of custody forms state that sample containers for groundwater were laboratory supplied and contained the appropriate preservatives for the chemicals analysed. Water samples were stored/transported in chilled eskies. These procedures were considered to be adequate and consistent with the referenced guidelines. Soil vapour samples were collected on adsorbent materials supplied by the laboratory and transported in chilled eskies. The sample receipt forms and chain of custody forms indicated that samples were received by the laboratory chilled and with cooling media and that sample containers and integrity were suitable. Ambient air samples were collected in evacuated stainless steel (Summa) canisters supplied by the laboratory and transported at ambient temperature (note that Summa canisters are not required to be chilled or otherwise preserved according to method TO-15). One summa canister during the first round of sampling was received at the laboratory at higher pressure than shipped, indicating potential contamination during transport.
Number and type of field quality control samples AS4482.1 and AS4482.2	The number and type of field quality control samples collected during each phase of the soil and groundwater investigations is summarised below. URS December 2009 Soil and Groundwater Sampling (reported in URS, 2010a) Of the 17 primary soil samples submitted for analysis four trip blanks, nine rinsate blanks and nine field blanks were submitted to the primary analytical laboratory. Additionally, two blind field duplicates and two split samples were submitted to the primary and secondary analytical laboratories respectively. Of the four primary groundwater samples collected, one duplicate and one split sample was submitted to the primary and secondary analytical laboratories respectively. Additionally, one trip blank, one field blank and one rinsate blank were submitted to the primary analytical laboratory for analysis. Overall the quality control sampling resulted in a frequency of greater than 1 in 20 for each of the chemical parameters included in the suite of analysis. For blanks, chemical concentrations were generally below the limit of laboratory reporting, indicating adequate decontamination of equipment and no cross contamination. URS May 2007 Soil and Groundwater Sampling (reported in URS, 2007a) Of the 5 primary soil samples submitted for analysis, 5 rinsate blanks, 4 field blanks and 3 trip blanks were submitted to the primary analytical laboratory. Additionally, one blind and one split samples were submitted to the primary and secondary analytical laboratories, respectively. Of the 10 primary groundwater samples submitted for analysis, 3 rinsate blanks, 3 field blanks and 3 trip blanks were submitted to the primary analytical laboratory. Additionally, one blind and one split samples were submitted to the primary analytical laboratory. URS stated that, due to error, the split (triplicate) sample was not forwarded to the secondary laboratory. An inter-laboratory assessment of data reproducibility could therefore not be made. The Auditor noted elevated Relative Percentage Differences (RPDs) for BTEX compounds and TPH C₆-C₉ between the primary soil sample and both the inter- and inter-laboratory field replicate samples. URS considered the results of all replicate samples in their interpretation of results. URS May/August 2006 (reported in URS, 2007d) Of the 30 primary soil samples submitted for analysis, nine trip blanks, 11 rinsate blanks and nine field blanks were submitted to the primary analytical laboratory. Additionally, four blind field duplicates and four split samples were submitted to the primary and secondary analytical laboratories respectively. Blind and split samples were collected at a rate of at least 1 in 20.



Component of Investigation and DQI¹	Compliance Review Comment
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The Auditor considers that the number and type of soil and groundwater QC samples collected during the Audit was sufficient. Although AS 4482.1 applies to the sampling of soils, the Auditor considers AS4482.1 appropriate for groundwater QC/QC purposes.

Soil Vapour Sampling

No field duplicates were analysed during the first round of sampling (May 2006; on site bores only).

One field duplicate sample was collected during each of the May 2007 and July 2007 sampling rounds (off-site soil vapour bores only), however it was not stated whether this sample was collected after or in parallel with the parent sample. URS stated that the RPDs between the duplicate and primary sample were less than 30%, however these were not presented and the Auditor's review indicated that RPDs ranged from 50% to 150%. The implication of these results is difficult to assess given that soil gas bores were not leak tested and field measurements of soil gas were not undertaken to assess stabilisation and/or changes in soil gas composition over the sampling period. The reported variability could result from small scale spatial and/or temporal variability in soil gas concentrations, or from bore integrity issues leading to increasing amounts of ambient air contamination of soil vapour samples during the sample collection period.

One field duplicate sample was also collected during the October 2008 sampling round, however the majority of analytical results were below laboratory reporting limits in both the primary and duplicate sample.

Air Sampling

Only one field duplicate sample was collected over the three monitoring rounds undertaken, and the RPDs reported between parent and duplicate sample were within adopted acceptance criteria. While the overall frequency of field duplicate samples is in accordance with that recommended by AS4482.1 (and commonly applied to environmental samples in general), the non-compliance is not considered to adversely affect the interpretation of the data. It is also noted that additional air monitoring is recommended and is expected to be undertaken in the future to address this uncertainty.

Overall, while the frequency and/or results of field quality control samples did not strictly comply with acceptance criteria, the Auditor is of the opinion that the data are generally suitable for assessment of the environmental condition of the site. Additionally, further soil vapour and air monitoring events are proposed and the additional data collected can be used to supplement existing data and guide remedial efforts.

Quality Control Sample Results

The results of the quality control samples (intra and inter laboratory duplicates, rinsate blanks, trip and field blanks) were generally within acceptable limits to form a basis for understanding the primary analytical results.

NATA Accreditation

Laboratory analyses of soil and groundwater were undertaken by a number of companies including Australian Laboratory Services, Amdel Laboratories and Labmark Environmental Laboratories (Labmark). A review of the analytical reports noted that these laboratories were accredited by NATA to perform the analyses required.

Laboratory analyses of soil vapour samples were undertaken by Labmark. Labmark was accredited by NATA to perform thermal desorption analyses for BTEX (relevant to off-site samples with relatively low soil vapour concentrations), but was not accredited for analysis of TPH fractions by this method. Labmark was also not accredited to perform the carbon tube analyses (by solvent extraction) which were required to quantify the higher soil vapour concentrations present in samples collected from on-site locations SV01 to SV03.

Laboratory analyses of ambient air samples were undertaken by Air Toxics Ltd, which is an overseas laboratory (California, USA) and is therefore not accredited by NATA. However, Air Toxics are considered to be one of the leading air analysis laboratories, especially for analysis of Summa canisters by USEPA Method TO-15, which is recommended by NEPC (2004). At the time of the works, only one Australian laboratory (SGS) was accredited by NATA for the analytical method used (TO-15), and SGS was not accredited for analysis of naphthalene by this method. The quality of the analytical data provided by Air Toxics is therefore considered to be comparable (or to a higher standard) to that from a NATA accredited laboratory within Australia.

Sample holding times

EPA 441.7, AS4482.1 and AS4482.2

Soil and groundwater samples were generally analysed within sampling holding times specified in reference documents with the exception of the following noted by



Component of Investigation and DQI¹ Compliance Review Comment

	URS: - moisture content, total cyanide, and total fluoride in the following, which failed by 5-6 days as noted by URS: - MPE01 (0.5-0.7); - MPE06 (1.0-1.2); - MPE10 (0.5-0.7); and - SVE05 (1.0-1.2). - TPH (C₆-C₉) and BTEX also failed by 1-3 days for several samples: - MW01 (0.5-0.6) - MW01 (8.0-8.2) - MW02 (0.5-0.6) - MW02 (2.0-2.2) - MW02 (2.7-2.8) - MW03A (0.2-0.3) - MW03A (4.0-4.2) - MW04A (0.5-0.6) - MW04A (6.0-6.2) - SV1 (0.2-0.3) - SV1 (1.0-1.2) It is noted that these samples were refrigerated; however, the holding time exceedences indicate some potential that results may not reflect original sample concentrations. The holding time exceedences for TPH (C₆-C₉) and BTEX may have resulted in some loss of volatiles for soil samples, therefore underreporting volatile constituents. Soil vapour and air samples were analysed within holding times specified for the analytical methods used (30 days).
Laboratory reporting limits EPA 441.7, AS4482.1 and AS4482.2	Laboratory reporting limits were generally appropriate for the contaminants of concern. In particular, they were appropriate for comparison with the site specific objectives that were derived. The exception to this was benzo(a)pyrene in groundwater for which the LOR (0.5 µg/L) exceeded the adopted water quality guidelines for primary contact recreation and stock watering beneficial uses (0.01 µg/L). While this indicates that benzo(a)pyrene may be present at concentrations exceeding the adopted criteria, unacceptable risks due to benzo(a)pyrene in groundwater, if present, are not expected based on the following: - Benzo(a)pyrene has not been reported in soils at the site and is of low solubility, such that the risk of significant impacts to groundwater are considered low. - The beneficial use criteria exceeded by the LORs are not currently relevant on the site and are considered unlikely to be realised in the future. - Benzo(a)pyrene is not sufficiently volatile to pose a vapour intrusion risk and is therefore not considered a concern if present in off-site groundwater.
Assessor/Auditor verification duplicates EPA 759.1	No Auditor verification samples were collected during the various stages of the assessments. The Auditor's representative did review and confirm the utility pit monitoring results during the 13 August 2008 investigations by URS. During that monitoring it was noted that the connector to the sample tubing from the PID was loose, potentially under reporting VOC results. This was rectified during the period of monitoring.
Laboratory generated quality control data	The Auditor conducted a review of laboratory generated quality control data, inclusive of: - Frequency of quality control testing; - Method blanks; - Internal laboratory duplicates; - Matrix spikes; - Surrogate spikes. Whilst there were some non-compliances with adopted assessment criteria identified for the above quality control data, the Auditor is satisfied that they do not adversely affect interpretation of the data. Multiple phases of groundwater sampling were conducted providing further confidence in the quality of the laboratory analytical



Component of Investigation and DQI ¹	Compliance Review Comment
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	data. Additionally, remediation and validation of the site is proposed and the data collected from these investigations can be used to guide remedial efforts.
Reporting of unusual or anomalous results	No unusual or anomalous results were identified with the exception of strong hydrocarbon odours from GMW1 in May 2006 sampling which only reported low dissolved phase concentrations. Subsequent monitoring has only reported low TPH concentrations at this location.

7.2 Vapour Risk Assessment Data Quality

The URS (2010b) QRA was undertaken in general accordance with nationally accepted and endorsed methodologies (enHealth, 2004; NEPC, 1999), and the majority of the adopted exposure and toxicity parameters are considered to be appropriate and/or sufficiently conservative for the purposes of the assessment. However the following is noted:

- The vapour transport modelling undertaken by URS (2010b) assumed that migration of subsurface vapours to indoor air occurred predominantly via diffusion, and that migration due to pressure driven advective flow was negligible. This is likely to be a reasonable assumption for the current off-site residential properties (which are observed to be constructed with subfloor crawlspaces), but the potential for advective effects cannot be discounted in the current on-site commercial building and/or potential future residences of slab on ground or basement construction.
- Incorrect soil vapour concentrations were utilised by URS (2010b) in some risk assessment calculations, due to unit conversion and/or data transposition errors.
- The soil vapour bores from which soil gas samples were collected were screened at near surface depths (1 to 1.2 m bgl). Soil gas at these depths has the potential to be influenced by atmospheric effects resulting from changes in barometric pressure, temperature, soil moisture and advection, and therefore:
 - The reported soil vapour results may not be representative of concentrations present beneath a large slab or other structure (which would reduce the extent of near surface effects); and
 - The concentrations at the sampling locations may be subject to significant temporal variability, the range of which may not have been captured during the previously conducted sampling rounds (which have been conducted in winter and spring only).

The Auditor has undertaken an independent assessment of the extent to which the above issues may impact on the overall assessment of risk, as summarised in the table below. Overall, the Auditor is of the opinion that risks to human health associated with the migration of volatile contaminants to indoor or outdoor air are likely to be low and acceptable for the current land use conditions in both on-site and impacted off-site locations. However, the potential for vapour intrusion related health risks would require further assessment if the site is to be redeveloped and/or if a building with basement is constructed in off-site areas which are impacted by site-derived petroleum hydrocarbon contamination.

Potential Health Risk Assessment Issue	Auditor Review Comment
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Advective vapour flow not considered in risk assessment	Significant advective flow from the subsurface to current on-site and off-site buildings is considered unlikely, however the Auditor has independently recalculated risks with advective vapour flow included in the modelling as a conservative measure. The resulting
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**Potential Health Risk
Assessment Issue**
Auditor Review Comment

	estimated health risks were low and acceptable for current on-site and off-site receptors.
Unit conversion errors resulted in incorrect soil vapour concentrations utilised in vapour modelling	Recalculation of risks by the Auditor with correct soil vapour concentrations indicated low and acceptable health risks to current off-site and on-site receptors, including when advective vapour flow was included in the calculations.
Shallow soil vapour bore screen depths adjacent to buildings (such that vapour concentrations may not be representative of conditions beneath building foundations).	While screened at shallower depths than would be recommended for assessment of soil gas concentrations beneath a large building foundation, the soil gas sampling locations were located in paved and/or concreted areas, and are therefore considered likely to be representative of those which would be present beneath smaller building slabs, such as those currently present on and off the site (e.g. the existing on-site service station shop building and off-site commercial buildings). It is also noted that the shallow screen depth (whether located beneath paved or unpaved areas) is likely to be representative and/or conservative for assessment of concentrations in the subsurface beneath the existing off-site homes with crawlspace. The screen depths used are therefore considered acceptable for assessment of risks to current on-site and off-site receptors (small building foundation areas and/or homes with crawlspace), however further assessment may be required to assess potential vapour intrusion impacts if further development is undertaken in impacted areas.

7.3 Overall Summary of Data Quality

In summary, sufficient sampling (notwithstanding identified data gaps) was undertaken over the course of the investigation to provide the Auditor with assurance regarding the quality of available data and to form an opinion on the contamination status of the site. In the Auditor's opinion, the quality and reliability of information generated from the investigations undertaken taking into account all limitations as identified in previous sections, were sufficient for the purposes of this environmental Audit.



8.0 Clean Up Measures

8.1 EPA Requirements

The EPA s.62A Notice requirements for the preparation of a Clean Up Plan are reproduced as an extract of the s.62A Notice below:

3. ...the occupier must submit a Clean Up Plan to EPA for the clean up of contaminated land on the premises; and groundwater on and from the premises. The plan must include:

Land and aquifer characterisation, including a hydrogeological conceptual model, including details on:

- i. Site geology and hydrogeology;*
- ii. The extent of the groundwater dissolved phase plume/s, NAPLs and the nature and spatial and temporal distribution of contaminants;*
- iii. The current and potential impact of contaminants on the beneficial uses of land and groundwater.*

Outline the clean up objectives consistent with State environment protection policy (Prevention and Management of Contamination of Land) [SEPP (PMCL)], State environment protection policy (Groundwaters of Victoria) [SEPP (GoV)] and State environment protection policy (Waters of Victoria) [SEPP (WoV)] for the clean of contaminated land and groundwater that includes, but is not limited to the following:

- iv. Prevention of further off-site migration of contaminated groundwater;*
- v. Clean up existing NAPLs and dissolved phase polluted groundwater.*

Include a review of available remediation strategies and their ability to restore the beneficial uses of land and groundwater, including an assessment of the practicability (including technical, logistical and financial) of the strategies to meet the clean up objectives.

Specify the proposed remediation strategy, including an implementation timetable, to be implemented on and off the premises to meet the clean up objectives, which includes the rationale for selecting the remediation strategy.

The proposed remediation strategy must outline the following:

- vi. Proposed monitoring and auditing programs to be conducted during and after implementation of the clean up measures;*
- vii. Proposed trigger levels that will indicate if the proposed clean up measure/s will not meet the clean up objectives;*
- viii. Contingency plan/s to be implemented in the event that a trigger level is exceeded;*
- ix. Safeguards proposed to be implemented to protect the environment and human health and amenity during implementation of the clean up measures;*
- x. Measures and controls proposed to be taken to treat, reuse or dispose of contaminated soil and groundwater;*
- xi. Measures and controls proposed to be taken for the management of air emissions in accordance with State Environment Protection Policy (Air Quality Management);*
- xii. Measures and controls proposed to be taken for the management of prescribed wastes in accordance with Industrial Waste Management Policy (Prescribed Industrial Wastes), IWMP (PIW); and*
- xiii. Proposed measures for notification and provision of information to occupiers of premises under which contaminated groundwater exists.*



4. *By 30 September 2008 submit to EPA a time-line and schedule of remediation works in accordance with the clean up plan referred to in Requirement 3.*

The following sections describe the proposals presented by URS for the remediation of the site.

8.2 Clean Up Plan Measures Proposed

8.2.1 Clean Up Objectives

The Clean Up Plan prepared by URS (July 2008a, amended as URS, 2010a) outlines the following clean up objectives:

- Render the premises and surroundings suitable for their permitted use; and
- Permit the restoration of the beneficial uses of groundwater to the extent practicable.

URS outlined that source management works proposed have the following objectives:

- Aggressively remove LNAPL on and off-site.
- Address dissolved phase impacts on and off-site.
- Prevent further off-site migration of LNAPL and dissolved phase impacts.
- Minimise risks to human health and the environment.

URS outlined primary (UPSS) and secondary (LNAPL) source control measures to achieve land and groundwater clean up objectives as follows:

- Primary Source Control – confirm decommissioning or removal of all non-operational pipework and repair of failed infrastructure.
- Management of Soil Impacts – attainment of soil quality objectives or site specific risk based objectives in the context of the clean up of adsorbed phase hydrocarbons to the extent practicable.
- Management of Groundwater Impacts – Removal of LNAPL to comply with Clause 18 of the SEPP (GoV) dissolved phase impacts to the extent practicable. In this case consultation with EPA will be required determine if groundwater has been cleaned up to the extent practicable.

8.2.2 Clean Up Strategy

URS as developed a clean up strategy on the basis of ongoing service station operations (i.e. UPSS removal). Following review of hydrocarbon remedial technologies, URS proposed a strategy for the site comprising on-site shallow Soil Vapour Extraction (SVE) for unsaturated (soil) clean up and Multi Phase Extraction (MPE) to address LNAPL and dissolved phase impacts on and off-site.

URS considered the most efficient technology for unsaturated (soil) zone clean up at an operating service station to be SVE. Soil excavation was also considered but rejected, unless a tank replacement program was proposed for the site (refer URS 2008a, section 4.3).

For the unsaturated (soil) zone clean up, URS initially considered three technologies comprising:

- Soil excavation and disposal.
- On-site treatment (biopiles).
- Soil vapour extraction.

Based on site logistics (i.e. clean up in the context of an operational service station), URS as indicated above identified SVE as the preferred option for unsaturated (soil) zone clean up.

For the saturated (groundwater) zone clean up, URS considered seven technologies comprising:

- Passive skimming.



- Active skimming.
- Vacuum enhanced skimming.
- Pump and treat.
- Air sparging
- Multiphase extraction.
- Monitored natural attenuation.

A summary of the advantages and disadvantages of each remedial technology is presented in URS (2008a, section 4.4.8). Following shortlisting, MPE was selected for pilot testing and ultimately selected for application, principally as an LNAPL clean up strategy. The results of the pilot trial were presented in URS (2007c). The Auditor notes that the radius of MPE influence (corresponding to 100 Pascal vacuum influence to remove LNAPL and adsorbed hydrocarbon) presented by URS ranged between 8 and 20 metres. The system proposed for the site comprises a site bound MPE well spacing of 20 metres with SVE focussed near the fill point area.

The remedial strategy proposed by URS includes a range of operational controls, environmental monitoring requirements, trigger levels for corrective action and requirements for regulatory approval of the system. Section 5 of URS (2008a) outlines these requirements. Future management requirements are also addressed including the development of a Site Management Plan and a Groundwater Monitoring Plan.

Section 9.8 of this Audit report provides a review of the adequacy of the risk mitigation measures proposed for the site.



9.0 Assessment of Risk Posed by Site Conditions

9.1 Risk Management Methodology

The Auditor has assessed the risk posed by contaminants from petroleum hydrocarbon storage and use at the site in general accordance with the methodology outlined in the following national and international :

- Australian Standard AS 31000:2009 – Risk Management – Principles and Guidelines (Standards Australia, 2009b).
- IEC / ISO 31010:2009 - International Standard: Risk management – Risk assessment techniques (IEC/ISO, 2009).

The broad risk management process described in the above standards includes the following components:

- Communication and Consultation – consultation with external and internal stakeholders concerning the risk assessment process as a whole.
- Establishing the Context – defining the objectives of the risk assessment, to ensure that the risk management approach is appropriate to the circumstances
- Risk Assessment, including:
 - Risk Identification;
 - Risk Analysis; and
 - Risk Evaluation
- Risk Treatment

The above elements are further detailed in the following sections.

9.2 Risk Communication and Consultation

Risk communication is the process of consulting with internal and external stakeholders concerning the risk assessment process as a whole. The communication and consultation stage should address issues relating to the risk itself, its causes, its consequences and the measures being taken to treat risk.

The risk communication and consultation actions undertaken as part of this Audit included the following:

- The EPA requested the Environmental Audit for the reasons described in the Clean Up Notice (s.62A Notice) served on Caltex Australia Petroleum Pty Ltd on 9 July 2008.
- Caltex issued a request for a proposal to complete this Environmental Audit.
- The Auditor prepared a draft Audit scope and circulated that draft to the EPA Environmental Performance Unit and the South West Region. EPA provided comment on the draft scope in a meeting with Caltex and the Auditor on 3 March 2008.
- URS/Caltex discussions with the occupier of the commercial property to the west to conduct vapour monitoring.
- The Auditor worked with Caltex and its consultants, URS, through meetings, site inspections and review of reports.



9.3 Context Establishment

Context establishment involves identification of the objectives of the risk management process being undertaken, definition of the external and internal parameters to be taken into account when managing risk and setting of the scope for the remaining process.

The risk context for this Audit has been defined based on the scope agreed with EPA and Caltex (see **Section 2.4**). In accordance with this scope, the risk of harm or detriment caused by past and current service station activities at the premises to the following elements of the environment has been assessed:

- Impact to the protected beneficial uses of the land environment (which includes the vapour and liquids within interstitial space), including:
 - Maintenance of highly modified ecosystems.
 - Human health.
 - Buildings and structures.
 - Aesthetics.
- Impact to the protected beneficial uses of the groundwater environment, including:
 - Maintenance of ecosystems.
 - Stock watering.
 - Primary contact recreation.
 - Buildings and structures.

9.4 Risk Identification

The aim of the risk identification step is to generate a list of risks that may impact the achievement of identified objectives.

The identification of risks for this Audit has comprised evaluation of specific means by which site contaminants may impact the protected beneficial uses of land or groundwater listed above.

Potential risks or impacts were identified based on consideration of potentially complete exposure pathways (also termed 'pollutant linkages') via which human, ecological or other receptors (e.g. buildings and structures) may be exposed to and adversely affected by contaminants associated with past and current service station activities at the site.

As defined by NEPC (1999) and USEPA (1989), an exposure pathway describes the course a chemical or physical agent takes from a source to an exposed receptor, and consists of the following four elements:

- A source and/or mechanism of chemical release.
- A pathway or transport medium (or media in cases involving media transfer of contaminants).
- A point of potential contact with the contaminated medium (exposure point);
- An exposure route (e.g., ingestion, inhalation).

Where one or more of the above elements is not present, the exposure pathway is considered to be incomplete.

The identification of contamination sources and potentially complete exposure pathways is detailed in **Sections 9.4.1 to 9.4.4** below.

9.4.1 Contamination Sources

The primary sources of contamination were petroleum and fuel storage infrastructure (i.e. USTs and fuel lines), since repaired. Current UPSS infrastructure will remain at the site as it is an operational service station.



The primary sources of site related contamination have resulted in what would now be considered “secondary” sources, following the historical release of contaminants into the environment. These sources typically include free phase hydrocarbons (LNAPL) that exist in the vicinity of site infrastructure and deeper at the interface with the water table.

9.4.2 Transport and Exposure Pathway Analysis – Human Receptors

The following table summarises potential human receptors and the potentially complete exposure pathways by which these receptors may be exposed to site-related contaminants and/or hazards (petroleum hydrocarbons in soils, as dissolved groundwater contamination, or LNAPL).

Contaminant Migration Pathway	Exposure Point	Exposure Pathway or Hazard	Receptor			
			On Site Commercial Workers	Off-site Commercial Workers or Residents	Off-site Surface Water Users	On or Off-site Intrusive Workers
Vapour Migration	Indoor and/or outdoor air	Inhalation of groundwater or LNAPL derived vapours	✱1	✱2	-	✱3
Vapour Migration	Indoor and/or outdoor air	Inhalation of soil derived vapours	✱4	-	-	✱5 (on site)
Vapour Migration	Indoor and/or outdoor air	Noticeable odour generation from soil, LNAPL and/or groundwater contaminants	✱6	✱7	-	✱8
Airborne particulate generation (due to wind or excavation)	Indoor and/or outdoor air	Inhalation of soil-derived particulate material (fugitive dust)	✱9	✱10	-	✱11
Direct contact exposure	Surface/shallow soils or perched groundwater	Ingestion, dermal contact or inhalation	✱12	✱13	-	✱14
Groundwater transport (including leaching to groundwater)	Point of groundwater extraction and/or use	Ingestion, dermal contact or inhalation of contaminants in groundwater during extractive use	-	✱15	-	-
Groundwater transport and discharge to surface water/sediment	Corio Bay	Ingestion, dermal contact or inhalation of contaminants in surface water or sediment	-	-	✱16	-
Groundwater transport via preferential pathway (e.g. underground service), and discharge to surface water/sediment	Corio Bay	Ingestion, dermal contact or inhalation of contaminants in surface water or sediment.	-	-	✱17	-

✱ = Potentially complete and significant exposure pathway (number indicates hazard ID used in subsequent sections)

- = Incomplete pathway, or not applicable to receptor.

9.4.3 Transport and Exposure Pathway Analysis – Ecological Receptors



The table below summarises potential ecological receptors and the exposure pathways by which the receptors may be exposed to site-related contaminants and/or hazards (petroleum hydrocarbons in soils, as dissolved groundwater contamination, or LNAPL).

Contaminant Migration Pathway	Exposure Point	Exposure Pathway	On-site Terrestrial Ecological Receptors	Aquatic Ecological Receptors (Corio Bay)	Off-site Livestock (if groundwater used for stock watering)
Direct contact and/or bioaccumulation within the food chain	Surface soil and/or food	Direct contact or ingestion of foodstuff	✱18	-	-
Groundwater transport (including leaching to groundwater)	Point of groundwater extraction and/or use	Direct Contact or ingestion of extracted waters (i.e. stock watering)	-	-	✱19
Groundwater transport (including leaching to groundwater) then discharge to surface water and/or sedimentary environment	Surface water (Corio Bay)	Direct contact with surface water or sediment in Corio Bay, or ingestion of flora/fauna in which bioaccumulation has occurred	-	✱20	-
Transport via preferential pathway (e.g. underground service), discharge to surface water and/or sedimentary environment	Surface water (Corio Bay)	Direct contact with surface water or sediment in Corio Bay, or ingestion of flora/fauna in which bioaccumulation has occurred	-	✱21	-

✱ = Potentially complete and significant exposure pathway (number indicates hazard ID used in subsequent sections)

- = Incomplete pathway, or not applicable to receptor.

9.4.4 Transport and Exposure Pathway Analysis – Other Receptors and/or Issues

Contaminant Migration Pathway	Exposure Point	Exposure Pathway or Hazard	Potentially Complete Pathway and Hazard ID
Vapour migration and accumulation in enclosed spaces	Utility pits, service lines or other enclosed spaces	Accumulation of explosive hydrocarbon concentrations	✱22
Direct contact with Hydrocarbons in vadose zone soil	Building foundations or other subsurface structures (e.g. service conduits or infrastructure)	Degradation or corrosion of buildings and structures	✱23
Direct contact with hydrocarbons in groundwater or LNAPL			- (buildings and structures do not extend to depth of groundwater table)



- ✱ = Potentially complete and significant exposure pathway (number indicates hazard ID used in subsequent sections)
- = Incomplete pathway or not applicable.

9.5 Risk Analysis

9.5.1 Methodology

In accordance with ISO 31010, the methodology adopted for risk analysis consisted of determining the consequences and probabilities of identified risks, and subsequent combination of the consequences and probabilities to determine a level of risk. ISO 31010 describes a range of risk analysis methodologies, including qualitative, semi-quantitative and quantitative. A qualitative methodology was used for this analysis, whereby risk consequences, probabilities and overall levels were defined by a range of significance levels. It is noted that in some cases the qualitative descriptor(s) were selected based on results of a quantitative risk assessment process (e.g. for exposure pathways which had been previously evaluated using a quantitative health risk assessment methodology).

The criteria used to classify consequences and probabilities of the identified risks are summarised in the following tables.

Criteria Used to Classify Consequences of Identified Risks

Consequence Classification	Description
Massive	Irreversible and irrecoverable impact to a protected beneficial use of the relevant environmental element. Impact to the beneficial use on a regional scale. Impact to the beneficial use with little prospect of recovery to pre-incident conditions.
Major	Major impact to a protected beneficial use of the relevant environmental element. Eventual restoration of the beneficial use possible, but not necessarily to the same pre-incident conditions.
Substantial	Significant impact to a protected beneficial use of the relevant environmental element. Restoration of the beneficial use to pre-incident conditions is possible with substantial remedial measures.
Moderate	Impact to a protected beneficial use of the relevant environmental element. Impact is limited to a local scale with some change to pre-incident conditions. Restoration of the beneficial use to pre-incident conditions is likely with remedial measures.
Minor	Small impact to a protected beneficial use of the relevant environmental element. Minor changes evident to pre-incident conditions. Restoration of the beneficial use to pre-incident conditions is possible with minimal remedial measures.
Slight	Incidental impacts to a protected beneficial use of the relevant environmental element. No measureable change from pre-incident conditions.

Criteria Used to Classify Likelihood of Identified Risks

Likelihood Classification	Description
Almost Certain	The event is expected to occur in most circumstances
Likely	The event will probably occur in most circumstances (i.e. >50% chance of occurring)
Possible	The event could occur at some reasonable time in the future
Unlikely	The event is unlikely to occur although there is a chance of occurrence over the long term
Improbable	The event is highly unlikely to occur in the long term



Following classification of risks/hazards based on the consequence and likelihood descriptors above, a qualitative evaluation of the level of each risk was undertaken using the matrix depicted in the following table.

Likelihood/Consequence Matrix Used to Assess Level of Identified Risks

Consequence	Likelihood				
	Improbable	Unlikely	Possible	Likely	Almost Certain
Massive	Medium	High	High	Severe	Severe
Major	Medium	Medium	High	Severe	Severe
Substantial	Medium	Medium	High	High	Severe
Moderate	Low	Low	Medium	High	High
Minor	Low	Low	Medium	Medium	Medium
Slight	Low	Low	Low	Low	Low

9.5.2 Results

The following table summarises the risk analysis results for the identified risks associated with petroleum hydrocarbon releases due to past and current service station. The analysis was undertaken based on the information describing the site at the time of the assessments undertaken, i.e. prior to the implementation of any control measures and assuming additional releases of petroleum hydrocarbons do not occur in the future.



Hazard ID	Receptor	Hazard Description	Consequence	Likelihood	Overall Risk Rating	Notes	Recommended Management Measure/Risk Treatment
1-3	On site workers, off-site residents/workers, on or off-site intrusive workers	Inhalation of contaminants in vapours derived from groundwater or LNAPL	Moderate	Improbable	Low	QRA based on soil vapour data and indoor air monitoring in Scope Centre do not indicate unacceptable human health risk	Ongoing vapour monitoring. Revise QRA if warranted (e.g. if higher air or vapour concentrations than previously measured are reported).
4-5	On site commercial workers and on site intrusive workers	Inhalation of contaminants in vapours derived from vadose zone soil					
6-8	On site workers, off-site residents/workers, intrusive workers	Odour impacts (during normal site use)	Minor	Improbable	Low	Predicted and measured indoor and outdoor air concentrations do not exceed odour thresholds. No odour issues are known to have been reported during normal use. Odours associated with ongoing fuel use and storage likely to be more significant than those from subsurface contamination.	No action required provided unacceptable odours not reported.
6-8	Intrusive workers (and others in vicinity of intrusive work)	Odour impacts (during intrusive works)	Minor	Likely	Medium	Odours have been reported during intrusive investigations, although predominantly below depths of 7 m bgl (i.e. near and below the water table). However, odorous soils are likely to remain within the tank farm area and odour releases during intrusive works in this area, while likely to be isolated and short term in nature, are considered likely.	Prepare and implement Site Environmental Management Plan (SEMP) with measures to control/minimise odours during intrusive works. Remediate shallow soil impacts to the extent practicable.
9-10	On site workers, off-site residents or workers	Inhalation of contaminants in airborne dust generated from surface soil	Moderate	Improbable	Low	Shallow soil impacts are limited to vicinity of former fuel infrastructure and currently present under hardstand,	Ensure areas with impacted shallow soil are covered by hardstand. Remediate shallow soil impacts to the



Hazard ID	Receptor	Hazard Description	Consequence	Likelihood	Overall Risk Rating	Notes	Recommended Management Measure/Risk Treatment
12-13		Direct contact with contaminated surface soil				thereby limiting likelihood of complete exposure pathway	extent practicable.
11, 14	Intrusive workers	Direct contact with or inhalation of contaminants in surface soil during intrusive works	Minor	Likely	Medium	Exposure likely to be short term and only expected to occur during intrusive works in areas of former fuel infrastructures (i.e. source zones)	Prepare and implement SEMP with measures to minimise direct contact and dust exposure during intrusive works Remediate shallow soil impacts to the extent practicable.
15	Off-site residents or workers who may extract groundwater	Exposure to groundwater contaminants during extractive use of groundwater	Substantial	Possible	High	Registered groundwater extraction bores not reported within 1 km of site and use is considered unlikely within affected area. However potential for unauthorised or future extraction of groundwater from impacted areas cannot be discounted.	Remediation of groundwater to the extent practicable. Prepare and implement Groundwater Quality Management Plan (GQMP), specifying measures to ensure that hydrocarbon impacted groundwater is not extracted and used. A Groundwater Quality Restricted Use Zone (GQRUZ) could be used as a means of identifying the extent of impact to alert in the area.
16, 17	Off-site recreational users of surface water (Corio Bay)	Exposure to contaminants in surface water or sediment following groundwater discharge to surface water (Corio Bay)	Moderate	Improbable	Low	Site derived dissolved phase groundwater impacts, highly unlikely to reach Corio Bay, approximately 1.5 km from site, in concentrations that would pose an unacceptable risk.	Further delineation of off-site groundwater impacts and ongoing groundwater monitoring. Reassessment of risk if groundwater impacts are found to expand and reach vicinity of Corio Bay.



Hazard ID	Receptor	Hazard Description	Consequence	Likelihood	Overall Risk Rating	Notes	Recommended Management Measure/Risk Treatment
18	On site terrestrial ecological receptors	Exposure to surface soil contaminants via direct contact and/or food chain accumulation	Minor	Improbable	Low	Terrestrial ecological environment is highly modified given commercial use of site and developed nature of surrounding properties. Shallow soil impacts are limited to vicinity of former fuel infrastructure and currently present under hardstand, thereby limiting likelihood of complete exposure pathway	Ensure areas with impacted shallow soil are covered by hardstand. Remediate shallow soil impacts to the extent practicable.
19	Off-site livestock	Exposure to contaminants via ingestion or direct contact during stock watering use	Substantial	Improbable	Medium	Registered groundwater extraction bores not reported within 1 km of site and stock watering use is considered highly unlikely based on suburban and commercial nature of site vicinity. However potential for unauthorised or future extraction of groundwater from impacted areas cannot be discounted.	Remediation of groundwater to the extent practicable. Prepare and implement GQMP, specifying measures to ensure that hydrocarbon impacted groundwater is not extracted and used.
20, 21	Aquatic ecological receptors (in Corio Bay)	Exposure to contaminants in surface water or sediment following groundwater discharge to surface water (Corio Bay)	Moderate	Improbable	Low	Site derived dissolved phase groundwater impacts, while not yet completely delineated, are not likely to extend more than 200 m from the site boundary, and therefore highly unlikely reach Corio Bay (approximately 1.5 km from site).	Further delineation of off-site groundwater impacts and ongoing groundwater monitoring. Reassessment of risk if groundwater impacts are found to expand and reach vicinity of Corio Bay.
22	Multiple	Acute explosive risk due to accumulation of hydrocarbons in utility pits or other enclosed spaces	Massive	Improbable	Medium	Elevated LEL results in some locations, but readings do not appear to be associated with hydrocarbons. Elevated results may be associated with natural gas pipeline in area.	Further investigation of source of elevated VOCs/LELs to east of site. Continue pit venting and notification of utility providers as warranted.



Hazard ID	Receptor	Hazard Description	Consequence	Likelihood	Overall Risk Rating	Notes	Recommended Management Measure/Risk Treatment
23	Buildings and structures	Degradation or corrosion due to direct contact with hydrocarbons	Moderate	Improbable	Low	Shallow soil impacts are isolated and limited to a small area. Unlikely that buildings or non-UPSS infrastructure would come into contact with shallow impacts under current site use condition. Potential for impacts during future site development works should be considered.	Prepare and implement SEMP with measures to prevent adverse impacts to underground services due to direct contact with petroleum hydrocarbons in soils. Remediate shallow soil impacts to the extent practicable.



9.6 Risk Evaluation

Risk evaluation involves comparison of the level of risk identified during the risk analysis process with risk criteria, and determining the required level of treatment, management and/or further monitoring.

The adopted risk evaluation framework for this Audit is summarised in the table below. In general, the framework is based on the objective of reducing potential contaminant exposure to levels below those which may potentially pose a human health or ecological risk.

Risk Rating	Recommended Treatment
Low	Immediate action not required. Depending on level of uncertainty associated with the risk analysis, further monitoring or data collection may be recommended.
Medium	Remediation and/or management controls required to reduce risk and/or Additional monitoring/data collection should be undertaken to refine the risk analysis. Risk analysis to be reviewed following additional data collection.
High Severe	Immediate treatment and/or controls required.

9.7 Risk Treatment

Risk treatment is the process of identifying one or more options for reducing risks which are considered to be unacceptable.

The Auditor's recommended risk treatment measures are included in the risk analysis table above. The recommendations were primarily selected to meet the objective of reducing or eliminating the potential for chemical exposures (and associated health or ecological risks) to below acceptable levels. In some cases, it is considered that treatment may not be required, but additional data collection has been recommended to enable further refinement of risk.

9.8 Adequacy of Existing Risk Mitigation Measures

Based on the information sources reviewed over the course of the Audit, the Auditor presents the following comments with respect to mitigation measures known or proposed for the site.

9.8.1 EPA Requirements for the Restoration of Protected Beneficial Uses of Groundwater

In accordance with SEPP (GoV) and EPA Publication 840 (EPA, 2002), where groundwater is polluted it should be cleaned up to restore beneficial uses (pollution is defined as exceedence of indicator objectives). Where this is not possible or feasible, groundwater must be cleaned up to the extent practicable (CUTEP). The EPA is the only entity that can determine what constitutes clean up to the extent practicable. As such, a long term objective for the clean up of the site may be considered the restoration of beneficial uses.

Achieving CUTEP may require a number of remedial stages comprising aggressive source mass removal and enhanced monitored natural attenuation. The proposed approach with consideration to policy is discussed below.



9.8.2 Receptor Management - Risk Communication and Information

The highest risk item is the potential for off-site extraction and use of groundwater (e.g. although of marginal irrigation quality, groundwater could be used for garden irrigation). The focus on remedial measures (risk treatment) at the site is source removal and management. Based on the potential for off-site groundwater use, an additional element of risk treatment whilst beneficial uses are being restored should include receptor management. As such the current approach is considered inadequate and it is recommended that communication actions are initiated as follows:

- EPA should consider a determination that the site is within a Groundwater Quality Restricted Use Zone (GQRUZ).
- Groundwater quality information should be provided to the Rural Water Corporation (Southern Rural Water) and the community to inform existing and potential users of the impacts.
- Groundwater quality information should be provided to immediately downgradient property owners.

9.8.3 Primary Source Control Measures (Infrastructure)

The Auditor notes that repairs have been made to existing UPSS pipework over several occasions. The last tank integrity testing is understood to have been completed in August 2008. Ongoing UPSS monitoring by SIRA should continue to be monitored to assess the need for future tank integrity testing.

As recommended in **Section 8.2**, UPSS surplus to needs or of unknown decommissioning status should be properly decommissioned as per EPA Publication 888.1 (EPA, 2009). During these works or should a tank replacement program be instigated at the site, impacted soil beneath UPSS should be cleaned and/or validated as being suitable for ongoing commercial/industrial land use.

9.8.4 Secondary Source (Soil and Groundwater) Control Measures (Proposed Remediation System)

The existing management measures at the site are considered inadequate to manage the site impacts and as such source zone remediation is required. The remedial approach proposed for the site (MPE) comprises adoption of a proven remedial technology for the removal of LNAPL that works in a range of lower permeability formations. This technology is also useful, although to a lesser extent in the management of dissolved phase hydrocarbon impacts. MPE is considered an aggressive source zone reduction technique, however as acknowledged by URS, further consideration based on the success of the system will be required to manage dissolved phase impacts, in particular off-site impacts to the north and north east of Church Street (under the adjoining residential area).

URS also proposes SVE to remove hydrocarbon vapours in shallow soils adjacent the fill points at the site. This approach is also a proven technology in the management of soil source zone petroleum hydrocarbons.

The success of MPE in managing the entire plume will be dependent upon the extent of the vacuum influence and therefore the extent of the vertical MPE well network. The Auditor notes the proposed system is limited to onsite extraction only and it is understood that there are currently no immediate plans to actively manage the off-site plume for areas beyond the probable radius of influence of the MPE system.

URS proposes that the initial six month period of operation of the system will be used to refine and provide additional design data to address dissolved phase plume and shallow soil impacts. The Auditor is of the opinion that the current approach will provide useful information to assist in refining the clean up program, however it is highly likely that an off-site active extraction system will be required to manage off-site dissolved phase impacts and ultimately stabilise the dissolved phase plume.



It is also considered that the details of the staged approach proposed by URS should be clearly articulated such that data needs are addressed ahead of decisions to switch technologies or move to monitored natural attenuation. The key to determining when to turn off the MPE system will be around demonstrating reduced source mass recovery and that an alternative process (if required) can be applied to continue clean up (even if that process is monitored natural attenuation (MNA)). This will require information on:

- Defensible estimates of biodegradation rates and defensible groundwater modelling. Site specific data collected from an active bioremediation phase could also support the groundwater modelling and a decision to move to MNA by providing defensible estimates of the attenuative capacity of the aquifer. This should be assessed before the MPE system is turned on and during operation as well as post shutdown. This can also be used to estimate the timing for the restoration of beneficial uses at the site.
- Estimating bioremediation rates by respiration testing using samples of the consortium of bacteria collected from the aquifer. There are methodologies available, through overseas laboratories (e.g. Planreal AG and Microbial insights), for sampling bacteria from an aquifer using a porous carbon matrix left in wells for a number of weeks. Respiration testing can then be done in the laboratory using the samples to determine the rates of degradation that may be achieved by bacteria from within the plume at different oxygen levels and, potentially, other enhancements. Based on this testing, more defensible assessment could be made of the mass of contaminants being degraded at various oxygen levels and what may be achieved by increasing oxygen levels. The mass of contaminants being degraded can only be estimated in sealed systems (e.g. a respiration testing vessel) and is likely to be the key parameter in assessing the attenuative capacity of the aquifer. This information can then be used in developing a quick field procedure for measuring activity and likely assimilative capacity of the aquifer (such as monitoring DO or redox potential) and be used in the groundwater model to support an MNA argument.

The Audit recommendations to support the chosen approach to the clean up of the site are presented in **Section 11.0**.



10.0 Summary of Audit Findings

On the basis of the information that is currently available, the findings of this environmental Audit are summarised in the following sections.

In the Auditor's opinion, the quality and reliability of on-site information generated from the investigations undertaken taking into account all limitations as identified in previous sections, were sufficient for the purposes of this environmental Audit.

Based on review of available documentation, the Auditor concludes:

- The site is currently an operational service station and has been used for the storage and handling of petroleum related products for approximately 30 to 40 years.
- Since 2007, Caltex has commissioned numerous environmental investigations to assess the contamination status of the site. These have included installation of soil bores and groundwater monitoring bores on-site/off-site.
- Investigations to date have targeted the vadose zone soils and uppermost regional water bearing unit, which comprises the Moorabool Viaduct Sand of the Geelong-Bellarine region, underlying and directly adjacent to the site.
- As a result of petroleum hydrocarbon sources both on- and off-site, LNAPL and dissolved phase TPHs have impacted the unsaturated soils directly underlying the site and groundwater within the Moorabool Viaduct Formation Aquifer in both on and off-site locations.

Specific conclusions relating to risk to segments of the environment as defined in the Audit scope are presented in the following sections.

10.1 Land Pollution and Risk

The Auditor is of the opinion that soils are polluted by elevated concentrations of petroleum hydrocarbons, primarily in the vicinity of the UST fill points near the western boundary.

The Auditor is of the opinion that health risks to current site users are likely to be acceptable, however the risk assessments undertaken have not considered potential future reconfiguration or redevelopment of the site.

Further investigation and assessment of additional lines of evidence relating to potential vapour intrusion and/or direct contact risks should be undertaken if usage or occupancy patterns at the site are modified in the future to include, for example:

- Construction or occupation of a new building on the site.
- Movement of an existing building to a different location on the site.
- Reconfiguration of the site such that polluted soils are no longer covered by concrete or other hardstand material which prevents direct contact with the soil.
- Activities which involve significant direct contact with or excavation of contaminated soil at the site.
- A significant change in land use.

10.2 Groundwater Pollution and Risk

The Auditor is of the opinion that groundwater at the site is polluted with respect to a number of beneficial uses, however the potentially precluded beneficial uses are not currently realised at the site.



The Auditor is of the opinion that hydrocarbon contamination derived from the site has resulted in off-site pollution of groundwater with respect to a number of beneficial uses. The lateral extent of off-site groundwater pollution has not been fully delineated and may be expanding.

Based on the available information, it is the Auditor's opinion that protected groundwater beneficial uses in impacted off-site areas are not currently likely to be realised. Despite this, given the magnitude of dissolved phase hydrocarbons and NAPL off-site, together with uncertainty over the lateral extent of the plume migration, further risk management measures are warranted to ensure that future groundwater users are made aware of potential groundwater pollution.

Groundwater contamination derived from the site is unlikely to be currently discharging to the nearest Aquatic Ecosystem (Corio Bay located approximately 1.5 km to the east of the site).

Based on policy drivers (e.g. Clause 18 regarding the removal of LNAPL) and the overall objective to restore protected beneficial uses, clean up and management of the existing NAPL and dissolved phase pollution are required. Clean up should be completed to the extent practicable where beneficial uses cannot be restored.

10.3 Air Pollution and Risk

The Auditor considers that health risks to current on and off-site receptors are acceptable, however the results of the risk assessment should be reviewed and refined as future soil, soil vapour, air and/or groundwater quality information becomes available. Additionally, further investigation and assessment of additional lines of evidence relating to potential vapour intrusion risks should be undertaken if usage or occupancy patterns at the site are modified in the future to include the items previously noted in **Section 10.1**. Further investigation and assessment would also be required if significant modification or redevelopment of off-site areas immediately down hydraulic gradient of the site (i.e. in areas where site derived groundwater pollution is present) is proposed or occurs.

In relation to services and utility pits in the vicinity of the site, the available data indicate that accumulation of petroleum hydrocarbon vapours derived from the site is not significant. However, further investigation of the source(s) of elevated LEL readings reported in utility pits to the east of the site (along the boundaries of the former Mobil service station) is warranted.



11.0 Recommended Measures

Based on the results of the Audit, the following management responses are recommended in the table below. The priority for commencement of works is considered on the following basis:

- Long term priority – commence works to address issues within 12 months.
- Medium term priority – commence works to address issues within 6 – 12 months.
- Short term priority - commence works to address issues within 6 months.

Issue	Recommended Actions	Relevant Section(s) of Report	Priority
Petroleum Hydrocarbon Source Identification	Council files should be sought to further assess: • the possible location(s) of historical and as yet unidentified UPSS infrastructure at the site; and • the location and/or further details of the former mechanical workshop reported to have been present at the site.	5.1	Short
Underground Petroleum Storage System Management	UPSS infrastructure (underground petroleum fuel and waste oil tanks and lines) should be properly decommissioned (i.e. removed) where surplus to needs, if possible. This applies in particular to the 'unknown' USTs in the north and south of the premises.	5.1	Long
Delineation of Groundwater Impacts	Further delineation of the dissolved phase impacts should be completed, particularly around MW5, MW9 and MW19	5.3, 10.2	Short
Refinement and Implementation of Remedial Approach	The remedial approach should be refined to ensure management of the off-site component of the plume. The proposed system should be installed and commissioned. The Auditor notes that Caltex has prepared a revised schedule for remediation works, a copy of which is provided in Attachment 1 and the revised timeframes should be discussed with EPA. EPA should also be engaged in the process of determining clean up of groundwater to the extent practicable (refer also to Site Environmental Management Plan recommendation below).	8.2	Short
Ongoing Groundwater Monitoring	Development of a groundwater quality management plan (GQMP) prepared with consideration of elements of Section 7 of EPA Publication 840, <i>The Clean Up and Management of Polluted Groundwater</i> (EPA, 2002). The GQMP should incorporate a wider network of bores than currently assessed to build on the spatial data.	5.3	Medium
Ongoing Soil Gas Monitoring	As part of ongoing assessment and monitoring of risk, soil gas monitoring (including utility pit monitoring) should continue to be undertaken, noting the Auditor's recommendations for improvement in the program.	5.4.1, 5.4.3, 10.3	Short
Additional Indoor Air Monitoring (Scope Centre)	As part of ongoing assessment and monitoring of risk, further indoor air monitoring should be undertaken in the Scope Centre to the west of the site, noting that the previous sampling did not meet the minimum requirements specified in the Air Toxics NEPM for assessment of seasonal and/or annual variation.	5.4.2, 10.3	Short



Issue	Recommended Actions	Relevant Section(s) of Report	Priority
Site Environmental Management Plan	A site specific Environmental Management Plan should be prepared to identify site hazards and alert occupants to control measures required to manage site impacts appropriately. The site owner should engage with EPA in the development of a GQRUZ for the site and the provision of information to adjoining affected parties and the Rural Water Corporation (Southern Rural Water).	9.8	Medium



12.0 Report Limitations

This Audit report was prepared for Caltex Australia Petroleum Pty Ltd in accordance with Part IXD of the Environment Protection Act 1970. The Audit report was prepared in response to a request from EPA to Caltex Australia Petroleum Pty Ltd to assess the risks to human health and environment associated with the past and current service station activities at 35-37 Hannon Avenue, Manifold Heights. In reaching their conclusions about the site, Caltex Australia Petroleum Pty Ltd and EPA Victoria may use this Audit report.

The Audit and this report are limited by and rely upon the Audit's scope. The scope of work performed as part of the Audit process may not be appropriate to satisfy the needs of any other person. Any other person's use of, or reliance on, the Audit document and report, or the findings, conclusions, recommendations or any other material presented to them, is at that person's sole risk.

The Audit is based on a review of the condition of the site at the time of assessment, as described in documents provided by Caltex Australia Petroleum Pty Ltd, the assessment reports referenced in the Audit report and site inspections conducted by the Auditor. The Auditor used reasonable care to avoid reliance upon data and information that may be inaccurate. The Auditor's conclusions presented in this report are therefore based on the information made available to him and on his own observations during the Audit.

The Auditor notes that subsurface conditions can vary over short distances. The actual characteristics of sub-surface and surface materials may vary significantly between adjacent sampling locations and intervals.



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Figures

Figure 1: Site Layout and Soil, Groundwater and Soil Vapour Bore Locations

Figure 2: Groundwater Contour Plan (July and November 2009)

Figure 3: Utility Pit Monitoring Locations and Results (July 2009)

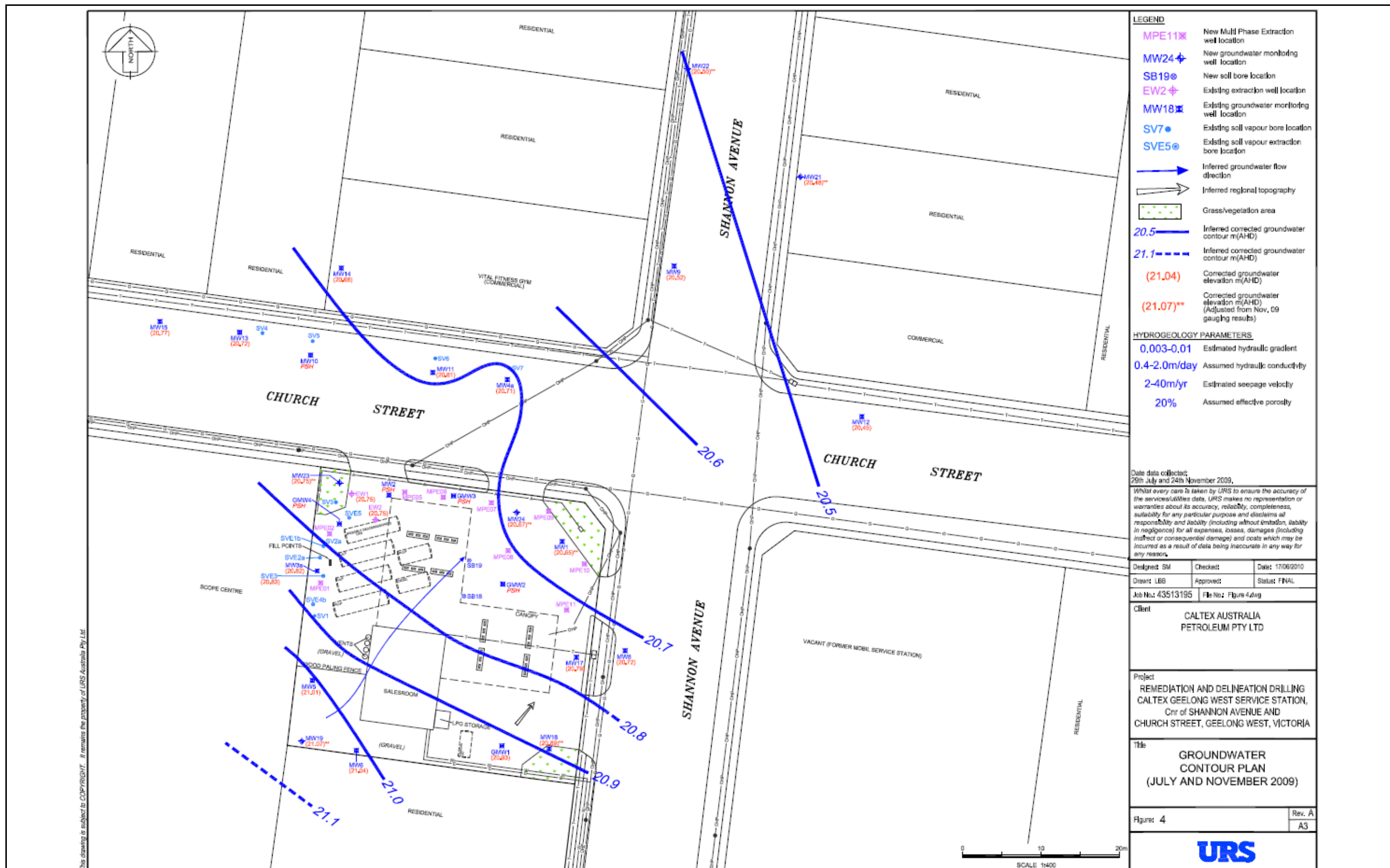


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Figure 1: Site Plan and Soil, Groundwater and Soil Vapour Bore Locations

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Client: Caltex Australia Petroleum Pty Ltd

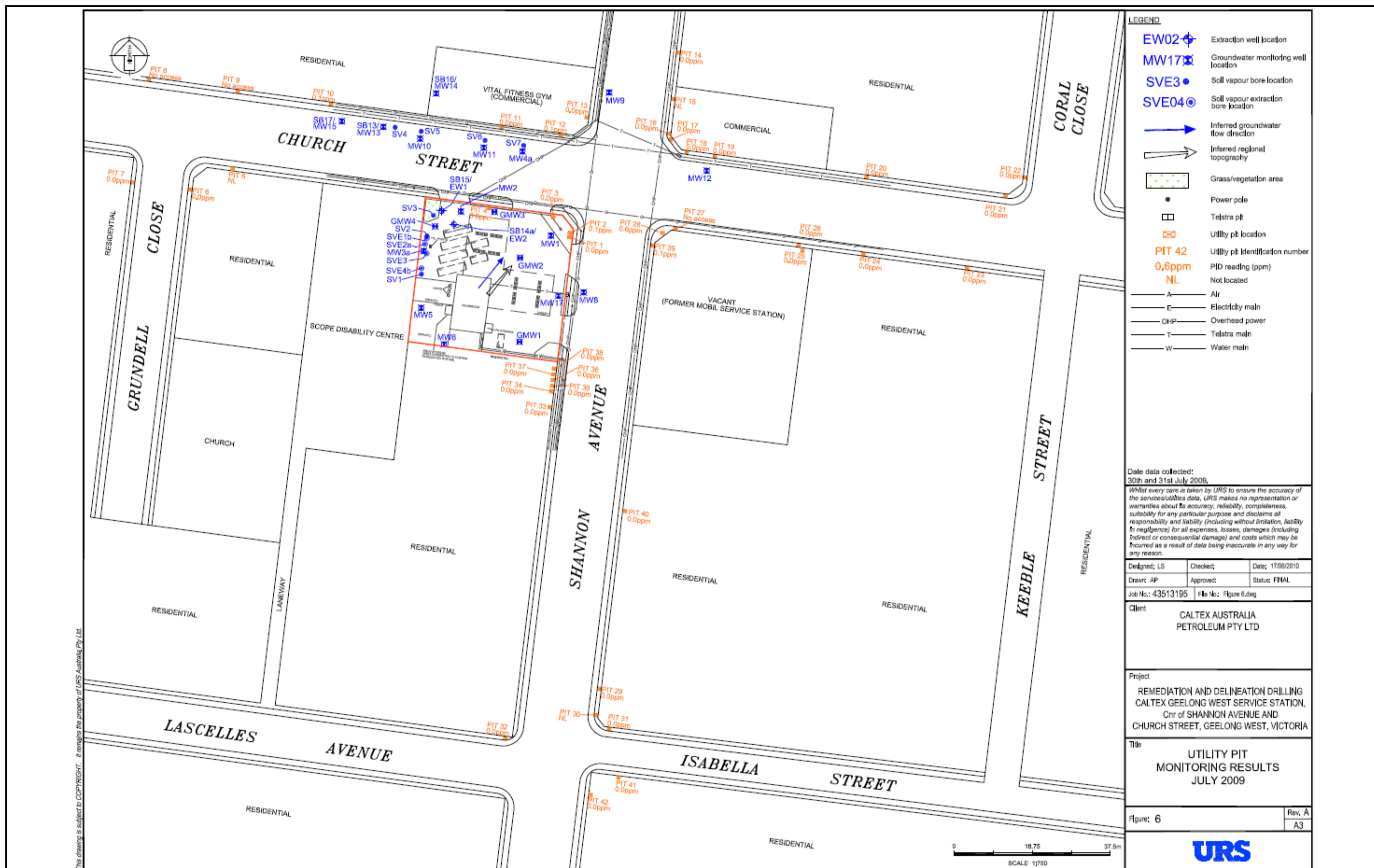


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