ENVIRON

31 March 2005 Ref: 31-0230

Mobil Oil Australia Pty Ltd
Pegasus Centre
PO Box 484
Altona VIC 3018

Attn: Bogusia Smolenski

Dear Bogusia,

Interim Opinion Letter – Quix Service Station, Lansvale

1 INTRODUCTION

As a NSW EPA accredited site auditor, I am conducting an audit relating to the Quix Service Station that is operated by Mobil located at 161 Hume Highway, Lansvale, NSW. This interim opinion letter has been prepared to provide an opinion on the proposed remediation of the site.

It is understood that Mobil has been requested to prepare a Voluntary Remediation Proposal (VRP) for the site for agreement with the NSW Department of Environment and Conservation (DEC). Mobil has prepared a Remediation Action Plan (RAP, URS, 7 July 2003) and a subsequent RAP Addendum (3 March 2005) outlining their remediation proposal. The DEC indicated in their letter to Mobil dated 8 February 2005 that a site auditor should audit the proposal. This letter presents the results of my audit of the proposal and provides an opinion on whether the proposal will meet the objectives of phase separated hydrocarbon (PSH) removal within two years and prevention of off-site migration of dissolved phase contamination.

Consistent with the NSW DEC (formerly Environmental Protection Authority (EPA)) requirements for staged 'signoff' of sites that are the subject of progressive assessment, remediation and validation, I am required to advise that:

- This opinion letter does not constitute a Site Audit Report or Site Audit Statement.
- At the completion of the remediation and validation, I will provide a Site Audit Statement and supporting documentation that will conclude as to the suitability of the site for its intended purposes.

The scope of work for this interim letter comprised a site visit on 15 March 2005 and review of the following:

- Report 'Environmental Site Assessment, Quix Service Station, 161 Hume Highway (Cnr Chadderton Street), Lansvale, NSW (Site No. NJ 3565)'. 9 January 2002 (2002a), by Handex Australia Pty Ltd (Handex);
- Report 'Additional Well Installation and Groundwater Monitoring, Mobil/ Quix Service Station, 161 Hume Highway (Cnr Chadderton Street), Lansvale, NSW (Site No. NJ 3565).' 5 September 2002 (2002b), by Handex;
- Report 'Multi-Phase Extraction Program Summary Report, Mobil Service Station,

161 Hume highway, Lansvale, NSW (Site No. NJ 3565)'. 21 February 2003, by Handex;

- Final Report 'Groundwater Monitoring Event, Mobil Service Station, Site No. NJ 3565, 161 Hume Highway, Lansvale, NSW'. 26 May 2003 (2003a), by URS Australia Pty Ltd (URS);
- Letter to Mobil 'Re: Significant Risk of Harm Assessment of Mobil/ Quix Site, Lansvale'. 30 May 2003, from NSW EPA;
- Letter to NSW EPA 'Re: 161 Hume Highway, Lansvale, NSW'. 30 June 2003, from Mobil;
- Final Report 'Remediation Action Plan, QUIX Service Station, 161 Hume Highway, Lansvale, NSW (NJ 3565)'. 7 July 2003 (2003b), by URS;
- Letter to Mobil 'Re: Declaration of Site As 161 Hume Highway, Lansvale'. 2 December 2003, from NSW EPA;
- Letter Report 'Re: Groundwater Multiphase Extraction and Air Treatment Event (14 & 15 September 2004), Active Mobil Service Station, Corner Hume Hwy & Chadderton Street, Lansvale, NSW'. 19 November 2004, by Handex;
- Final Report 'Post Phase 2 Environmental Site Assessment, Quix Service Station (NJ 3565), 161 Hume Highway, Lansvale, NSW'. 14 January 2005 (2005a), by URS;
- Final Report 'Quantitative Risk Assessment, Quix Service Station, Lansvale (NJ 3565), 161 Liverpool Road, Lansvale'. 28 January 2005 (2005b), by URS;
- Letter to Mobil 'Re: Quix Service Station, Lansvale, NSW'. 8 February 2005, from NSW DEC;
- Letter to EPA 'Re: Remedial Action Plan Addendum, Quix Service Station (Mobil Site No, NJ 3565), 161 Hume Highway, Lansvale, NSW'. 3 March 2005 (2005c), from URS;
- Letter to Mobil 'Re: Lansvale Wellfield Assessment'. 17 March 2005 (2005d), from URS;
- Letter to Mobil 'Re: Response to Auditor Comments'. 24 March 2005 (2005e), from URS; and
- Email to ENVIRON 'Re: Lansvale Questions for URS/ Mobil'. 29 March 2005, from Mobil.

2 SITE DETAILS

2.1 Location

The site details are as follows:

Street address:	161 Hume Highway, Lansvale, NSW 2166
Identifier:	Lot 204 DP 732440
Local Government:	Fairfield City Council
Owner:	Modern Motels Pty Ltd (leased by Mobil since 1986)
Site Area:	approximately 1894 m^2

2.2 Zoning

Handex (2002a) identifies the current zoning of the site to be 4(c) Industrial Special under the Fairfield City Council LEP 1994.

2.3 Adjacent Uses

The surrounding land use is primarily vacant land or commercial/ light industrial premises. Adjacent uses are as follows:

- North – vacant land then light industrial premises (including transport, auto parts, body repairs, mechanic);
- West – vacant land followed by a motel;
- South – Hume Highway then mixed premises (including welders, storage facility, glass manufacture); and
- East – Chadderton Street and Hume Highway intersection followed by mixed premises (including mechanic, car dealer).

There are numerous potential sources of contamination in the site vicinity, with the main ones being the existing auto parts and mechanics facilities across Chadderton Street, and any previous industrial uses in this location. However, this area is believed to be downgradient from the site therefore onsite migration of any contamination would not be expected. There were no obvious offsite sources of contamination immediately adjacent to the site. Handex (2002a) reported three service stations located approximately 200m to the east of the site.

Nearby sensitive receptors include residential properties and a school located approximately 200m and 500m from the site, respectively.

2.4 Site Condition

A site plan is included as Attachment A. The site is occupied by an operational Quix/ Mobil Service Station with the following main features:

- Sales room/ office in the east of the site;
- Four known active USTs in the south west of the site (refer Table 2.1, below);
- Three fuel dispensers with canopy in the central south of the site;
- Diesel dispenser on the western boundary of the site;
- The site is concrete paved with the exception of grass and garden areas primarily on the street frontages (southern and eastern boundaries);
- Concrete pavement was observed to be cracked with some hydrocarbon staining around the fuel dispensers; and
- The site is generally flat, with a very slight slope towards the east/ north east.

Table 2.1 – UST Details

UST	Contents	Capacity (L)
T1	Unleaded petrol (ULP)	45 000
T2	Premium ULP (PULP), leaded petrol (LP) prior to 2001	45 000
T3	Lead replacement petrol (LRP)	45 000
T4	Diesel	25 000

2.5 Proposed Development

No change to the current site usage is currently proposed.

3 SITE HISTORY

The site history was investigated by Handex (2002a), and was based on aerial photographs, staff interviews and Certificates of Title. The Auditor's summary of the site history is provided in Table 3.1.

Table 3.1 – Site History

Date	Activity
Pre 1954	Vacant land according to 1951 air photo, private ownership.
1954	Ownership by Modern Motels Pty Ltd commenced. Site was leased. Land use probably as mechanic and/or small service station. Details of any fuel infrastructure from this time are not known.
1961	One fuel dispenser was observed in the 1961 air photo. The location of this feature is not known.
1986	Lease by Mobil commenced. Current service station layout was probably built at this time (between 1978 and 1986 according to air photos). Refurbishment reportedly occurred in 1986 (URS, 2005a)
Pre 1992	The installation date for the USTs reported in staff interviews was pre 1992, however, it is likely that the current tanks were installed at the time the current layout was developed, in 1986.
2001	Weep in tank check valve from UST T1 to pumps 1 and 2 identified during UST testing (March 2001, MassTech Australia Pty Ltd). Passed testing after repair.
2002	Additional UST testing undertaken by MassTech Australia Pty Ltd.
December 2002	A Dangerous Goods Search by WorkCover has reportedly been undertaken (date 6 December 2002) and did not identify any additional USTs for the site. This was commissioned by Mobil.

The summary indicates that the site has been used as a service station since 1986 and a possible small service station/mechanics most likely since 1954. In the Auditor's opinion, the site history provides an indication of likely past activities, however, there is a significant unknown being details of specific activities and any below ground fuel infrastructure or other contaminant sources previous to the current site usage, between 1954 and 1986.

4 CONTAMINANTS OF CONCERN

Handex (2002a) determined the potential contaminants of concern for the initial site assessment to be as follows:

- Total petroleum hydrocarbons (TPH)
- BTEX compounds – benzene, toluene, ethylbenzene, xylenes
- Heavy metals – arsenic, cadmium, chromium, copper, nickel, lead, zinc, mercury
- Polycyclic aromatic hydrocarbons (PAH)
- Volatile chlorinated hydrocarbons (VCH)
- Phenols
- Organochlorine/ organophosphorous (OC/OP) pesticides

URS (2003a) provided a more detailed assessment of potential sources and associated contamination, as summarised in Table 4.1.

Table 4.1 – Contaminants of Concern

Activity	Potential Contaminant
Storage of all fuels, solvents and waste oils	TPH
Diesel fuel and waste oil storage	Phenols and PAH
ULP, LRP and LP storage	BTEX
LP storage	Lead
Use of solvents	Volatile halogenated compounds (VHC)
Surface fill	Heavy metals (copper, zinc, cadmium, chromium, nickel, arsenic, mercury)

The Auditor considers that the analyte lists used by Handex and URS are appropriate. URS report the possible use of solvents and storage of waste oil associated with a previous workshop, location unknown (URS, 2005e). These activities are not current.

The proposed remediation is aimed at remediation of diesel and leaded petrol impacts to groundwater for which the contaminants of concern are TPH, BTEX and naphthalene. Metals are also included in the validation analytical suite for groundwater (refer Section 10).

5 STRATIGRAPHY AND HYDROGEOLOGY

Investigation of the subsurface at the site has been undertaken in a number of stages, as follows. Attachment A shows the groundwater well locations.

- Handex Environmental Site Assessment (9 January 2002) - 12 boreholes to maximum 6.7 m below ground level (bgl) and six GeoProbe® locations to maximum 4.5 m bgl. 12 wells installed, three offsite on vacant land to west;

- Handex Additional Well Installation (5 September 2002) – two boreholes to maximum 7.2 m bgl with wells installed; and
- URS Post Phase 2 Environmental Site Assessment (14 January 2005) – four onsite boreholes and five offsite boreholes to maximum 10mbgl with wells installed.

Following a review of the reports provided, a summary of the site stratigraphy and hydrogeology was compiled below.

5.1 Stratigraphy

Geological maps indicate the regional geology at the site to be Quaternary sands, clays and silts associated with the Georges River Basin (Penrith Geological Series Sheet 9030, 1:100 000). The stratigraphy of the site is summarised in Table 5.1.

Table 5.1 – Stratigraphy

Depth (m bgl)	Description
0 - 0.1	Grass or concrete (majority of site)
0.1 - 1.4 (generally <1 m)	Fill: varies - sand, topsoil, sandy gravelly clay Bitumen/ concrete fill at LMW9, timber at LMW11 Fill was believed to have been brought onto the site for levelling purposes.
	Alluvial sediments:
0.2 - 7.1	Clay/ Sandy clay: yellow/ brown/ orange/ grey, soft-firm, occasional ironstone fragments
1.2 - >10	Sand/ clayey sand: brown/ grey, fine to medium grained sand, with silt, river gravel at depth (LMW16) Aquifer material (most locations terminate in this layer) Thickness ranges from 1 to 7 m. Aquifer thickness is highly variable in the east end of site (bordering Chadderton Street). 1-1.4m thickness at LMW17 and 18, while LMW19 (over the road) has 7.2 m thickness.
7 - >10 (top of layer)	Clay: yellow/grey, firm, occasional ironstone gravel Lower confining unit of the aquifer (six locations terminate in this material, four onsite)

A continuous layer of clean sand occurs across the site, although the thickness of this layer varies substantially. The thickest area of the sand is in the vicinity of the PSH plume. The sand is underlain by clay at between 7 and 8 m bgl within the site area based on a limited number of locations. The depth of this basal clay layer is not well defined across the site since the majority of wells are terminated at 6 m bgl.

5.2 Hydrogeology

The site is located in a flat area of alluvial sediments. Potential receptors of groundwater migrating from the site include:

- Prospect Creek approximately 500 m to the northeast; and
- Chipping Norton Lake approximately 600 m to the south southeast.

The regional groundwater flow direction is inferred to be to the northeast.

A search of groundwater bores within a 1.5 km radius of the site was undertaken in 2001 (Handex, 2002a). 14 registered groundwater bores were identified – one for waste disposal, four for irrigation and nine for monitoring. The irrigation bores are located within 500 m of the site to the west south west. These bores are not considered to be located in a downgradient position to the site. The depth to water in these bores was between 2 and 5 m bgl.

The most recent groundwater monitoring (July 2004) yielded the following groundwater quality parameters (excluding wells that contained PSH):

Table 5.2 – Groundwater Parameters– July 2004

Parameter	Units	Range	Interpretation
pH		5.48 (LMW19) – 6.83 (LMW22)	Slightly acidic to neutral
Dissolved oxygen	mg/L	0.5 (LMW3) – 3.2 (LMW10)	Poorly oxygenated
Redox potential	mV	66 (LMW3) – 311 (LMW5)	Reducing
Electrical conductivity	mS/cm	0.86 (LMW20) – 12.43 (LMW16)	Fresh to saline
Total dissolved solids	mg/L	576 (LMW20) – 8328 (LMW16)	Fresh to saline

Groundwater is inferred to occur within a continuous unconfined sand or clayey sand aquifer, with a lower confining unit of clay. The aquifer materials are quite heterogeneous (see Table 5.1) and the measured properties (discussed below) indicate the aquifer to be moderately to highly anisotropic. The surface of the groundwater table occurs within the sand layer across most of the site, however, the overlying clay extends deeper in the east of the site. In this area, the deeper occurrence of clay would be expected to be a barrier to PSH migration and may influence the direction of PSH migration, causing a lateral spread of PSH.

Groundwater levels (corrected for PSH occurrence) have remained within a similar range over multiple groundwater monitoring events (GMEs), with an overall range of 3.4-4 m bgl. The measured hydraulic gradient at the site is very low and changes in flow direction have been observed between GMEs. Monitoring in April 2001 (Handex, 2002a) supported a northeasterly flow direction. However, monitoring in September 2002, February 2003 and July 2004 (Handex, 2003; URS 2003b; URS, 2005a) found an element of on-site flow to the south/ southwest in the eastern end of the site. This could be related to the aquifer thickness in this area which is narrow when compared to the remainder of the site. The aquifer permeability in this area was also measured to be low, at around 5 m/year (URS, 2003a). September 2002 monitoring (Handex 2003) also found that recharge appeared to be occurring at LMW2, in the area of the USTs.

Although the groundwater flow direction is not well known, the groundwater gradient does appear to be quite flat, and based on the shape of the PSH plume, the flow direction at the site seems to be consistent with the regional flow direction to the northeast.

Handex (2002a) determined the groundwater seepage velocity to range from 7 to 150 m/year (based on assumptions plus the measured hydraulic gradient). Aquifer permeability testing was subsequently conducted by URS by recovery tests (14 wells, 2003a and 1 repeat well, 2005a) and pumping tests (LMW15 and 18, 2005a). URS determined the following range of aquifer parameters:

Table 5.3 – Aquifer Properties (URS, 2005a)

Property	Units	Pure Sand	High Clay Content in Sand
Permeability (K)	m/year	350 (maximum)	3 (minimum)
Porosity (n) (assumed)	-	0.3 (Maximum)	0.1 (minimum)
Hydraulic gradient (i)	-	0.002 (minimum)	0.009 (maximum)
Velocity (v)	m/year	2.3 (maximum)	0.4 (minimum)

A wide range of permeability was determined from across the site, ranging from 3 m/year (LMW4) to 350 m/year (LMW12). The average seepage velocity was calculated by URS as 0.7 m/year (2003a). Assuming a fingerprinted age of the petrol plume of around 10 years (refer Table 9.3), a seepage velocity of around 2 m/year seems consistent with the extent of plume migration that has occurred (around 20 m). The calculated maximum seepage velocity of 2.3 m/year therefore appears reasonable in the plume area which is dominated by pure sand.

Stormwater from the site would be collected via onsite drains. The site is very flat, with no obvious offsite stormwater flow pathways. It is unlikely that belowground stormwater lines would be a possible groundwater flow path since the groundwater depth at the site is greater than 3 m bgl and stormwater lines usually occur within 1mbgl.

6 EVALUATION OF QUALITY ASSURANCE AND QUALITY CONTROL

The Auditor has assessed the overall quality of the data by review of the information presented in the referenced reports. In this review, the Auditor has focussed on issues relating to assessment of the proposed remediation such as the quality of groundwater data for the contaminants of concern.

The Auditor's assessment follows in Tables 6.1 and 6.2.

Table 6.1 – QA/QC – Sampling and Analysis Methodology Assessment

Sampling and Analysis Plan and Sampling Methodology	Auditor Comments
Sampling Pattern and Locations	Investigation locations were spaced to gain coverage of the site with a particular focus on the UST area and defining the bounds of the groundwater plume. Additional unknown source areas have not been targeted, however, in the Auditor's opinion the coverage of the investigation locations is adequate to gauge the approximate extent of the groundwater plume.

Sampling and Analysis Plan and Sampling Methodology	Auditor Comments
Sampling Density	The combined sampling density from the Handex and URS investigations (21 locations onsite, 8 locations offsite) exceeds the minimum recommended by EPA (1995) "*Sampling Design Guidelines*" for a 0.2 ha site which is only seven locations. It is noted that there have been four rounds of monitoring for the majority of groundwater wells (LMW1-14), however only one round of monitoring for wells LMW15 to LMW23. Given the detected variation between monitoring rounds (refer Section 9), it is likely that there is undetected variation in groundwater concentrations for wells LMW15 to 23.
Sample depths	Soil samples were collected and analysed from a range of depths, with a focus on impacted soils in the vicinity of the groundwater table. Groundwater wells were installed from between 6 and 10 m bgl and all intersected the unconfined aquifer present onsite. Shallow fill samples were analysed for the full suite of analytes (including heavy metals, pesticides and VCH/ VHC), while soils from within the contaminant plume were analysed for hydrocarbon contaminants only. In the Auditor's opinion, the sampling strategy was appropriate and adequate to characterise the primary material types present onsite.
Sample Collection Method	**Soil:** Collection of soil samples was via a split spoon sampler (Handex and URS) or GeoProbe® sampler tube (Handex ,2002a). The method for duplicate soil sample collection was not stated. **Groundwater:** Wells were installed by hollow flight augers, developed with a bailer or tubing with footvalve (URS only), and samples were collected by disposable or dedicated Teflon bailers with VOC sampling attachments (URS only reported this).
Well construction	Wells were installed to between 6 and 10mbgl. Only six of the wells (four onsite, two offsite) were extended into the clay that underlies the sand aquifer at the site. Remaining wells were terminated within the aquifer. The top of the screened interval was between 1.5 and 3 m bgl, and therefore the screens of all wells should extend above the groundwater table which occurs at >3 m bgl. Wells were constructed of 50 mm diameter Class 18 uPVC threaded screen and casing, with a sand filter pack sealed with bentonite. Three of the original Handex wells (LMW1, 2 and 3) may have been installed within a GeoProbe® location. A borehole diameter of 57 mm was recorded on these logs but it appears likely this is an error since the well diameter is 50 mm. Remaining wells LMW4 to LMW14 were reportedly installed in 100 mm diameter boreholes, and LMW15 to 23 were installed in 150 mm diameter boreholes.

Sampling and Analysis Plan and Sampling Methodology	**Auditor Comments**
Decontamination Procedures	**Soil**: Soil sampling equipment (trowel and sampler) was cleaned with detergent and rinsed with tap water between sampling events to prevent cross contamination. URS reported high pressure wash of augers between borehole locations, however, decontamination of augers between locations was not explicitly reported by Handex. **Groundwater**: Handex report that all sampling equipment was cleaned with detergent and rinsed with tap water between sampling events. Specific details relating to groundwater equipment were not provided. Dedicated single use or disposable sampling equipment was used by URS during the groundwater sampling therefore decontamination was not required. The oil/water interface probe was reported by URS as being washed with detergent and rinsed with water.
Sample handling and containers	All samples were placed into appropriately prepared and preserved sampling bottles provided by the laboratory and chilled during storage and subsequent transport to the labs. Groundwater samples to be analysed for heavy metals were field filtered.
Chain of Custody	Completed chain of custody forms were provided in the URS and Handex reports.
Detailed description of field screening protocols including calibration	Both Handex and URS undertook field screening for volatiles in soil using a PID and report these on the borelogs, however, details of the methods of measurement are not provided. URS reported that calibration was undertaken but no calibration records are included in the report. Handex did not discuss calibration of the PID.
Sampling Logs	Soil logs are provided within the report, indicating sample depth, PID readings and lithology. As noted above, there is believed to be an error on the Handex (2002a) logs for wells LMW1, 2 and 3 which note a 57 mm borehole diameter. This is more likely to be 100mm. Groundwater field sampling records were provided.

Table 6.2 – QA/QC – Field and Lab Quality Assurance and Quality Control

Field and Lab QA/QC	Auditor Comments
Field quality control samples and results	Field quality control samples including soil and groundwater duplicate and triplicate samples, groundwater equipment rinse samples, trip blanks and field blanks were generally undertaken at appropriate frequencies in accordance with the Mobil specifications. The first Handex investigation (2002a) did not include trip blank or field blank samples. Equipment rinsate samples were free from detections with the exception of the detection of total phenolics by URS (2003a). The reported PQL was raised for this batch of groundwater samples. All trip blanks and field blanks were free from detections. Not all duplicate sample RPDs were reported by URS (2003a). Duplicate sample results (intra-laboratory) were acceptable. Some discrepancies were found between triplicate sample results (inter-laboratory) for three of the groundwater sampling rounds (Handex, 2002a & 2002b, URS 2003a). RPDs were found to be outside the acceptable range for TPH, BTEX and PAH. Triplicate results were not consistently higher or lower. Some results were close to the detection limit. It seems likely that these differences are due to the nature of organic compound concentrations to vary and different sample handling or preparation techniques employed by the different laboratories. The noted discrepancies do not change the findings for each investigation. Overall, the above findings are not considered likely to affect the data usability for this investigation.
NATA registered laboratory and NATA endorsed methods	Laboratories used were: **Handex:** Amdel, AGAL, AEL **URS:** ALS, Amdel, Leeder Consulting. Laboratory certificates were NATA stamped with the exception of the Leeder Consulting report.
Analytical methods and holding times	Holding times were reported by the Consultants as having been met. The Auditor has not conducted a review of all COCs and laboratory certificates to confirm this.
Practical Quantitation Limits (PQLs)	PQLs were below the threshold criteria for the primary contaminants of concern in groundwater – TPH and BTEX. PQLs were above the threshold concentration for two PAHs - anthracene and benzo(a)pyrene – in URS (2003a) however the PQL for naphthalene (the primary PAH of concern) was below the threshold criteria.
Laboratory quality control samples and results	Laboratory quality control samples including duplicates, surrogates, method blanks, matrix spikes and matrix spike duplicates were undertaken by the laboratories generally at appropriate frequencies and in accordance with the Mobil specifications. The first URS investigation (2003a) did not include matrix spike or matrix spike duplicate analyses for all analytes. The results from laboratory quality control samples were generally acceptable. It is noted that some samples had slightly high

Field and Lab QA/QC	Auditor Comments
	recovery of TPH in URS (2005a) however this indicates the reported results are conservative. The findings are not considered likely to affect the data usability for this investigation.
Data Quality Objectives (DQOs) and Data Evaluation (completeness, comparability, representativeness, precision, accuracy)	Handex did not specifically address DQOs, however, an assessment of QA/QC was performed. Handex concluded (2002a and b) "It is concluded that the overall data quality for this investigation is acceptable." URS did not specifically address DQOs, however, a field method validation and analytical data validation were performed. URS concluded (2003a and 2005a) "On the basis o the analytical data validation procedure employed, the overall quality of the analytical data produced is considered to be of an acceptable standard for interpretative use." Specific issues were then identified as appropriate.

In considering the data as a whole, including the consistency of data between groundwater sampling rounds, the Auditor concludes that the data is likely to be reliable and useable for the purpose of this audit. The primary concern with regards to QA/QC is the adequacy of investigation coverage in identifying historical contaminant sources, including the source of diesel impact in the east of the site.

7 ENVIRONMENTAL QUALITY CRITERIA

The Auditor has assessed the soil data in reference to Soil Investigation Levels for Urban Redevelopment Sites in NSW (SIL Column 4 – 'commercial/industrial') in EPA (1998) "*Guidelines for the NSW Site Auditor Scheme*".

EPA (1994) "*Guidelines for Assessing Service Station Sites*" have also been referred to for assessing soil TPH and BTEX results. These guidelines relate to sensitive land uses and are therefore conservative when applied to the risk to human health at the site.

The Auditor has assessed the groundwater data in reference to ANZECC (2000) "*Australian and New Zealand Guidelines for Fresh and Marine Water Quality*" for fresh waters. Trigger values (TVs) provided are concentrations that, if exceeded, indicate a potential environmental problem and "trigger" further investigation. However, a trigger level for total PAHs within groundwater is not provided within the ANZECC (2000) guidelines. As such, the threshold level for protection of aquatic ecosystems of 3µg/L from the EPA (1994) "*Guidelines for Assessing Service Station Sites*" has been adopted.

The current DEC position with respect to PSH is that there should be no PSH in groundwater.

8 EVALUATION OF SOIL ANALYTICAL RESULTS

Soil samples collected during the course of the investigations were analysed for a variety of contaminants including TPH, BTEX, heavy metals, PAHs, Phenols, VHC/VCH and pesticides.

Soils from both on and offsite were assessed by Handex (2002a and b, onsite only) and URS (2005a, on and offsite). The results have been assessed against the criteria listed in Section 7, and are summarised in Table 8.1, below.

Table 8.1 - Evaluation of Soil Analytical Results – Summary Table (mg/kg).

Analyte		n	Detections	Maximum	n > EPA (1994)	n > SIL Column 4 (EPA 1998)
TPH	C6-C9	66	16	6500	**9**	-
	C10-C14	65	14	1900	-	-
	C15-C28	65	2	120	-	-
	C29-C36	65	0	<50	-	-
	Total C10-C36	65	13	2020	**4**	-
BTEX	Benzene	65	11	63	**10**	-
	Toluene	65	10	570	**10**	-
	Ethyl benzene	65	11	240	**9**	-
	Xylenes	65	11	1490	**10**	-
TOC	Total organic carbon	3	0	<0.2	-	-
Metals	Lead	67	54	46	-	0
	Arsenic	9	5	8	-	0
	Barium	6	6	253	-	-
	Cadmium	8	0	<5	-	0
	Total Chromium	9	7	40	-	0
	Copper	9	7	37	-	0
	Mercury (inorganic)	9	0	<0.1	-	0
	Nickel	9	6	38	-	0
	Vanadium	6	6	70	-	-
	Zinc	9	8	104	-	0
PAH	Naphthalene	13	3	30.8	-	-
	Phenanthrene	13	1	0.9	-	-
	Total PAH	13	3	31.7	-	0
Phenols	Phenol	10	1	0.8	-	-

Analyte		n	Detections	Maximum	n > EPA (1994)	n > SIL Column 4 (EPA 1998)
	p-cresol	10	1	0.7	-	-
	Total phenolics	13	2	1.5	-	0
VCH	(Handex)	3	0	<0.1	-	-
VHC	(URS)	7	0	<PQLs	-	-
Pesticides	OCP	3	0	<0.1	-	0
	OPP	3	0	<0.5	-	0

n number of samples
PQL laboratory practical quantification limit
- No criteria available/used

The key findings from the soil analytical assessment are as follows:

- 10 sample exceedences for TPH C6-C9/ BTEX came from eight locations surrounding the UST/ fuel dispensers, within the groundwater plume area. The exceedences were in samples from between 3.2 and 6 m bgl and were associated with the groundwater table.
- Most of the samples had a non-contaminated sample from above, and two of the samples had a non-contaminated sample from below (there were no deeper samples for most locations). These samples act to vertically delineate the soil impact to within the upper section of the groundwater table.
- No significant source of diesel in soil was identified by the investigations, however, the soil samples analysed from LMW13 (where diesel impact is present in groundwater, refer Section 9) were from 1 and 6mbgl, with none analysed from near the surface of the groundwater table. Ethylbenzene and xylenes were detected at concentrations exceeding the respective guidelines in a triplicate of the 1m sample, and there were no hydrocarbon detections in the 6m sample.
- There were no other significant petroleum hydrocarbon soil detections from the outlying areas of the plume.
- Analysis of 10 shallow fill samples did not indicate any contamination by petroleum hydrocarbons, heavy metals, PAH, solvents or pesticides.

One round of PID measurements of utility and drainage pits immediately surrounding the site was undertaken in June 2001 by Handex (2002a). No odours were detected during this exercise and there were negligible PID detections. These results further indicate that the subsurface impact is generally restricted to at or below the groundwater table at a depth of over 3mbgl.

In the Auditor's opinion, the soil analytical results are consistent with the site history and field observations. There is some uncertainty regarding the mechanism for diesel impact to groundwater at LMW13 (refer Section 9) and it is likely that there is an unidentified area of diesel impact to soil in the east of the site.

9 EVALUATION OF GROUNDWATER ANALYTICAL RESULTS

Groundwater samples have been collected from 15 onsite wells and eight offsite wells during the course of the investigations. Remediation events and permeability testing have also been conducted at the wells. The well locations are shown on Attachment A.

A timeline of events with respect to groundwater assessment and remediation works at the site is summarised in Table 9.1, below.

Table 9.1 – Timeline of Groundwater Assessment/ Remediation Works

Date	Activity	Details	Consultant	Report
April 2001	GME	3 wells sampled (LMW1-3)	Handex	2002a
July 2001	GME	9 wells sampled (LMW4-12)	Handex	2002a
January 2002	GME	2 wells sampled (LMW13-14)	Handex	2002b
February 2002	Gauging round	2 wells gauged (LWMW1-2)	Handex	2002b
February 2002	ORC socks installed	Refer Table 10.1	Handex	2002b
May 2002	Gauging round	14 wells gauged (LWMW1-14)	Handex	2002b
July 2002	MPE remediation events	Refer Table 10.1	Handex	2003
September 2002	GME	14 wells sampled (LMW1-12)	Handex	2003
February 2003	GME plus recovery tests at all wells	14 wells sampled. PSH fingerprinting for two wells (LMW1 & 4 - LMW2 PSH appeared the same as LMW1)	URS	2003a
February 2003	PSH Baildown tests	LMW1, 2 and 4	URS	2003a
February 2004	MPE remediation event	Refer Table 10.1	Handex	None supplied
July 2004	GME	21 wells sampled (LMW1-6, 8, 10-23)	URS	2005a
September 2004 (1st, 2nd)	GME, recovery test and pumping tests	2 wells sampled (LMW7, 9) LMW13 recovery test LMW15 & 18 pumping tests, samples taken at 0.5,1.5 and 3hrs	URS	2005a
September 2004 (14th, 15th)	MPEAT events	Refer Table 10.1	Handex	2004

GME Groundwater Monitoring Event
ORC Oxygen Reducing Compound
MPE Multiphase Extraction
MPEAT Multiphase Extraction and Air Treatment

Over the course of the investigations, groundwater samples have been analysed for a variety of contaminants including TPH, fingerprint analysis of PSH, BTEX, heavy metals, PAHs, Phenols, VHC/VCH and natural attenuation indicators. Wells that contained PSH were not analysed for dissolved phase concentrations. The results from the most recent complete GME (July 2004) are summarised in Table 9.2, below.

Table 9.2 – Evaluation of Groundwater Analytical Results – July 2004 - Summary Table (μg/L).

Analyte		n	Detections	Maximum	Well # (LMW)	n > Criteria (refer S7)	Well #'s (LMW)
PSH	Phase separated hydrocarbon	6	6	0.54m	15	**6**	1 2 4 6 9 15
TPH	C6-C9	17	1	6370	3	-	-
	C10-C14	17	4	8650	13	-	-
	C15-C28	17	3	1060	13	-	-
	C29-C36	17	0	<50	-	-	-
	Total C10-C36	17	4	9710	13	-	-
BTEX	Benzene	17	3	3040	3	**1**	3
	Toluene	17	1	9	3	**0**	-
	Ethyl benzene	17	1	5	3	0	-
	Xylenes	17	1	53	3	0	-
Metals (mg/L)	Lead	17	0	<0.001	-	0	-
	Arsenic	12	5	0.005	11	0	-
	Barium	12	12	0.11	12	-	-
	Cadmium	12	5	0.0005	16 (FT)	**1**	16 (FT)
	Total Chromium	12	0	<0.001	-	0	-
	Copper	12	10	0.003	12	**7**	7 12 16 18 21 22 23
	Mercury (inorganic)	12	3	0.003	10	**2**	10 11
	Nickel	12	11	0.005	20	0	-
	Vanadium	12	1	0.01	22	-	-
	Zinc	12	12	0.019	13	**11**	7 10 12 13 16 18 19 20 21 22 23
PAH	Naphthalene	17	3	19.5	3	**1**	3
	Acenaphthene	17	3	8.3	3	-	-
	Total PAH	17	4	45.9	3	**2**	3 13

Analyte		n	Detections	Maximum	Well # (LMW)	n > Criteria (refer S7)	Well #'s (LMW)
Phenols	2,4-dimethyl phenol	17	2	5.2	3	-	-
	Phenol	17	1	2.6	3	0	-
VHC	(URS)	12	0	<PQLs	-	0	-
Natural Attenuation Indicators (mg/L)	Sulphate	12	12	489	14	-	-
	Iron (II)	9	1	28.1	13	-	-
	Iron (III)	9	2	0.3	7	-	-
	Total organic carbon	12	11	27	3	-	-
	Nitrate as N	12	12	33.8	18	**10**	3 5 7 13 14 17 18 19 22 23
	Methane	12	3	109	3	**3**	3 13 22

n number of samples
\- No criteria available/used
PQL Practical Quantitative Limits
FT Field triplicate sample

As shown in Table 9.2, PSH was detected in six wells from the latest round of monitoring (July 2004). A summary of the occurrence of PSH in all wells over the course of the project is provided in Table 9.3.

Table 9.3 – Details of PSH Occurrence

Well #	First Detection	Detected Thickness Range (m)	Date of Maximum	Notes
LMW1	April 2001	0.01-0.474	May 2002	Fingerprinted as degraded leaded petrol between 2 and 8 years old in February 2003. Actual thickness estimated to be minimal (occurs in the capillary fringe above the aquifer) from baildown test in February 2003.
LMW2	April 2001	0.04-0.57	February 2003	Fingerprinted as degraded leaded petrol between 2 and 8 years old in February 2003. Actual thickness estimated to be 0.05m from baildown test in February 2003. MPE caused increase July 2002.
LMW3	February 2004	0.001-0.003	February 2004	Only recorded as PSH for MPE event in February 2004, reported as a sheen in other rounds
LMW4	February 2003	0.12-0.33	February 2004	Fingerprinted as degraded leaded petrol between 2 and 8 years old in February 2003. Actual thickness estimated to be minimal

Well #	First Detection	Detected Thickness Range (m)	Date of Maximum	Notes
				(occurs in the capillary fringe above the aquifer) from baildown test in February 2003.
LMW6	February 2004	0.355-0.39	July 2004	MPE caused increase, February 2004
LMW9	February 2004	0.2-0.421	February 2004	Max after MPE, 0.322m before MPE (MPE caused increase, February 2004)
LMW15	February 2004	0.54-0.67	September 2004	Recently installed well close to centre of PSH plume.

Considering the above findings, and the results from multiple rounds of groundwater monitoring, there are two distinct groundwater impacts onsite, as follows, which are discussed further below.

1. A plume of petrol impact with a central area of PSH, and dissolved phase contamination covering around one third of the site area. This extends to the south and east from the UST area and is believed to comprise degraded leaded petrol (LP) from an historical leak. The likely source is either UST 2 which contained LP prior to 2001 or UST 3 which currently contains lead replacement petrol. URS report the source to be UST 3 (URS, 2003a).
2. A diesel impact in LMW13 with an unknown source. The source may be from historical usage onsite, or else an offsite source. No PSH has been detected in this location.

Heavy metals exceedences do not correlate with the above hydrocarbon impacts and are likely to be representative of background concentrations within the alluvial aquifer or else localised unrelated impacts. No sources of heavy metal contamination were identified by the soil analytical assessment.

Petrol plume

The petrol plume is characterised by PSH and elevated dissolved phase concentrations of TPH C6-C9, BTEX and naphthalene.

The current inferred plume extent is shown on Attachment A.

Prior to February 2004, PSH was only observed in three wells (LMW1, 2 and 4). By February 2004 this has increased to six wells. An MPE remediation event occurred in February 2004, but according to reports, PSH was present prior to commencement of the event. The gauging prior to this detection was February 2003, therefore, the distribution of PSH increased from three wells to six wells between February 2003 and February 2004. One of the three additional wells was a newly installed well close to the USTs (LMW15), but the other two (LMW6 and 9) were existing wells that had previous dissolved concentrations, but no PSH. The dissolved concentrations in LMW9 were high, but the LMW6 concentrations were not very high, indicating that the biggest unexpected change has been the presence of PSH at LMW6. Extraction from LMW6 has only occurred once, by MPE on 29 July 2002.

PSH thicknesses and the concentration of dissolved phase contamination within the plume area have varied substantially over time. The occurrence of extraction events and ORC remediation treatments may be the cause for some of this variation, or else normal plume dynamics.

The PSH response in three wells has been to increase in thickness following MPE – LMW2 in July 2002, and LMW6 and LMW9 in February 2004. The dissolved phase concentration response to pumping tests in LMW15 and 18 was a substantial drop in concentration between 0.5 and 1.5hrs, followed by no or a small drop between 1.5 and 3hrs.

Only one other well currently displays a significant petrol impact, being LMW3 with 6370µg/L TPH C6-C9 in July 2004. The dissolved phase concentrations in this well have remained relatively stable since April 2001. A further two wells (LMW7 and 8) currently have very low concentrations (3µg/L or less benzene), but concentrations in these wells have been higher in previous rounds. No offsite wells currently display any impact by petrol. There are five downgradient offsite wells covering south through to northeast, between 10 to 20 m from the site boundary.

Given the presence of PSH at LMW9 and the high dissolved phase concentration in LMW3, both near the southern site boundary, it is likely that some offsite migration has occurred underneath the Hume Highway. However, sufficient migration has not occurred to reach the other site of the road at a distance of around 20m.

The three upgradient offsite wells located on the vacant land (LMW10, 11 and 12) had no organic detections during the July 2004 sampling. These wells previously contained low concentrations of TPH C10-C14, with the concentrations increasing slightly from July 2001 to February 2003 before the latest non-detect round in July 2004.

The extent of the PSH plume is considered to be relatively well defined.

The PSH in the centre of this plume was determined to be degraded leaded petrol between 2 and 8 years old by fingerprint analysis in February 2003 (URS, 2003a). Earlier chromatograms suggested petrol with possibly also diesel fuel present (Handex, 2002a).

Diesel impact

The diesel impact is characterised by elevated dissolved phase concentrations of TPH C10-C28 and naphthalene.

The maximum dissolved phase concentration in LMW13 was around 65000µg/L TPH C10-C28 in February 2003. The current levels are lower than this, around 1000µg/L TPH C10-C28 in July 2004.

There is some evidence of similar impact surrounding this location, but not to the same extent as LMW13.

- TPH C10-C14 was detected in LMW14 (to the southeast) at 61µg/L in July 2004. Benzene and toluene were detected in this well in February 2003.
- TPH C15-C28 was detected in LMW18 (to the northwest) at 910µg/L at the start of the pump test in September 2004.
- TPH C10-C28 was detected in offsite well LMW23 (approximately 40m south of LMW13, over the Hume Highway) at around 200µg/L in July 2004.

Offsite wells are located to the east of LMW13 (no hydrocarbons detected) however there are no offsite wells located to the north east of LMW13 indicating that undetected offsite migration may be occurring in this area.

The source of this impact is not known and the extent of impact is not well defined. URS (2005e) report the source is probably in the vicinity of the current salesroom. LMW13 experienced one of the lowest recovery rates for all wells onsite, with the recovery being too low for conducting a pumping test such as was conducted at nearby well LMW18. The different aquifer properties at LMW13 may be a reason for the detection of diesel in this location but no obvious impact to surrounding locations.

Natural attenuation

No field measurements or laboratory analysis for natural attenuation indicators were performed for wells impacted by PSH. Other wells within and outside the plume area were assessed, however, with the following results:

- Dissolved oxygen results indicate that aerobic degradation is unlikely to be occurring in wells LMW3, 8 and 11 (<1mg/L);
- Anaerobic degradation could occur using sulphate in all tested locations;
- Nitrate appears to have been used up in anaerobic degradation in LMW3 but is still available in the other tested locations; and
- Methanogenic degradation appears to have occurred in LMW3 and 13.

The overall conclusion regarding natural attenuation is that the conditions onsite are not adequate for remediation of the plume to occur solely by this method.

10 EVALUATION OF REMEDIATION

10.1 Remediation Already Undertaken

A number of remediation events have already been carried out at the site, as summarised in Table 10.1, below. All events were carried out by Handex and were reported on as listed in Table 9.1.

Table 10.1 – Remediation Undertaken to Date

Event	Date	Locations	Dur'n (hrs)	Liquid Volume Removed (L)	Equivalent Vapour Volume Removed (L)	Notes
ORC	7 Feb 2002	LMW3, 4, 6, 7 and 9	Unkn.	NA	NA	Removal date unknown
MPE	26July 2002	LMW1, 2, 3, 4, 9, 11	9	17500	NR	
	29July 2002	LMW1, 2, 3, 4, 6, 7	10	16700	NR	
MPE	27 Feb 2004 #	LMW1, 2, 4, 15	8.45	6960	35.39	5-18m groundwater ROI 12-18m vacuum ROI

Event	Date	Locations	Dur'n (hrs)	Liquid Volume Removed (L)	Equivalent Vapour Volume Removed (L)	Notes
MPEAT	14, 15 Sept 2004	LMW1, 2, 4, 15	7-8	12400	59.75	5-13m groundwater ROI 5-12 vacuum ROI

NA Not Applicable
NR Not reported
ORC Oxygen Releasing Compound socks
MPE Multiphase Extraction
MPEAT Multiphase Extraction and Air Treatment
ROI Radius of Influence
Information sourced from URS (2005a), no Handex Report was provided for this event

The usefulness of the above remediation activities has been evaluated by the DEC (see below). It is possible that the above activities may have confused the measured groundwater flow directions and concentration trends.

10.2 DEC Requirements for Voluntary Remediation Proposal

In their letter of 8 February 2005, the DEC requested Mobil to submit a Voluntary Remediation Proposal (VRP). Key elements of this letter are as follows:

- *The multiphase extraction events conducted on the site have removed some source contamination, but have not been successful in removing the bulk of the PSH that is present.*
- *An active remediation system is required.*
- *The remedial action must remove the PSH within 2 years and prevent offsite migration of dissolved phase contamination.*
- *The prevention of offsite migration may be through containment or treatment.*
- *This proposal ... must include a detailed program of works to be performed and a schedule of measurable performance targets.*
- *The proposal must be audited by an EPA accredited site auditor.*
- *..please ensure that your voluntary proposal and subsequent reports address the issues of source identification and management, improved estimation of groundwater gradients and flow direction, and more timely delivery of reports.*

The DEC requires the objectives of the remediation to be *PSH removal within two years and prevention of offsite migration of dissolved phase groundwater contamination.*

10.3 Remediation Strategy and Methodology

The proposed remediation works are described in the Remediation Action Plan (RAP) dated 7 July 2003 and RAP Addendum dated 3 March 2005, both prepared by URS. The original RAP was prepared in response to a letter from the EPA (now DEC) regarding Significant Risk of Harm in May 2003, while the Addendum was prepared in response to the DEC's additional letter in February 2005 regarding the need for a VRP. Further information has been provided by URS (2005e) in response to questions from the Auditor while preparing this letter.

The proposed remediation system is as follows:

- Primary source control via testing of fuel infrastructure and excavation of soil (if required), this was included in the 2003 RAP but not repeated in the 2005 RAP Addendum, therefore, it is unclear if this is still planned
- Total fluids pumping and treatment system to address PSH and dissolved phase hydrocarbons
- Capacity for extraction from eight existing wells is proposed (LMW1, 2, 3, 4, 5, 9, 15 and 16), pumping from LMW16 will only occur if impact to this well occurs in the future
- Pumping system will provide hydraulic control of the plume (to be proven by numerical modeling)
- Effluent treatment method will be determined based on initial concentrations (air stripper plus liquid and vapour phase GAC or just liquid phase GAC), monitoring proposed prior to installation and commissioning to determine mass per unit time of contaminants requiring treatment
- Disposal of treated effluent to stormwater or sewer under consent from Sydney Water Corporation
- Delivery of oxygen via insitu Submerged Oxygen Curtain (iSOC) system or Oxygen Release Compounds (ORC) in eight wells in the east and northeast edges of the site (LMW13, 14, 17 and new wells PW1, 2, 3, 4 and 5)
- Groundwater sampling will be undertaken following removal of PSH to determine if continued extraction and treatment is required to address remaining dissolved phase hydrocarbons
- Possible application of the iSOC/ ORC system to the central plume area to aid the remediation of dissolved and adsorbed phase impacts once the PSH has been removed (if required)

10.4 Evaluation of Remedial Action Plan

The Auditor has assessed the RAP and RAP Addendum by comparison with the checklist included in "Guidelines for Consultants Reporting on Contaminated Sites". The RAP was found to address the required information for most items, as detailed in Table 10.2, below. Of the items not addressed adequately, the ones considered significant and warranting addressing are:

- The remediation goals/ end points for dissolved phase groundwater and TPH/ BTEX in soil are not defined. These were to be determined based on risk assessment and the EPA's advice regarding significant risk of harm. This has been deferred to after PSH removal.
- Further work is required in developing a detailed operational and validation monitoring program for groundwater and vapour.
- The RAP documents do not include details of a site management plan or

contingency plans for environmental incidents. It is stated that these documents are planned to be developed (Environmental Management Plan and Operation and Maintenance Manual).

- The RAP schedule covers the period of design through to commissioning. The operational period is not discussed. There is no discussion of the likely timeframe of operation of the remediation system required in order to remove the PSH plume.
- The required licences and approvals are not clearly defined.
- Details of any proposed progress reporting are not provided.
- The need for long term site management following PSH removal is not discussed and may be required depending on the groundwater quality following PSH removal.

Table 10.2 - Evaluation of Remedial Action Plan.

Remedial Action Plan	Comments
Contaminants of concern	Based on the results of all investigations, URS (2005a) determined the contaminants of potential concern for the site to be as follows: ▪ TPH fractions (C6-C36) ▪ BTEX ▪ PAHs ▪ Metals including copper, zinc and mercury The 2003 RAP excludes the metals from this list since the concentrations are considered representative of background conditions. The Auditor considers that the above list is appropriate and that the listed heavy metals should be retained since the upgradient "background" wells LMW10 to 12 have previously displayed impact by hydrocarbons that are likely to have been site derived (July 2001, November 2002, February 2003). It is noted that the TPH fractions are limited to C6-C28, not C6-C36.
Remediation objective	The objective of the remediation plan is to remove PSH in groundwater and mitigate the potential off-site migration of dissolved phase groundwater contamination through hydraulic control of the dissolved phase plume (2005 RAP Addendum). In the Auditor's opinion, this objective is considered appropriate, however, it is noted that it does not include the two year time frame specified by the DEC for removal of PSH.
Remedial Goal	Potential remediation goals with respect to source control, transport control and exposure control are discussed in the 2003 RAP. The following goals were selected: ▪ Remove all primary sources of potential impact (leaking USTs, fuel lines, dispensers and interceptors) ▪ Remove PSH ▪ Remediate subsurface impacted soil to a standard suitable for ongoing commercial/ industrial land use

Remedial Action Plan	Comments
	▪ Remediate dissolved phase groundwater impact to low risk levels ▪ Implement a groundwater monitoring program to monitor remediation activities ▪ Demonstrate residual impacts are acceptable
Remediation 'end points'	Remediation 'end points' were proposed in the 2003 RAP as follows: ▪ NEPM HIL Level F (commercial/ industrial) for soil for PAH ▪ Risk based assessment of fate and transport if ANZECC 2000 Trigger Values and EPA 1994 Service Station Threshold Concentrations are not met ▪ Risk based assessment for contaminants with no guidelines The 2005 RAP Addendum.does not provide anything further regarding specific remediation 'end points'. However, based on the 2005 RAP Addendum objectives, it appears that the need for remediation of dissolved phase contamination and adsorbed (soil) contamination is planned to be reviewed following PSH removal.
Discussion of the extent of remediation required	Remediation is required for the petrol plume and dissolved phase diesel impact. Impacted soil is associated with the hydrocarbon contamination in groundwater. Details of the extent of impacts are provided in the 2003 RAP however it is noted that this is not well known for the diesel impact.
Remedial Options	The 2003 RAP includes a detailed discussion, a Remediation Technology Review Matrix and Net Present Value analysis that address numerous applicable remediation methods. Unsaturated zone: *Soil vapour extraction* *Bioventing* *Natural and/or enhanced attenuation* Saturated zone: *Passive skimming* *Active skimming* *Pump and treat (bore extraction and interception trench)* *Multiphase extraction* *Bio-sparging* *Air sparge with SVE* *Reactive barrier wall* *Containment* *Natural and/or enhanced attenuation*
Selected Preferred Option	The 2003 RAP analysis identified the preferred remediation options as *total fluids pumping, soil vapour extraction and air sparging*. Source control by way of *fuel infrastructure testing and repair* was also proposed. The 2005 RAP Addendum defined the preferred remediation

Remedial Action Plan	Comments
	approach as *total fluids pumping and treatment and enhanced bioremediation*. The current RAP does not specifically address all of the stated remediation goals, including: ▪ *Remove all primary sources of potential impact (leaking USTs, fuel lines, dispensers and interceptors)* ▪ *Remediate subsurface impacted soil to a standard suitable for ongoing commercial/ industrial land use* None of the proposed source control works relating to fuel infrastructure and contaminated soil have been completed to date, and it is not clear if these are still proposed to be completed.
Rationale	There is no justification for the change in proposed remediation method between the 2003 and 2005 RAP documents. Further discussion has been provided by URS (2005e) and the Auditor is satisfied with the stated rationale.
Proposed Validation Testing	**Soil** The 2003 RAP proposed validation of imported fill at a rate of 1 in 1000m^3 for VENM and 1 in 100m^3 for non-VENM. Soil validation is proposed by drilling boreholes on a 10m grid. Two samples will be analysed from each location, with samples collected at 1m intervals to beyond the depth of original impact. The proposed soil analytes are considered appropriate. It is noted that the soil TPH/ BTEX guidelines have not yet been determined. The relevance of the above soil validation activities is unclear given that soil remediation works are not discussed in the 2005 RAP Addendum. **Groundwater** Quarterly groundwater monitoring of all on and offsite wells is proposed as validation and also during groundwater remediation. Further work is required in developing a detailed monitoring program. For example, if the extraction wells are also proposed to be used for monitoring, the waiting period between system shutdown and monitoring should be consistent. For this project, the Auditor considers that establishment of an independent monitoring system (pumping wells separate to monitoring wells) is important for the collection of meaningful data. The installation of purpose built extraction wells would allow for maintenance of the existing monitoring well network and would result in more meaningful data trends. The end points for remediation are defined as follows: ▪ PSH end point – asymptotic recovery or <5mm in all wells over three events ▪ Dissolved phase end point – three consecutive events less than guidelines The proposed groundwater analytes are appropriate however

Remedial Action Plan	Comments
	the Auditor considers that mercury should be added to the proposed heavy metal suite. It is noted that the dissolved phase groundwater remediation goals have not yet been determined. **Vapour** Ongoing monitoring of vapour levels in utility pits around the site prior to and during the course of the remediation works is proposed by URS (2005e). Details of the proposed monitoring frequency and locations are not provided.
Contingency Plan if Selected Remedial Strategy Fails	An alternate remediation approach is identified in the 2005 RAP Addendum, being regular MPEAT events (if the site infrastructure does not allow for the installation of the proposed in-situ remediation system). There is no other consideration of contingencies if the selected remedial strategy fails.
Contingency Plans to Respond to site Incidents. Site Management Plan for the Operation Phase.	The 2003 RAP states that an EMP (which includes contingency planning) and an Operation and Maintenance Manual will be prepared for the remediation but details are not provided.
Remediation Schedule	The 2005 RAP Addendum provides a breakdown of the remediation schedule from design in May 2005 to system commissioning in November 2005. There is no discussion of the likely timeframe of operation of the remediation system in order to remove the PSH plume.
Licence and Approvals	The RAP documents do not provide specific details of regulatory requirements, licences and approvals. The only information provided is that "...local council approval may be required..." and "...a trade waste agreement from Sydney Water might also be required...".
Contacts/Community Relations/	Details of contacts would be provided in the Operation and Maintenance Manual (not yet prepared). None of the proposed documentation addresses community relations.
Progress reporting	Regular monitoring activities are discussed in the RAPs however details of any proposed progress reporting are not provided.
Long term site management plan	The need for long term site management is not discussed in the RAP documents.

10.5 Aquifer Modelling

Simplistic analytical modelling of the aquifer underlying the site was undertaken by URS (2005d) to determine required pumping rates to obtain hydraulic control of the PSH plume. The maximum capacity for extraction from seven wells (LMW1-4, 6, 15 and 16) was calculated as 4.64L/min based on the available drawdown, saturated aquifer thickness and an average aquifer permeability value. URS has compared this value with the calculated groundwater flow over the plume boundary of 0.25L/min to demonstrate that the extraction rate will exceed the plume flow rate.

The Auditor has checked the *extraction rate* calculations using actual permeability values rather than an average value and the difference to the result is not significant. However, the wells used by URS for calculating the extraction rate are different to those proposed to be pumped from initially. LMW9 not LMW16 is to be included in the initial pumping network. When using the LMW9 values, not LMW16, the maximum capacity for extraction (based on actual permeability values) is 2.4L/min. This large difference (reduction by almost half) is due to the greater depth and available drawdown at LMW16 and hence significant contribution to the calculated extraction rate.

The Auditor has also checked the *boundary groundwater flow* calculation. There is no basis presented by URS for the aquifer transmissivity (=permeability*thickness) and hydraulic gradient values used in the calculation. A worst case groundwater flow of 1.6L/min has been calculated based on the worst case field measurements for gradient (0.009 in high clay content), permeability (1m/day in pure sand) and aquifer thickness (4.2m at LMW16).

Based on the above, a proposed extraction of 2.4L/min compared to the groundwater flow of 1.6L/min is a much more marginal situation when compared to the URS calculated extraction of 4.64L/min compared to groundwater flow of 0.25L/min.

The Jacob analytical equation of radial flow, below, was used to calculate drawdown at the boundaries of the plume:

$$s = \frac{2.3Q}{4\pi T} \log \frac{2.25Tt}{r^2S}$$

This calculation is very sensitive to small changes in the transmissivity (T) and flow (Q) values in particular. For example:

- Adjusting the assumed transmissivity (T) from the URS assumed value of $1.2m^2/day$ to the worst case of $4.2m^2/day$ reduces the first drawdown calculation (at 0.1m) by more than factor of 3, from 0.7m to 0.2m.
- Adjusting the assumed flow from $0.72m^3/day$ (average 0.5L/min) to $0.42\ m^3/day$ (actual 0.28L/min at LMW3) first drawdown calculation (at 0.1m) by almost half, from 0.7m to 0.4m.

In addition, the time period for the calculations performed by URS is 1000 days, which is in excess of the two year time limit required by the DEC.

Due to the high sensitivity of all of the above calculations depending on the assumed aquifer parameters and pumping extraction rates, the Auditor considers that further consideration of the aquifer parameters and achievable pumping rates at each of the proposed extraction locations (including LMW9 but excluding LMW16) is required to confirm that the proposed extraction will be sufficient to maintain hydraulic control of the PSH plume. Further modelling could be undertaken to this end, however, the overall basis appears reasonable.

10.6 Discussion

The Auditor has been asked to address the question - will the proposed remediation meet the objectives of *PSH removal within two years and prevention of offsite migration of dissolved phase groundwater contamination?*

The Auditor considers that the remediation approach recommended by URS, total fluids pumping and treatment, is likely to be successful in removing the PSH plume.

There is no discussion of the likely timeframe of operation of the remediation system required in order to remove the PSH plume. Information regarding the estimated volume of product in the subsurface, proposed pumping rates and the estimated rate of PSH recovery is not provided. URS do not propose a timeframe for this process, and I cannot comment on the likelihood of removal of PSH within two years.

Prevention of offsite migration is proposed by hydraulic control within the area of the remediation pumps, as well as treatment via enhanced bioremediation along the east and northeastern edges of the site.

Numerical modelling has been undertaken by URS and while it appears likely that hydraulic control of the plume will be achieved by the assumed pumping rates, further consideration of the aquifer parameters and achievable pumping rates at each of the proposed extraction locations would be required to confirm that the proposed extraction will be sufficient to maintain hydraulic control of the PSH plume. Further modelling could be undertake to this end, however, the Auditor considers that incorporation of monitoring for this aspect into a validation monitoring program to demonstrate that hydraulic control is being achieved is the most effective way to deal with this issue. Modifications to the remediation system can then be made if necessary to achieve hydraulic control of the plume if that is considered necessary.

The proposed network of wells for enhanced bioremediation provides good coverage over this lower permeability area of the site. The proposed enhanced bioremediation remediation is considered an appropriate treatment method in the east and northeast of the site.

11 CONTAMINATION MIGRATION POTENTIAL

The migration of contamination in groundwater from underneath the site is relevant to this review.

Potential receptors of groundwater migrating from the site include:

- Prospect Creek approximately 500 m to the north east; and
- Chipping Norton Lake approximately 600 m to the south southeast.

The regional groundwater flow direction is inferred to be to the northeast. Onsite groundwater levels generally support this flow direction, however, some anomalies have been observed, including an area of reversed flow in the east of the site (onsite, towards the south/ southwest) and a possible area of recharge at LMW2, in the area of the USTs. The groundwater flow directions are not clear due in large part to the relatively flat hydraulic gradient present onsite.

There is evidence of offsite contamination impact in one location, with 217μg/L TPH C10-C28 in LMW23 in July 2004, located on the other side of the Hume Highway, around 20 m southeast of the site boundary. The type of contamination present suggests that migration could have occurred from the diesel impact onsite. This location is approximately 40 m south of LMW13, however, there is a well with no hydrocarbon detections in a similar downgradient direction from LMW13 (LMW17) and therefore direct migration from this location seems unlikely. It is possible that the source of contamination at LMW13 is also migrating offsite towards LMW23 between the location of boundary wells LMW7 (which does not have any TPH C15-C28 impact) and LMW17 (which has no hydrocarbon impact).

A current or historical offsite source of contamination may also be the cause of the detection at LMW23 which is located adjacent to an industrial facility, currently occupied by a welding company.

Undetected offsite migration of diesel impact may be occurring from LMW13 towards the northeast. There are no offsite wells in this direction, however, there are offsite wells located to the east with no hydrocarbons detected.

In the area of the petrol plume, there is PSH at LMW9 and high dissolved phase concentrations in LMW3, which are both near the southern site boundary. It is likely that some offsite migration of this impact has occurred underneath the Hume Highway, however, sufficient migration has not occurred to reach the other site of the road at a distance of around 20 m where offsite wells display no hydrocarbon impact.

The three offsite wells located upgradient of the petrol plume on the vacant land (LMW10, 11 and 12) had no organic detections during the July 2004 sampling. However, these wells previously contained low concentrations of TPH C10-C14, indicating that the plume was previously impacting on offsite groundwater in the upgradient direction.

The URS Quantitative Risk Assessment (QRA, 2005b) included a qualitative assessment of the potential for adverse impact to Prospect Creek and Chipping Norton Lakes due to the site groundwater and found the risk to be negligible. Although no specific investigation of the potential for migration in underground services such as stormwater drains has been undertaken, this migration pathway was not considered likely since the groundwater depth (>3mbgl) is below the typical depth of stormwater drains.

Given the aquifer properties and calculated seepage velocities (refer Section 5), the potential for site groundwater to adversely impact the downgradient groundwater receptors (Prospect Creek and Chipping Norton Lake) is considered by the Auditor to be low assuming remediation of the PSH plume goes ahead.

In the Auditor's opinion, there is a very high potential for undetected offsite migration of contamination to have occurred to the southeast of the petrol plume. There is a lesser potential for significant offsite migration to have occurred from the diesel impact in the east of the site.

12 ASSESSMENT OF RISK

The QRA (URS, 2005b) included a quantitative assessment of risks to human health and a qualitative assessment of risks to environmental receptors from the groundwater contamination onsite. A detailed audit of the QRA methodology has not been undertaken by the Auditor.

12.1 Risks to Human Health

The primary risks to human health at the site are associated with vapours due to the depth to groundwater at the site and the fact that the subsurface impact appears limited to at or below the level of the groundwater table.

Only one survey of utility pits for vapours has been reported on in the reviewed reports, being a PID survey by Handex (2002a) on 22 June 2001. This survey indicted negligible accumulation of hydrocarbon vapours in surrounding utility pits and no odours detected. URS advise (2005e) that they have recently monitored the utility pits on and surrounding the site, with no hydrocarbon vapours or explosive atmosphere detections using a PID and LEL monitor.

The QRA evaluated human health risks for both on and offsite occupants. Potentially complete exposure pathways were determined to be:

- Inhalation (indoors and outdoors) of vapours by existing and future workers;
- Inhalation (indoors and outdoors) by offsite workers; and
- Inhalation (outdoors) by intrusive workers.

The results of the quantitative human health risk assessment were as follows:

- Risks are considered to be low and acceptable for onsite commercial/ industrial workers for ongoing use as a service station;
- Risks are considered to be generally acceptable for other industrial/ commercial usage, however, indoor inhalation exposure could be a concern and further work is recommended if the site is to be re-developed for other commercial/ industrial usage;
- Risks are considered to be low and acceptable for offsite commercial/ industrial workers assuming there is no PSH present under offsite buildings; and
- Risks are considered to be low and acceptable for on and offsite intrusive maintenance workers assuming the services accessed are not deep enough to intersect the groundwater table (>3mbgl).

The Auditor considers the above findings and assumptions to be reasonable.

12.2 Risks to Environment

The QRA (URS, 2005b) included a qualitative assessment of the potential for adverse impact to Prospect Creek and Chipping Norton Lakes due to the site groundwater and found the risk to be negligible. This was due to the distance of the receptors (over 500m), the potential for natural attenuation and dilution to occur, and the fact that the groundwater depth (>3mbgl) is below the typical depth of stormwater drains. The Auditor agrees with this assessment, which is further supported by the aquifer properties and calculated seepage velocities (refer Section 5).

12.3 DEC Assessment of Risk

The EPA (now DEC) wrote to Mobil on 30 May 2003 and advised that "... there are reasons to believe that contamination at the site presents a significant risk of harm to human health and the environment". Although not explicitly stated, it seems that the DEC are now satisfied that the dissolved phase concentrations onsite do not present a risk to site occupants or users. The most recent DEC correspondence (8 February 2005) has requested remediation via a Voluntary Remediation Proposal to remove PSH and prevent offsite migration of the groundwater plume. Remediation of onsite dissolved phase contamination is not specifically required with respect to risk to human health of site occupants.

12.4 Other Risk Issues

Other risk issues for the site are as follows:

- There is a risk of unidentified offsite migration of groundwater contamination, with a high risk of migration to the southeast of the petrol plume and a lesser risk of migration to have occurred from the diesel impact in the east of the site. The QRA (URS, 2005b) identified this issue as "potentially insufficient delineation of dissolved phase hydrocarbons in groundwater to the east and southeast of the site").
- Details of specific activities and any below ground fuel infrastructure or other contaminant sources previous to the current site usage are not known. The current layout is very simple for an old facility (>40 years) and it seems likely that there have been other USTs abandoned, removed or moved. There is at least one unknown source of contamination (diesel impact at LMW13) and there is a risk that there are additional sources and unidentified soil/ groundwater impacts onsite.
- The QRA (URS, 2005b) identified the risk that the highest concentration soil and groundwater impacts have not been measured since samples have not been collected from the immediate vicinity of the tank pits or the fuel dispensers due to safety concerns. This data gap is not considered significant since the proposed remediation works will address this area.

13 CONCLUSIONS AND RECOMMENDATIONS

Investigations on and off the site have been carried out by Handex and URS since 2001. The key findings from these investigations are as follows:

- Details of specific historical activities and any below ground fuel infrastructure or other contaminant sources previous to the current site usage are not known.
- A plume of petrol impact to groundwater covers around one third of the site area. There is a central area of PSH within the plume. This extends to the south and east from the UST area and is believed to comprise degraded leaded petrol (LP) from an historical leak. The likely source is either UST 2 which contained LP prior to 2001 or UST 3 which currently contains lead replacement petrol. The extent of the PSH plume is considered to be relatively well defined.
- There is a dissolved phase diesel impact to groundwater in LMW13 with an unknown source. The source may be from historical usage onsite, or else an offsite source. The scale of impact detected suggests that there is an unidentified area of diesel impact to soil and possibly higher diesel impact to groundwater nearby to LMW13. Further investigations to determine the source of this impact are recommended by the Auditor.
- There is no evidence of significant migration of contamination having occurred offsite, with no significant detections in offsite wells. However, there is a very high potential for undetected offsite migration of contamination to have occurred under the Hume Highway to the southeast of the petrol plume. There is a lesser potential for offsite migration to have occurred from the diesel impact in the east of the site under Chadderton Street.

The proposed remediation works are described in the Remediation Action Plan (RAP) dated 7 July 2003 and RAP Addendum dated 3 March 2005, both prepared by URS. The original RAP was prepared in response to a letter from the EPA (now DEC) regarding Significant Risk of Harm in May 2003, while the Addendum was prepared in response to the DEC's letter in February 2005 requesting a Voluntary Remediation Proposal for the site.

I have reviewed the contents of the RAP documents and have the following comments regarding the proposed remediation and/or the adequacy of the RAP documentation:

- The remediation goals/ end points for dissolved phase groundwater and TPH/ BTEX in soil are not defined. These were to be determined based on risk assessment and the EPA's advice regarding significant risk of harm. The DEC appears satisfied that the dissolved phase concentrations in groundwater and soil onsite do not currently present a risk to site occupants or users since they have not required remediation of the dissolved phase plume/ soil. URS plans to assess dissolved phase concentrations following PSH removal to determine if further remediation is required.
- Source control by way of *fuel infrastructure testing and repair* was proposed in the 2003 RAP but this was not repeated in the 2005 RAP. None of the proposed source control works relating to fuel infrastructure or contaminated soil have been completed to date, and it is not clear if these are still proposed to be completed.
- Further work is required in developing a detailed operational and validation monitoring program for groundwater and vapour. For this project, the Auditor considers that establishment of an independent monitoring system is preferable to monitoring from extraction wells. The installation of purpose built extraction wells would allow for maintenance of the existing monitoring well network and would result in more meaningful data trends.
- The monitoring program should include monitoring to demonstrate that hydraulic control of the dissolved phase plume is being achieved.
- The proposed groundwater validation analytical suite includes heavy metals excluding mercury. The Auditor considers that mercury should be added to this suite of analytes.
- The Environmental Management Plan and Operation and Maintenance Manual documents for the remediation works have not yet been prepared.
- There is no discussion of the likely timeframe of operation of the remediation system required in order to remove the PSH plume. The volume of product in the subsurface is not estimated, and details of the proposed pumping rates and the estimated rate of PSH recovery are not provided.
- The required licences and approvals are not detailed.
- Details of any proposed progress reporting are not provided.
- The need for long term site management following PSH removal is not discussed and may be required depending on the groundwater quality following PSH removal.

With respect to the DEC's specific requirements (8 February 2005) I provide the following comments:

DEC Requirement	Auditor Comments
An active remediation system is required.	The proposed remediation system is an active system.
The remedial action must remove the PSH	The Auditor considers that the proposed remediation is likely to remove PSH.
... within 2 years	There is no discussion of the likely time required to remove the PSH. Plume volumes and recovery rates are not provided. I cannot comment on the likelihood of removal of PSH within two years.
... and prevent offsite migration of dissolved phase contamination	Hydraulic control of the dissolved phase plume appears likely but further consideration of this issue would be required for confirmation. Incorporation of monitoring for this aspect into a validation monitoring program to demonstrate that hydraulic control is being achieved is recommended. The enhanced bioremediation network appears appropriate for treatment of groundwater in the east and northeast of the site.
The prevention of offsite migration may be through containment or treatment.	A combination of containment via hydraulic control and treatment via enhanced bioremediation is proposed to prevent offsite migration.
This proposal ... must include a detailed program of works to be performed and a schedule of measurable performance targets.	Most of the remediation system details are provided in the RAP Addendum, however, some items are yet to be decided upon (eg, dissolved phase groundwater treatment method). A program of works is provided from design through to commissioning but not beyond that stage. Performance targets are not defined for the proposed remediation system.
The proposal must be audited by an EPA accredited site auditor	This Interim Opinion Letter documents the audit.
... ensure that your voluntary proposal and subsequent reports address the issues of source identification and management	The current (2005) proposal with respect to source identification and management is not clear. Additional investigations into the source of diesel contamination at LMW13 are recommended.
... improved estimation of groundwater gradients and flow direction	The Consultants have prepared groundwater contour plots with very small contour intervals. The results are difficult to interpret largely due to the relatively flat groundwater gradient, and suggest anisotropic aquifer conditions. A more accurate estimation is not likely to be achieved. Given the influence of pumping, the subsurface conditions and the relatively flat groundwater gradient, this issue is probably better addressed by the ongoing monitoring program.
... and more timely delivery of reports.	The Consultant has not provided details of any proposed progress reporting.

In summary, the Auditor considers that the remediation approach recommended by URS, total fluids pumping and treatment, is likely to be successful in removing the PSH plume, and enhanced bioremediation is considered an appropriate treatment method in the east and northeast of the site. Achievement of hydraulic control of the dissolved phase groundwater plume appears likely but further consideration of this issue would be required for confirmation. I cannot comment on the likelihood of meeting the two year timeframe by implementing the proposed system.

A number of issues have been raised herein that the Auditor believes are best addressed in the VRP which should proceed to allow commencement of remediation as soon as possible. A detailed operational and validation monitoring program for groundwater and vapour should be developed to ensure collection of high quality baseline data and accurate identification of trends.

* * *

Please do not hesitate to contact myself or my colleague Rowena Salmon if you have any questions or comments on the above.

Yours faithfully,
ENVIRON Australia Pty Ltd

Graeme Nyland

Graeme Nyland
EPA Accredited Site Auditor 9808

// Attachment A: Site Plan

ATTACHMENT A: Site Plan