INFORMATION REGARDING ENVIRONMENTAL AUDIT REPORTS

August 2007

VICTORIA'S AUDIT SYSTEM

An environmental audit system has operated in Victoria since 1989. The *Environment Protection Act 1970* (the Act) provides for the appointment by the Environment Protection Authority (EPA Victoria) of environmental auditors and the conduct of independent, high quality and rigorous environmental audits.

An environmental audit is an assessment of the condition of the environment, or the nature and extent of harm (or risk of harm) posed by an industrial process or activity, waste, substance or noise. Environmental audit reports are prepared by EPA-appointed environmental auditors who are highly qualified and skilled individuals.

Under the Act, the function of an environmental auditor is to conduct environmental audits and prepare environmental audit reports. Where an environmental audit is conducted to determine the condition of a site or its suitability for certain uses, an environmental auditor may issue either a certificate or statement of environmental audit.

A certificate indicates that the auditor is of the opinion that the site is suitable for any beneficial use defined in the Act, whilst a statement indicates that there is some restriction on the use of the site.

Any individual or organisation may engage appointed environmental auditors, who generally operate within the environmental consulting sector, to undertake environmental audits. The EPA administers the environmental audit system and ensures its ongoing integrity by assessing auditor applications and ensuring audits are independent and conducted with regard to guidelines issued by EPA.

AUDIT FILES STRUCTURE

Environmental audit reports are stored digitally by EPA in three parts: the audit report (part A), report appendices (part B) and, where applicable, the certificate or statement of environmental audit and an executive summary (part C). A report may be in colour and black-and-white formats. Generally, only black-and-white documents are text searchable.

Report executive summaries, findings and recommendations should be read and relied upon only in the context of the document as a whole, including any appendices and, where applicable, any certificate or statement of environmental audit.

AUDIT REPORT CURRENCY

Audit reports are based on the conditions encountered and information reviewed at the time of preparation and do not represent any changes that may have occurred since the date of completion. As it is not possible for an audit to present all data that could be of interest to all readers, consideration should be made to any appendices or referenced documentation for further information.

When information regarding the condition of a site changes from that at the time an audit report is issued, or where an administrative or computation error is identified, environmental audit reports, certificates and statements may be withdrawn or amended by an environmental auditor. Users are advised to check EPA's website to ensure the currency of the audit document.

PDF SEARCHABILITY AND PRINTING

EPA Victoria can only certify the accuracy and correctness of the audit report and appendices as presented in the hardcopy format. EPA is not responsible for any issues that arise due to problems with PDF files or printing.

Except where PDF normal format is specified, PDF files are scanned and optical character recognised by machine only. Accordingly, while the images are consistent with the scanned original, the searchable hidden text may contain uncorrected recognition errors that can reduce search reliability. Therefore, keyword searches undertaken within the document may not retrieve all references to the queried text.

This PDF has been created using the Adobe-approved method for generating Print Optimised Output. To assure proper results, proofs must be printed, rather than viewed on the screen.

This PDF is compatible with Adobe Acrobat Reader Version 4.0 or any later version which is downloadable free from Adobe's Website, www.adobe.com.

FURTHER INFORMATION

For more information on Victoria's environmental audit system, visit EPA's website or contact EPA's Environmental Audit Unit.

Web: www.epa.vic.gov.au/envaudit

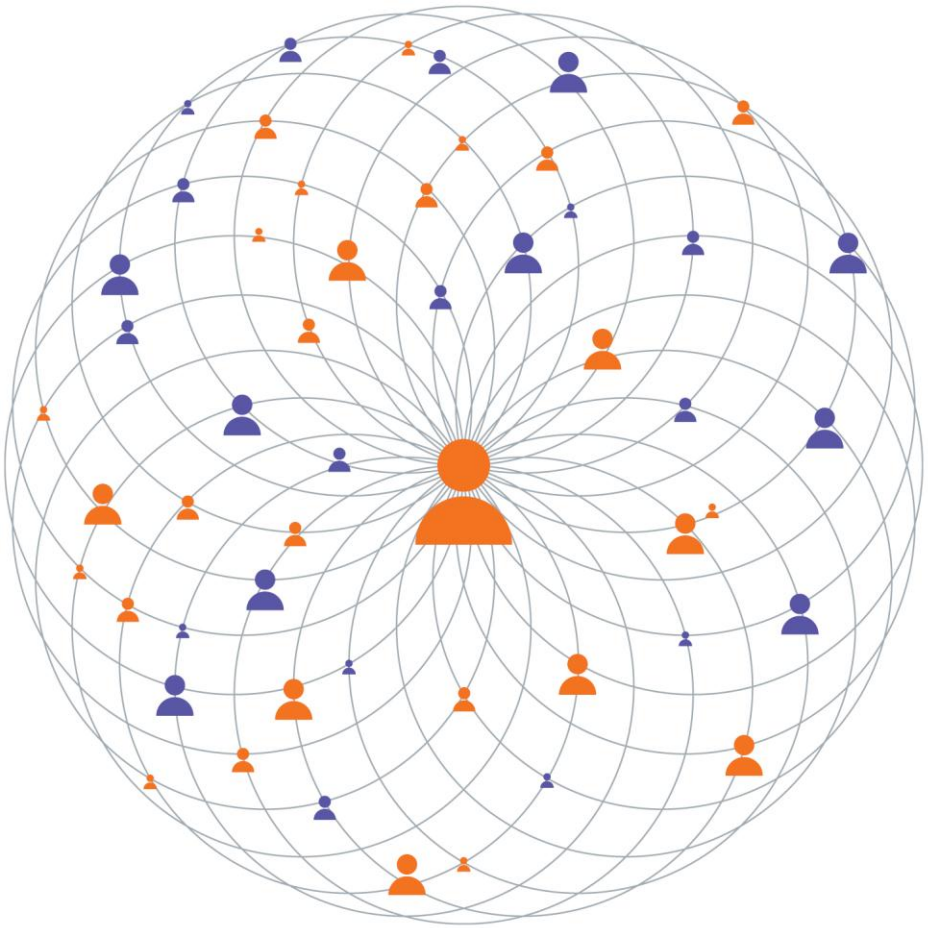
Email: environmental.audit@epa.vic.gov.au

Mobil Refining Australia Pty Ltd

53V Environmental Audit Report

Mobil Altona Refinery Corner of Millers Road and
Kororoit Creek Road,
Altona, VIC (Lots 11 to 15 and Lots 18 to 27, LP966)
CARMS NO 54969-2

25 September 2014



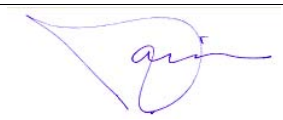
Leaders
who think
for themselves
and act
for each
other

RECORD OF DISTRIBUTION

Report Date: 25 September 2014

Report Ref: ENAUABTF09627AB_R01

Prepared for: Mobil Refining Australia Pty Ltd

Project Director	 David Lam Environmental Auditor (appointed pursuant to the Environment Protection Act, 1970)

No. of copies	Report File Name	Report Status	Date	Prepared for:	Initials
1	ENVIABTF09627AB_R01	Final	25 September 2014	EPA Victoria	DL
1	ENVIABTF09627AB_R01	Final	25 September 2014	Mobil Refining Australia Pty Ltd Matthew Walker	DL
1	ENVIABTF09627AB_R01	Final	25 September 2014	Mobil Refining Australia Pty Ltd Graeme Phillips	DL
1	ENVIABTF09627AB_R01	Final	25 September 2014	Coffey Environments Australia Pty Ltd	DL

CONTENTS

CONTENTS

CONTENTS

LIST OF ATTACHMENTS

Figures

LIST OF ATTACHMENTS

ABBREVIATIONS

ACM	Asbestos Containing Material
AHD	Australian Height Datum
ALS	Australian Laboratory Services
ANZECC	Australian and New Zealand Environment and Conservation Council
AST	Aboveground Storage Tank
C6-C36	Hydrocarbon chainlength fraction
bgs	below ground surface
BH	Borehole
BTEX	Benzene, Toluene, Ethylbenzene and Xylenes
COC	Chain of Custody
COPC	Chemicals of Potential Concern
DO	Dissolved Oxygen
EC	Electrical Conductivity
Eh	Oxidation/ Reduction Potential
ESA	Environmental Site Assessment
ID	Identification
IP	Interface Probe
H_2SO4	Sulphuric Acid
HIL	Health Investigation Level
HCl	Hydrochloric Acid
HNO_3	Nitric Acid
LNAPL	Light Non-Aqueous Phase Liquid
LOR	Limit of Reporting

ABBREVIATIONS

µg/L	micrograms per litre
mg/kg	milligrams per kilogram
mg/L	milligrams per litre
MW	Monitoring Well
NATA	National Association of Testing Authorities
NEHF	National Environmental Health Forum
NEPM	National Environment Protection Measure
NSW EPA	Environment Protection Authority of New South Wales
OCP	Organo-chlorine Pesticide
OPP	Organo-phosphorous Pesticide
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyls
PID	Photo-ionisation Detector
ppm	parts per million
ppmv	parts per million by volume
PVC	Polyvinyl Chloride
QA	Quality Assurance
QC	Quality Control
RL	Reduced Level
RPD	Relative Percentage Difference
SB	Soil Bore
SCN	Steam Cracked Naphtha
SOP	Standard Operating Procedures

ABBREVIATIONS

SWL	Static Water Level
TCE	Trichloroethylene
TEA	Tank Excavation Assessment
TD	Total Depth
TDS	Total Dissolved Solid
TOC	Top of Casing
TPH	Total Petroleum Hydrocarbon
UST	Underground Storage Tank
VOA	Volatile Organic Analysis
VOC	Volatile Organic Compound

EXECUTIVE SUMMARY

This report presents the results of an environmental audit which assessed the risk, to the nearby off-site environment, from the operation of the Mobil Altona Refinery, located at and in the vicinity of the Corner of Millers and Kororoit Creek Roads, Victoria. The environmental audit was conducted in accordance with Section 53V of the Environment Protection Act 1970.

The overall Refinery site consists of four major areas. Three of the areas effectively form one adjacent group, separated only by road or rail lines: the Refinery Processing Area (north of Kororoit Creek Road, east of Millers Road and west of the Melbourne-Altona railway line), the Blending Area (south of Kororoit Creek Road), and the North Crude Tank Farm (east of the Melbourne-Altona railway line and north of Kororoit Creek Road). This group of areas is collectively described as the "Refinery Area" in this document. The fourth area is located some 260 m east/south-east of the North Crude Tank Farm, south of Kororoit Creek Road, and is referred to as the South Crude Tank Farm. These areas are shown on **Figure 1.**

Summary of Audit Information

EPA Service order Number	8001852
EPA CARMS No	(54969-2)
Auditor	David Lam
Auditor term of appointment	17 May 2014 to 16 May 2019
Name of person requesting audit	Mr Ashley Water and subsequently Mr Matthew Walker of Mobil EMES
Relationship to premises/location	Mobil Refinery representative
Date of Request	11 May 2011
Date EPA notified of audit	12 May 2011
Completion date of audit	25 September 2014
Reason for audit	Requirement of Clean Up Notice number NO10753
Description of Activity	Operational petroleum refining and storage facility
Current land use zoning	Special Use Zone 2 (SUZ2), under the Hobsons Bay Planning Scheme
EPA region	Western Metropolitan
Municipality	Hobsons Bay City Council
Dominant – Lot on Plan	Lots 11 to 15 and Lots 18 to 27, on Plan LP966
Additional – Lot on Plan	Nil
Site premises/name **Street / Lot** **Street Name** **Street Type** **Suburb** **Postcode**	Mobil Refinery 122 Corner of Millers and Kororoit Creek Roads Road Altona 3018

EXECUTIVE SUMMARY

GIS coordinate of site centroid (GDA94 MGA) **Longitude / Easting (GDA94)** **Latitude / Northing (GDA94)**	 144.849200 -37.849170
Site area (hectares)	83
Members and categories of support team utilised	Dr Ben Petrides: hydrogeology Karen Teague: soil vapour risk assessment and adopted site assessment criteria review Nick Woodford: soil vapour monitoring program, soil vapour fate and transport, and soil vapour risk assessment Lyle Carpenter: remediation technologies and assessment It is also acknowledged that Mr Stephen Cambridge and Dr Adam Wightwick contributed as auditor support for reviewing reports and assistance in drafting text.
Outcome of the audit	Section 53V Environmental Audit Report
Further work or requirements	Implementation of recommendations as provided in this audit report.

Physical Site Information

Site aquifer formation	Groundwater below the site flows primarily through secondary porosity fractures within Quaternary aged Newer Volcanics basalt. There are also Quaternary aged sediments below the South Crude Tank Farm area and south of the Blending Area of the Refinery, in which groundwater is within the uppermost aquifer. Groundwater flows from the Newer Volcanics aquifer into the Quaternary aged sediments surrounding Kororoit Creek, to the south of the Blending Area.
Static water level range (approximate)	Refinery Area: 0.7 to 1.0 mAHD (2.0 to 6.8 m below ground surface) South Crude Tank Farm: 0.3 to 0.8 mAHD (1.2 to 1.4 m below ground surface)
Groundwater classification	Refinery Area: Segment C South Crude Tank Farm: Segment B
Regional groundwater flow direction	East to South-East
Past use/site history	• Pre 1949, the site was 'green fields' and is assumed to have been used for agricultural purposes. • 1949 – 1953: Refinery was commissioned • 1954 – 1960: Site expanded to become a 'cracking' refinery • 1961 – 1969: Altona Petrochemical Complex was

	commissioned and the Refinery provided raw product to the Complex. • 1970 – 1980: further modernised and expanded following the discovery of Gippsland Crude oil. • 1981 – 2004: instrumentation upgrade and in 1991 effluent discharge to industrial trade waste sewer commenced. Thermofor catalytic cracker replaced by Fluidised catalytic cracker. • 2005 – Present: Refinery invests in the Clean Fuels Venture to meet new clean fuels specification. No Oil to Sewer Policy implemented in 2006,
Surrounding land use	Refinery Area: • North - railway then residential and recreational areas. • East – commercial/industrial land. Railway line separates the Processing area from the North Crude Tank Farm. • South – Kororoit Creek and Kororoit Creek Reserve. • West – roadways and land owned by Mobil, part of which is leased to 7-Eleven for a service station and mechanics workshop. The remaining land contains the Pegasus Centre (Mobil office) which is currently vacant and open paddocks and pipeline easements. South Crude Tank Farm: • North - roadway and industrial/commercial land. • East – recreational land. • South – Kororoit Creek and Kororoit Creek Reserve. • West – industrial and commercial land with some residential use.
Surface Water	• Kororoit Creek located approximately 30 m south of the Refinery at its closed point, and approximately 20 m to the south of the South Crude Tank Farm; • Rowden's Swamp (part of Kororoit Creek) located adjacent to Pegasus Paddock and about 450 m to the west of the Refinery boundary; • Cherry Lake located approximately 500 m to the south-west of the Refinery; • Port Phillip Bay, located approximately 1,000 m to the south south-east of the Blending Area part of the Refinery, and approximately 400 m south of the South Crude Tank Farm; • There are other drains surrounding the site, including Paisley Drain located approximately 250 m to the east of the North Crude Tank Farm.
Activity Undertaken	Refining and storage of petroleum products including ancillary operations such as administration and wastewater management.

EXECUTIVE SUMMARY

Components of the activity considered	The activity audited is the former and current operation of the site as a petroleum refinery. The components considered are the risk of possible harm or detriment to beneficial uses of the groundwater and land. The scope of this Audit addresses risks to off-site receptors, and investigations were focussed on impacts in the off-site areas. On-site works included a review of site history monitoring data (such as biannual groundwater monitoring events), in the context of assessing risks to off-site receptors when considering the source-pathway-receptor model, in which sources on-site could affect receptors off-site.
Segments of the environment considered	The segment of the environment is defined as the premises boundary at the Corner of Millers Road and Kororoit Creek Road, Altona, VIC, 3018 (Lots 11 to 15, and Lots 18 to 27 on Plan LP966) as shown in the figure in the Clean Up Notice (**Appendix A**) and on **Figure 1**. Nearby off-site properties and environmental receptors are also considered to the extent that they may be affected by land or groundwater contamination originating from the subject site.
Elements of the environment considered	• Land and aesthetics within the area described above. • Groundwater beneath the site and beyond the site. • Vegetation. • Surface water receptors in the vicinity of the site. • Air quality at and immediately adjacent the site, due to potential emissions from soil and groundwater with respect to human health.
Beneficial uses to be considered	Beneficial Uses as prescribed in the various State Environment Protection Policies relative to the nominated elements of the environment under consideration.
Risk Assessment	The potential risks to receptors have been characterised using a qualitative risk-based approach, adapted from the HB436:2013 *Risk Management Guidelines (*Standards Australia, 2013). This has been used to *'specify the risks of any possible harm or detriment to beneficial uses of the environment'* as required in the Clean Up Notice issued by EPA.
Period of time over which the audit was conducted	The audit was conducted in consideration of the 2011/2013 monitoring periods, with some review of assessment, monitoring and remediation data within the 2014 calendar year. Where considered appropriate earlier assessment and monitoring data for the site has also been taken into account.

EXECUTIVE SUMMARY

A summary of the main findings of the audit is provided below.

The Final Clean Up Notice included the following requirement with respect to the Section 53V Environmental Audit:

Clause 3.2 - By 1 October 2014, you must submit to EPA an environmental audit report, prepared in accordance with section 53V of the Act by an EPA-appointed environmental auditor, that:

(a) delineates the extent of any contamination beyond the boundary of the premises caused by past or current industrial processes, activities or wastes;

(b) specifies the risk of any possible harm or detriment to beneficial uses of the environment; and

(c) recommends measures to reduce risks to beneficial uses to acceptable levels, or, where risks cannot be determined, measures to determine risks.

The Audit has been conducted in accordance with the agreed Audit Scope, based on the requirements of Clause 3.2 of the Clean Up Notice. The scope of this Audit addresses risks to off-site receptors, and investigations were focussed on impacts in the off-site areas. On-site works included a review of site history and monitoring data (such as biannual groundwater monitoring events), in the context of assessing risks to off-site receptors when considering the source-pathway-receptor model, in which sources on-site could affect receptors off-site.

Investigation and assessment works were targeted in high priority areas where risk mitigation measures are to be implemented, or where risk mitigation measures were already in place at the commencement of the Audit. The purpose of prioritising risks was to ensure that risks to beneficial uses were managed during the Audit process, where considered necessary, rather than at the completion of the Audit. This process was managed by establishing a Risk Register, which was prepared by the assessor at the Auditor's request.

In consideration of the Clean Up Notice requirements and the Audit Scope, the following findings were reached.

Delineation of extent of contamination beyond the site boundary

- **Soil:** investigation works targeted off-site areas where the historical review indicated potential for soil contamination from overflows of potentially contaminated water in drainage lines exiting from different parts of the site. Six historical drainage lines were identified exiting from the Blending Area and the South Crude Tank Farm. Soil contamination exceeding adopted criteria was reported for four former drainage lines south of the Blending Area and the former drainage line to the south of the South Crude Tank Farm.

Soil contamination in the former drainage areas is considered to be generally delineated; however some of the lateral extents of the soil contamination from the former drainage lines are not fully defined.

There is also potential for sediment contamination along Kororoit Creek due to historical activities and possible contribution of contamination from groundwater discharge into sediments associated with the creek.

- **Groundwater:** an extensive groundwater monitoring well network has been installed on-site and in off-site areas to monitor and assess groundwater. Groundwater contamination, including both Light Non-Aqueous Phase Liquid (LNAPL), and dissolved phase is considered to be delineated, to below the adopted criteria, in all off-site directions, except for the following areas:
    - To the south of the South Crude Tank Farm, towards Kororoit Creek, for dissolved petroleum hydrocarbons (TRH C_{10} to C_{36} fraction);
    - To the east/south-east of the North Crude Tank Farm, for ammonia (for which the source is as yet undetermined).
    - A potential delineation gap for the SCN LNAPL extent remains for groundwater near Kororoit Creek Road to the north-west of the Pegasus Centre and south-west of the 7-Eleven site, specifically north-west of monitoring bore MBB34 and south-west of GA031.

    There are four main LNAPL areas across the Audit area. These have been largely differentiated based on chemical composition of the LNAPL and source identification where feasible. The four main LNAPL areas are labelled as follows:

    - Steam Cracked Naphtha (SCN) LNAPL Zone: this LNAPL extends off-site to the west of the Refinery Area.
    - Mid-Blending Area LNAPL Zone: this area is inferred to be contained within the site boundaries.
    - Southern Blending Area LNAPL Zone: this area is inferred to be contained within the site boundaries.
    - Processing Area LNAPL Zone: this area is inferred to be mostly contained within the site boundaries, with the possibility of a small area of LNAPL extending off-site to the east of the Processing Area under the railway corridor, and also underneath Kororoit Creek Road.

    Dissolved phase petroleum hydrocarbons in groundwater are typically present close to and hydraulically down-gradient of LNAPL plumes. Dissolved phase petroleum hydrocarbons are present in the following off-site areas:

    - Beyond the fringes of the SCN LNAPL plume;
    - Beyond the southern extent of the Southern Blending Area LNAPL plume; and
    - To the north of the Refinery in the Ross Road area, although it is noted that there is likely to be a contribution from off-site sources in this area.

    Dissolved phase petroleum hydrocarbons are also present in the North Crude Tank Farm and South Crude Tank Farm areas, including off-site to the south and south-east of the South Crude Tank Farm.

Risk Assessment Findings and Measures to Reduce Risks or Further Assess Risks

The site assessment works completed by the assessment consultant, on behalf of Mobil, have been used to assess the potential risks to off-site receptors associated with contaminants inferred to be associated with the site. This has included comparison of reported concentrations against adopted site assessment criteria, and documenting the Source-Pathway-Receptor Models for the different areas of the site. Where a complete, or potentially complete, Source-Pathway-Receptor linkage is considered to

be present, a qualitative risk assessment has been conducted. This has also been conducted for areas where currently there is not a complete linkage, but where there is a protected beneficial uses of land or groundwater which may be subject to risk at some point in the future (for example, groundwater extraction). In some cases, the potential for protected beneficial uses to be realised in these off-site areas is low or very low (for example, groundwater extraction), and this likelihood is reflected in the risk assessment ranking assigned.

The assessment of risk also included appraisal of whether the existing contamination is likely to represent an 'imminent environmental hazard' to human health, the environment or third party property. Based on the information reviewed, the Auditor is of the opinion that the soil and groundwater conditions do not represent an imminent environmental hazard to off-site areas.

The approach adopted for characterising the potential risks has been based on consideration of the likelihood of a deleterious outcome occurring, and the potential consequences (a measure of severity) should the event occur. The level of risk for each potential event was then determined by combining the likelihood and consequence to rank the potential risk as very low, low, medium, high or very high according to a risk ranking matrix. This definition of event likelihood and consequences, and risk ranking has been adapted from EPA Publication 1321.1 (2010) '*Licence Assessment Guidelines, Guideline for Using a Risk Management Approach to Assess Compliance with Licence Conditions'*.

Based on this approach, an assessment of risk has been described for the protected Beneficial Uses of soil, groundwater, air, surface water and sediment. The risk rankings have been determined as the *inherent risk,* which is the risk that would be considered to exist without consideration of any existing risk management control measures. Risk is assessed in this way in order to ensure that the importance of any risk management measures is recognised, in mitigating significant risk issues. The risk assessment rankings, in order of priority (highest risk ranking to lowest) are presented in the following Table.

Environmental Segment and Beneficial Use	Source and Exposure Pathway	Risk Ranking	Risk Treatment Summary
Air (vapour) Human health	Steam Cracked Naphtha LNAPL Migration of vapours from SCN LNAPL plume to indoor air at the Pegasus Building	Very High	• Currently, the Pegasus Building is not occupied and there is continual air space monitoring in the basement, although it is understood that demolition of the building is being contemplated, which would clearly change any requirement for risk treatment. Mobil controls access to this building under a permit system. Therefore, with continuation of the current management controls (access and monitoring) the risk should remain low for human health exposure to SCN vapours, unless and until the building is demolished. • SCN LNAPL and dissolved phase contamination to be remediated to the extent practicable to reduce risks of vapour migration to enclosed spaces.
Air (vapour): Human Health – Subsurface Maintenance	Steam Cracked Naphtha LNAPL Migration of vapours from	High	• Mobil to maintain the 'Dial Before You Dig' hazard identification registration for off-site areas. • Notification of utility owners of potential hazards of working in underground service trenches or pits.

Environmental Segment and Beneficial Use	Source and Exposure Pathway	Risk Ranking	Risk Treatment Summary
Workers	LNAPL plumes to air within a trench, utility or sub-surface structure		• SCN LNAPL and dissolved phase contamination to be remediated to the extent practicable to reduce risks. • A potential delineation gap for the SCN LNAPL extent remains in groundwater near Kororoit Creek Road to the north-west of the Pegasus Centre and south-west of the 7-Eleven site, specifically north-west of monitoring bore MBB34 and south-west of GA031. Further delineation bores are required in this area to address this data gap.
Groundwater: Human health and explosive risk – subsurface maintenance or construction workers	SCN LNAPL Plume Excavations intercepting groundwater	High	• Mobil to maintain the 'Dial Before You Dig' notification which provides a hazard warning to subsurface maintenance and construction workers who use the Dial Before You Dig notification service. • Notification of utility owners of potential hazards of working in underground service trenches or pits. • SCN LNAPL and dissolved phase contamination to be remediated to the extent practicable to reduce risks of vapour migration to enclosed spaces.
Air (vapour) Human health – adult maintenance workers	LNAPL (excluding SCN LNAPL which is addressed separately) Migration of vapours through underground utilities (including backfill)	High	• Mobil to maintain the Dial-Before-You-Dig registration of potentially hazardous areas for third parties conducting sub-surface works; • Notify utility owners in the area of the potential for human health hazards to exist in the vicinity of the Refinery. The area covered by the notification needs to include all off-site areas where LNAPL is present, or dissolved phase contamination above the adopted criteria, including a suitable buffer distance. This is to be documented in the Clean Up Plan. • Ongoing monitoring in accordance with the Auditor-verified *Mobil Altona Refinery Groundwater Quality Management Plan* (Golder, 2013h), which may be amended or replaced subject to auditor endorsement. • Continue with periodic monitoring of utility pits in areas previously monitored. Prepare a program of continuous utility pit monitoring for utility pits in the vicinity of the Pegasus Building, where elevated vapours have been previously recorded. The intention is to have continuous monitoring over a period sufficient to capture significant low-pressure atmospheric conditions at least once.

Environmental Segment and Beneficial Use	Source and Exposure Pathway	Risk Ranking	Risk Treatment Summary
			• Investigate whether the utility pits previously identified to have elevated Volatile Organic Compound (VOC) concentrations, have any vapour pathway connection to the Refinery sewer system, as suggested by the site assessor (such as via intersecting trench backfill). This will provide further information on the source of the utility pit vapours reported in these pits, and whether these pits represent a significant risk of vapour intrusion.
Sediment due to groundwater discharge into Kororoit Creek – aquatic ecological receptors	Exposure to contaminants in sediment of Creek as a result of groundwater discharge south of Blending Area	Medium	• Further assessment of the potential ecological risks to Kororoit Creek associated with discharges of contaminants in groundwater to sediments of Kororoit Creek. This should include investigation of the accumulation of contaminants in Creek sediments from Refinery and potential risks to benthic organisms. • Ongoing monitoring in accordance with the Auditor reviewed *Mobil Altona Refinery Groundwater Quality Management Plan* (Golder, 2013h).
Surface water and sediment: Aquatic ecological receptors	Migration of contaminants from soil contamination in legacy areas, to surface water and sediments in Kororoit Creek	Medium	• Management/remediation of soil contamination present in four former drainage areas in Kororoit Creek Reserve, including the LNAPL in the former drainage line of the 'Legacy Area' south of the Blending Area. • Further assessment of the potential ecological risks to Kororoit Creek associated with discharges of contaminants in groundwater, surface run-off water and mobilisation of soil contaminants. This should include investigation of the accumulation of contaminants in Creek sediments from Refinery and potential risks to benthic organisms.
Sediment due to groundwater discharge into Kororoit Creek – aquatic ecological receptors	South Crude Tank Farm petroleum hydrocarbons in groundwater Exposure to contaminants in sediment of Creek as a result of groundwater discharge	Medium	• Further data required to understand interaction and potential for preferential flow pathways, along SCTF southern boundary (MB44, GA085 and GA086). Additional data required includes off-site groundwater bore(s) to the south of MB44, and an assessment of the flux of contaminant movement from groundwater to sediments and surface waters of Kororoit Creek. • Further assessment of the potential ecological risks to Kororoit Creek associated with discharges of contaminants in groundwater to sediments of Kororoit Creek. This should include investigation of the accumulation of contaminants in Creek sediments from SCTF and potential risks to benthic organisms.

EXECUTIVE SUMMARY

Environmental Segment and Beneficial Use	Source and Exposure Pathway	Risk Ranking	Risk Treatment Summary
Soil/Sediment: aquatic and riparian ecosystems	South Crude Tank Farm – Residual soil contamination in Assessment Area 4 Mobilisation of contaminated soil to sediments in Kororoit Creek	Medium	• Remediation of soil present in the former drainage area (Assessment Area 4) in Kororoit Creek Reserve.
Air (vapour): Human Health – Commercial Workers and Visitors of the 7-Eleven Sales Building	Steam Cracked Naphtha LNAPL Plume Migration of vapours from LNAPL plume to indoor air (7-Eleven Sales Building)	Low	• Additional vapour monitoring at the Sales Building for chemicals of potential concern and comparison to the Health Screening Levels. It is recommended that a minimum of an additional two monitoring events is conducted, to assess the variation in sub-ground vapour conditions due to changing weather and sub-surface conditions.
Air (vapour): Human Health – Commercial Workers and Visitors of the 7-Eleven Mechanics Workshop.	Steam Cracked Naphtha LNAPL Plume Migration of vapours from LNAPL plumes to indoor air (Mechanics Workshop)	Low	• Installation of an additional sub-slab monitoring bore within the mechanics workshop, and conducting monitoring to assess the risk to this receptor in more detail. • Additional monitoring of sub-slab bores in the Workshop for chemicals of potential concern and comparison to the Health Screening Levels. It is recommended that a minimum of an additional two monitoring events is conducted, to assess the variation in sub-ground vapour conditions due to changing weather and sub-surface conditions
Air (vapour): Human Health – Residents and, sub-surface maintenance or construction workers	Steam Cracked Naphtha LNAPL Plume Air (vapour): Human Health – Residents and sub-surface maintenance or construction workers to the north of the Refinery	Low	• Installation of an additional delineation monitoring well in the general vicinity of (but not close to) GA071 to provide further detail regarding SCN LNAPL northerly plume extent. • Ongoing monitoring for contaminant trend analysis and SCN LNAPL migration assessment. The GQMP is required to be updated and reviewed by an Auditor as part of the Clean Up Plan verification, to include trigger conditions and contingencies in relation to the assessment of the SCN LNAPL mobility, including the necessary response measures, if the SCN LNAPL was found to be migrating further north in this area towards residences. The GQMP may also include a rationale for future changes in monitoring scope, depending on monitoring results and risk profile. • Mobil to maintain the 'Dial Before You Dig' notification which provides a hazard warning to subsurface maintenance and construction workers who use the Dial Before You Dig notification service.

Environmental Segment and Beneficial Use	Source and Exposure Pathway	Risk Ranking	Risk Treatment Summary
			• The utility pit monitoring program to be extended to incorporate utility pits to the north of the Refinery, including utility pits along Ross Road. • Underground utility asset owners in the Ross Road area to be notified of the potential to encounter groundwater contamination in this area, and that appropriate exposure control measures should be implemented when workers enter underground pits.
Groundwater discharge to underground services (Human Health risk to workers)	Discharge of contaminated groundwater from the Processing Area into deeper sewers off-site to the north of the Refinery	Low	• Notification of sewer owner of the potential to encounter groundwater contamination in this area, and that appropriate exposure control measures should be implemented when workers enter the sewer system. • Ongoing monitoring for contaminant trend analysis and groundwater elevations in accordance with the GQMP. In addition, where monitoring well construction details are not known (such as MB53 and MB54), then further investigation to determine the well construction details, or replacement of monitoring wells, is recommended.
Groundwater: Extractive Uses	All off-site areas where groundwater contamination is present above adopted criteria due to Refinery operations. Exposure to contaminants in extracted groundwater	Low	• SCN LNAPL and associated dissolved phase contamination to be remediated to restore beneficial uses based on adopted criteria (to the extent practicable). • Notification of groundwater extraction licensing authority that groundwater should not be used for extractive uses in the areas where contaminated groundwater is present. • Ongoing monitoring in accordance with the Auditor reviewed *Mobil Altona Refinery Groundwater Quality Management Plan*.
Groundwater: Maintenance of Ecosystems, Primary Contact Recreation at point of discharge	Steam Cracked Naphtha LNAPL Discharge of groundwater in Kororoit Creek	Low	• Continue remediation of SCN LNAPL and dissolved phase contamination to mitigate the potential for SCN contamination to discharge to Kororoit Creek. • Ongoing monitoring of SCN plume stability.
Groundwater discharge to sub-surface excavations – Human Health	Exposure to contaminants in groundwater intercepted during excavation south of Blending Area	Low	• Notification of the land manager for Kororoit Creek Reserve of the potential to encounter groundwater contamination in this area (ie between the southern boundary of Blending and Kororoit Creek), and that appropriate exposure control measures should be implemented when workers are conducting sub-surface excavation works.

EXECUTIVE SUMMARY

Environmental Segment and Beneficial Use	Source and Exposure Pathway	Risk Ranking	Risk Treatment Summary
Air (vapour): Human Health	Migration of vapours from groundwater plume (outdoor air and sub-surface excavations) – south of Blending Area	Low	• Notification of the land manager for Kororoit Creek Reserve of the potential to encounter soil vapour in this area (ie between the southern boundary of Blending and Kororoit Creek), and that appropriate exposure control measures should be implemented when workers are conducting sub-surface excavation works.
Groundwater: Human health – adult maintenance workers	LNAPL (excluding SCN LNAPL which is addressed separately) Excavations intercepting groundwater	Low	• Mobil to maintain the Dial-Before-You-Dig registration of potentially hazardous areas for third parties conducting sub-surface works. • Notify utility owners in the area of the potential for human health hazards to exist in the vicinity of the Refinery. The area covered by the notification needs to include all off-site areas where LNAPL is present, or dissolved phase contamination above the adopted criteria, including a suitable buffer distance. This should be documented in the Clean Up Plan. • Ongoing monitoring in accordance with the Auditor reviewed *Mobil Altona Refinery Groundwater Quality Management Plan* (Golder, 2013h).
Groundwater: underground services	South Crude Tank Farm petroleum hydrocarbons in groundwater Discharge of groundwater into shallow sewers/stormwater	Low	• Notify utility owners in the area of the potential for human health hazards to exist in the vicinity of the SCTF. The area covered by the notification needs to include all off-site areas where dissolved phase contamination is above the adopted criteria, including a suitable buffer distance. This should be documented in the Clean Up Plan.

A summary of the Risk Treatment measures, and other recommendations regarding further delineation or risk assessment, as required under the Clean Up Notice, are presented in Section 9.2.1. Following the implementation of recommendations, it is considered that the identified risks to beneficial uses will be reduced to acceptable levels. In some instances, complete restoration of all beneficial uses may not be achievable, and therefore ongoing management of residual risk items may be required as a management measure to ensure those residual risks do not manifest as deleterious effects to the identified receptors.

The recommendations of this 53V Audit are required to be addressed in the Auditor Verified Clean Up Plan, to be submitted to EPA by 1 February 2015.

1 INTRODUCTION

1.1 Background

This Environmental Audit Report pertains to the Mobil Altona Refinery, and has been prepared by Mr David Lam of Coffey Environments Australia Pty Ltd (Coffey) with the aid of a support team, for Mobil Refining Australia Pty Ltd (Mobil). The Mobil Altona Refinery is located at the Corner of Millers Road and Kororoit Creek Road, Altona, VIC, 3018 (Lots 11 to 15, and Lots 18 to 27 on Plan LP966). The site is shown on **Figure 1,** attached, and is also shown in the Clean Up Notice in **Appendix A**.

The overall Refinery site consists of four major areas. Three of the areas effectively form one adjacent group, separated only by road or rail lines: the Refinery Processing Area (north of Kororoit Creek Road, east of Millers Road and west of the Melbourne-Altona railway line), the Blending Area (south of Kororoit Creek Road), and the North Crude Tank Farm (east of the Melbourne-Altona railway line and north of Kororoit Creek Road). This group of areas is collectively described as the "Refinery Area" in this document. The fourth area is located some 260 m east/south-east of the North Crude Tank Farm, south of Kororoit Creek Road, and is referred to as the South Crude Tank Farm.

A Final Clean Up Notice (the final notice, number NO10753, dated 27 June 2012) was issued to Mobil from Environment Protection Authority Victoria (EPA) for the site. A requirement of the Final Clean Up Notice included:

Clause 3.2 - By 1 October 2014, you must submit to EPA an environmental audit report, prepared in accordance with section 53V of the Act by an EPA-appointed environmental auditor, that:

- *(a) delineates the extent of any contamination beyond the boundary of the premises caused by past or current industrial processes, activities or wastes;*
- *(b) specifies the risk of any possible harm or detriment to beneficial uses of the environment; and*
- *(c) recommends measures to reduce risks to beneficial uses to acceptable levels, or, where risks cannot be determined, measures to determine risks.*

Mr David Lam was engaged by Mobil to undertake a Section 53V Environmental Audit in accordance with the requirements of the final notice. Mr David Lam is an Environmental Auditor (appointed pursuant to the *Environment Protection Act* 1970). An Audit Scope was prepared by Coffey and submitted to EPA (refer to **Appendix B**), which was approved by EPA on 15 October 2012. The Audit Scope is further discussed in Section 2.

The Clean Up Notice also requires that Mobil submit a Clean Up Plan verified by an EPA-appointed environmental auditor by 1 February 2015. Mr David Lam has been engaged by Mobil to complete the verification of the Clean Up Plan, and this 53V Audit report forms the basis for preparation of the Clean Up Plan by Mobil, and subsequent verification by the environmental auditor. The verified Clean Up Plan will be prepared as a separate document to the 53V Audit.

1.2 Purpose of Environmental Audit

The purpose of the Section 53V Environmental Audit was to comply with requirements of the Clean Up Notice (the final notice, number NO10753, dated 27 June 2012). The Clean Up Notice under Section 62A (1)(a) of the Environment Protection Act was issued on the basis that a non-compliance with the Act (1970), was considered to have occurred, in that EPA considered that “land and groundwater contamination exists at the premises and may extend beyond the premises”.

1.3 Objectives of Environmental Audit

To address the requirements of Clause 3.2 (indicated above) in the final notice, the following objectives have been adopted:

- Assess the extent of contamination at and beyond the site boundary caused by past or current industrial processes, activities or wastes that may impact upon the beneficial uses of land and groundwater; and
- Assess whether the past or current industrial process, activities or wastes at the site pose a risk of harm to the beneficial uses of groundwater and land.

The Audit scope prioritises the consideration of risk to off-site sensitive receptors, and investigations were focussed on these areas. The rationale for this focus on off-site areas is that this was the basis of the EPA Clean Up Notice, which was very specific in seeking delineation of contamination “beyond the site boundary”, and then evaluation of risks associated with that delineation. The appropriateness of the off-site focus was discussed with EPA and confirmed in the documented scope for the audit. On-site works were limited mainly to a review of existing data and review of ongoing routine monitoring data (such as biannual groundwater monitoring events), in the context of assessing risks from on-site sources to off-site receptors, when considering the source-pathway-receptor model.

1.4 Parties involved

The following is a list of parties involved in the Audit in addition to the Auditor and audit team:

Table 1.1 - Parties involved in the Environmental Audit

Role	Organisation
Site owner:	Mobil Refining Australia Pty Ltd
Project manager for site owner:	Matthew Walker (Mobil)
Site occupier:	Andrew Warrell (Mobil)
Environmental site assessors: (refer to list of reports in **Appendix D**)	• Golder Associates Pty Ltd (Golder) in conjunction with NewFields Environmental Forensics Practice LLC (NewFields), • AECOM Australia Pty Ltd (AECOM)
Primary laboratory used by site assessor:	Australian Laboratory Services Group Pty Ltd (ALS)

Role	Organisation
Secondary laboratory used by site assessor:	Eurofins-MGT Environmental Laboratories Pty Ltd (Eurofins)
Previous/ current environmental site assessors: (refer to list of reports in **Appendix D**)	• URS Australia Pty Ltd • AGC Woodward Clyde Pty Ltd • Handex

1.5 Time Period of Audit

Table 1.2 – Summary of time period for environmental audit

Details	Date
Term of appointment of auditor	17 May 2014 to 16 May 2019
Notification to EPA	12 May 2011
Issue date of Clean Up Notice	28 October 2011 (initial notice), subsequently updated on 27 June 2012 (final notice)
Proposed completion date	1 October 2014

1.6 Scope of Audit

Section 8 of EPA Publication 952.4, *"Environmental Auditor Guidelines for the Preparation of Environmental Audit Reports on the Risk to the Environment"*, (dated August 2007) provides guidance to environmental auditors undertaking an Environmental Audit pursuant to Section 53V of the Act. The auditor referred to the information contained in this guideline to prepare the Audit Scope (see **Appendix B**). The Audit Scope was submitted to EPA, and approved by EPA on 15 October 2012. The Audit Scope is described in the following sections of the report.

1.6.1 Activity undertaken and components

The activity audited is the former and current operation of the site as a petroleum refinery. The components considered are the risk of possible harm or detriment to beneficial uses of the groundwater and land.

1.6.2 Segment of environment

The segment of the environment is defined as the premises boundary at the Corner of Millers Road and Kororoit Creek Road, Altona, VIC, 3018 (Lots 11 to 15, and Lots 18 to 27 on Plan LP966) as shown in the figure in the Clean Up Notice attached (**Appendix A**) and on **Figure 1** attached.

Nearby offsite properties and environmental receptors are considered to the extent that they may be affected by land or groundwater contamination originating from the subject site.

1.6.3 Elements considered

- Land and aesthetics within the area described above.
- Groundwater beneath the site and beyond the site.
- Vegetation.
- Surface water receiving environments in the vicinity of the site.
- Air quality at and immediately adjacent the site, due to potential emissions from soil and groundwater with respect to human health.

The beneficial uses of these elements of the environment that require protection are presented in Section 5.

1.6.4 Risk assessment

To meet the requirement in Clause 3.1 of the final notice, the Audit assesses the risk to the relevant beneficial uses based on the nature and extent of soil and groundwater contamination found to be present as a result of the activity.

Where the risk assessment identified an unacceptable risk to beneficial uses requiring protection, recommended measures to reduce risk to beneficial uses to acceptable levels are provided. Where the risk could not be determined, recommendations regarding measures to determine the risks are presented.

The risk assessment method is presented in Section 2.2.4 and the risk assessment for the identified environmental elements is presented in Section 8.

1.6.5 Exclusions from the audit scope

The following items are beyond the scope of the 53V environmental audit:

- The assessment of site suitability for current or future use.
- An operational Audit (Industrial Facilities Operations Audit).
- Contamination or waste caused, or emitted by, sources other than the premises subject to the Clean Up Notice.

The scope of this Audit prioritises the consideration of risk to off-site sensitive receptors, and investigations were focussed on these areas. On-site works were limited mainly to a review of existing data, site history data, and review of on-site monitoring data (such as biannual groundwater monitoring events), in the context of assessing risks to off-site receptors when considering the source-pathway-receptor model. For example, LNAPL fingerprinting was conducted on-site to characterise the potential source of off-site dissolved phase groundwater contamination.

It is noted that investigation and assessment works were targeted in high priority areas, so that any high priority risks to beneficial uses could be managed (if required) during the Audit process, rather than at Audit completion. This process was managed by establishing a Risk Register, which was prepared by the assessor (Golder) for Mobil, at the Auditor's request, and included prioritisation of key off-site issues.

1.7 Auditor's support team

The following members of the Auditor's approved Expert Support Team were involved in completing this Environmental Audit.

- Dr Ben Petrides: hydrogeology.
- Karen Teague: soil vapour risk assessment.
- Nick Woodford: soil vapour monitoring program, soil vapour fate and transport, and soil vapour risk assessment.
- Lyle Carpenter: remediation technologies and assessment.

It is also acknowledged that Mr Stephen Cambridge and Dr Adam Wightwick contributed as auditor support for reviewing reports and assisting in drafting text.

1.8 Stakeholder Engagement

Stakeholders involved in the Environmental Audit, either directly or indirectly, are listed as follows:

- EPA Victoria;
- Local residents and landholders;
- Melbourne Water;
- Local Council (Hobsons Bay City Council);
- Utility owners;
- Vicroads;
- Mobil and its Environmental Consultant(s); and
- Environmental Auditor.

The Auditor has directly involved EPA Victoria through periodic meetings during the period that the audit was conducted. In addition, the Auditor presented the scope of the audit at the Mobil community consultation meeting, which is a forum whereby Mobil provide community updates on the progress and findings of the Clean Up Notice works. Mobil and the environmental assessor (Golder) have had ongoing interaction with other stakeholders as part of the audit, including Melbourne Water (as part of the Kororoit Creek Reserve investigation) and Dial Before You Dig as part of the registration of potential hazardous zones in the utility corridors adjacent to the Refinery (eg under Kororoit Creek Road). In addition, Mobil and Golder have liaised with 7-Eleven regarding investigation works at the 7-Eleven Service Station on the north-west corner of the Millers Road and Kororoit Creek Road intersection.

A recommendation of the Audit report in relation to stakeholder engagement, is that the Auditor presents the key findings of the Audit Report at a future Mobil Community Consultation meeting.

2 AUDIT FRAMEWORK AND METHODOLOGY

2.1 Environmental audit report methodology

This audit was carried out in accordance with "*Environmental Auditor Guidelines for the Preparation of Environmental Audit Reports on Risk to the Environment*", EPA Publication 952.4 (dated April 2013) and the principles of AS/ NZS ISO 14010 (Guidelines for environmental auditing). The risk assessment methodology is presented in Section 2.2.4.

The audit involved the following:

1. Assembly of the audit team.
2. Confirmation of the audit scope by seeking comments from EPA and Mobil.
3. Receipt and assembly of information pertaining to the Refinery facility.
4. Attendance at an inception meeting with EPA and Mobil to confirm scope and approach, and to identify any additional information that may be available.
5. Inspection of the Refinery facility and review of specific items required in the Final Clean Up Notice. The main objective of this work was to obtain an understanding of the Refinery facility operations, identify potential hazards and issues regarding further consideration, and to identify environmental management and improvement works that Mobil has undertaken or proposes to undertake.
6. Audit of the environmental condition of the site and off-site including:
    - Assessment of the extent of contamination at and beyond the site boundary caused by past or current industrial processes, activities or wastes that may impact upon the beneficial uses of land and groundwater; and
    - Assessment as to whether the past or current industrial process, activities or wastes at the site pose a risk of harm to the beneficial uses of groundwater and land.

The audit findings were documented and a draft audit report prepared for review and comment by Mobil regarding its factual correctness. A meeting with EPA, Mobil and the Auditor took place to discuss the auditor's findings in broad terms and to confirm that the audit meets the EPA's requirements. A final audit report was then issued.

2.2 Audit Methodology

2.2.1 Audit Roadmap

In order to provide a framework for the assessment required to support the preparation of the 53V Audit report, an Audit 'Roadmap' was prepared at the early stages of the audit process. The Roadmap was a summary document of how the technical work plans for assessment, monitoring and interpretative reports related back to the audit scope and the Clean Up Notice requirements. A copy of the Roadmap is included in **Appendix C**.

The Roadmap detailed the 'focus areas' for soil and groundwater assessment, based on the existing assessment data and known or suspected areas of contamination. These focus areas did not limit the areas assessed in the Audit, however they were provided to allow formulation of workplans in the areas where risks to beneficial uses were thought to be higher. As assessment data was gathered throughout

the audit process, and interpretation of data was conducted, the Roadmap was amended to reflect any changing needs for investigation, based on the Clean Up Notice requirements, including delineation and assessment of risk.

2.2.2 Risk Register

It is noted that investigation and assessment works were targeted in high priority areas, so that any high priority risks to beneficial uses could be managed (if required) during the Audit process, rather than waiting for the Audit completion. This process was managed by establishing a Risk Register, which was prepared by the assessor (Golder) for Mobil, at the Auditor's request, and included prioritisation of key off-site issues, such as the Steam Cracked Naphtha LNAPL plume.

The purpose of the Risk Register was to prioritise areas of known contamination, based on a qualitative assessment of risk, so that assessment and investigation works were focussed in these areas, and any ongoing management of higher priority risks could be conducted during the audit timeframe, as necessary. The risk assessment conducted in the Risk Register was used as a guide during the audit process, however it is noted that the final risk assessment included in this 53V Audit report supersedes any of the earlier risk rankings presented in the Risk Register.

2.2.3 Source Pathway Receptor Model

Risk identification has been conducted based on the conceptual site models, previous environmental investigations, and inspections of the site operations. The approach to risk identification has been conducted based on two approaches, in accordance with the risk management guidance provided in the Standards Australia HB436:2013 *Risk Management Guidelines – Companion to AS/NZS ISO standard 31010:2009*:

1. **Source-pathway-receptor (environmental risk assessment) model**. For items relating to the site which have the potential to cause environmental impact, based on migration through environmental media, this approach has been adopted.
2. **Qualitative Risk Assessment**. Where a complete, or potentially complete, source-pathway-receptor linkage is present, an assessment of risk has been conducted based on the likelihood of receptor exposure to the contaminant and the consequence if the exposure occurred. This method of risk assessment is further discussed in Section 2.2.4.

Conceptual Site Models for the Refinery Area (comprising Processing Area, Blending Area and North Crude Tank Farm) and the South Crude Tank Farm (and the relevant off-site areas) have been formulated to assess the presence of plausible complete exposure pathways and hence the presence of significant risk to susceptible receptors such as humans or ecosystems. For a significant or identifiable risk to exist, an exposure pathway must be present which requires each of the following to be identified:

- The presence of substances that may cause harm (SOURCE);
- The existence of a means of exposing a receptor to the source (PATHWAY); and
- The presence of a receptor which may be harmed (RECEPTOR).

In the absence of a plausible complete exposure pathway there is no risk. In this respect, the presence of measurable concentrations of contaminants or other hazardous substances does not automatically imply that a contamination source will cause harm. In order for this to be the case a plausible complete exposure pathway must be present allowing a source to potentially adversely affect a receptor. The

nature and importance of both receptors and exposure routes, which are relevant to any particular site, will vary according to the site's characteristics and its environmental setting.

The source-pathway-receptor linkages identified by the assessor in the *Review of Potential Offsite Risk Pathways and Receptors Report* (Golder, 2014e), have been reviewed by the Auditor in conducting the risk assessment. These linkages are critically reviewed and discussed in Section 8.

2.2.4 Approach to Risk Assessment

The site assessment works completed by the assessor(s) have been used to assess the potential risks to receptors associated with contaminants inferred to be associated with the site. This has included comparison of reported concentrations against the adopted Site Assessment Criteria and documenting the Source Pathway Receptor Models for the different areas of the site.

The potential risks to receptors have been further characterised using a qualitative risk-based approach, adapted from the HB436:2013 *Risk Management Guidelines (*Standards Australia, 2013), and EPA Publication 1321.1. This has been used to *'specify the risks of any possible harm or detriment to beneficial uses of the environment'* as required in the Clean Up Notice issued by EPA.

The potential risks have been assessed separately for the different areas of the site as detailed in Table 2-1

Table 2-1: Risk areas of site

On-Site Areas	Off-site Areas

Refinery Area:
• Processing Area
• Blending Area
• North Crude Tank Farm (NCTF)
South Crude Tank Farm Area:
• South Crude Tank Farm (SCTF)
	• North of Refinery Boundary
	• East of Refinery Boundary
	  ○ East of NCTF
	  ○ Rail Corridor east of Processing Area
	  ○ East of Blending Area
	• West of Refinery Boundary
	  ○ 7-Eleven Service Station
	  ○ Pegasus Paddock and Pegasus Building
	  ○ North-West Paddock
	• South of Blending Area
	• Utility and Transport Corridors
	• South Crude Tank Farm (SCTF) Off-site Areas

A detailed description of each of these areas is provided in Section 3.1.

The approach adopted for characterising the potential risks has been based on considering the likelihood of an impact occurring and the potential consequences (i.e. a measure of severity) should the impact occur. The level of risk for each potential impact was then determined by combining the

likelihood and consequence to rank the potential risk as very low, low, medium, high or very high according to a risk ranking matrix. The descriptors used to classify the likelihood and consequences are detailed in Table 2-2 and Table 2-3. The risk ranking matrix adopted is presenting in Table 2-4.

The specific methodology has been used to assess the risks for each of the different areas of the site involved the following.

- Defining the beneficial uses of land, groundwater and surface water requiring protection.
- Identifying the chemicals of potential concern (COPC).
- Defining the source-pathway-receptor model to identify the complete and potentially complete exposure pathways to be carried forward for further assessment. Incomplete exposure pathways have not been subject to the further risk assessment process.
- Characterising the potential risk, according to the likelihood and consequence matrix, for each of the complete and potentially complete exposure pathways identified for each beneficial use. The potential risks have been determined as the *inherent risk,* i.e. the risk that would be present without consideration of any existing or proposed risk management control measures.
- Determining the need for and nature of risk management measures considered necessary.
- Documenting uncertainties in the risk assessment.

Table 2-2: Descriptors used to classify likelihood

Likelihood	Description	Frequency
Almost certain	Multiple incidents have been recorded	Is expected to occur almost all of the time
Likely	Several incidents have been recorded	Is expected to occur most of the time
Probable	Some incidents have been recorded	Might occur
Not likely	Few recorded or known incidents	Might occur but not expected to occur
Rare	No recorded or known incidents	Only expected to occur under atypical conditions

Source: Adapted from Standards Australia (2013); EPA Victoria Publication 1321.1 (2010).

Table 2-3: Descriptors used to classify consequences

Indicator	Description
Severe	Human deaths or significant on-going health issues (e.g. disabilities); operations cause catastrophic off-site impacts, immense financial loss. Serious environmental harm, potential environmental impacts are irreversible, of high impact and/or widespread, rehabilitation of environmental impacts requiring major effort.
Significant	Extensive human injuries or illness, significant ongoing medical treatment, operations cause substantial off-site impacts, major financial loss. Significant harm to ecosystem with clear potential for significant long-term changes, potential impacts to regional ecosystem, significant effort required to mitigate or rehabilitate.
Medium	Some health impacts to humans with individuals requiring medical intervention (e.g. hospital admission), not considered to cause long-term health impacts, operations cause some external impacts, large financial loss. Harmful to ecosystem with possibility on long-term changes, potential impacts in local area; environmental impacts can be rehabilitated with a low to moderate effort.
Minor	First aid treatment, temporary human health effects, operations cause minimal off-site impacts, small financial loss. Potentially harmful to ecosystem with no significant long-term changes, restricted to small localised area, environment impacts easily rectified.
Negligible	Operations cause no injuries or harm to human health, negligible off-site impacts, and negligible financial loss. Temporary or short-term reversible environmental impact.

Source: Adapted from Standards Australia (2013); EPA Victoria Publication 1321.1 (2010).

Table 2-4: Risk Evaluation Matrix

	Consequences				
Likelihood	**Negligible**	**Minor**	**Medium**	**Significant**	**Severe**
Almost certain	Medium	High	High	Very High	Very High
Likely	Low	Medium	High	High	Very High
Probable	Low	Low	Medium	High	High
Not likely	Very Low	Low	Low	Medium	High
Rare	Very Low	Very Low	Low	Low	Medium

Source: Adapted from Standards Australia (2013); EPA Victoria Publication 1321.1 (2010).

2.3 Site Inspections

In conducting this environmental audit, the Auditor and/ or his representative have completed numerous site visits and attended community consultation meetings. Further information is provided in Table 2.5.

Table 2.5 - Site visits and community consultation meetings attended by Auditor and/ or his representative

Date	Purpose/ activity	Who attended
13 May 2011	Initial site inspection to view the audit area and adjacent receptors	David Lam Stephen Cambridge
6 June 2012	Attended community consultation meeting with David Lam presenting on the requirements of the 53V Audit and his role in preparing the report.	David Lam Stephen Cambridge
13 June 2012	Inspection of drilling of groundwater monitoring wells north of Ross Road and viewing of soil core trays from drilling works.	Stephen Cambridge
27 June 2012	View soil core trays from drilling works completed by Golder.	Ben Petrides
28 June 2012	Inspection to view remediation trial (air-sweep) in Pegasus Paddock area.	David Lam Stephen Cambridge Lyle Carpenter
12 November 2012	Inspection of soil vapour sampling conducted at 7-Eleven located on the corner of Kororoit Creek and Millers Roads.	Stephen Cambridge
5 December 2012	Attended community consultation meeting with Mobil presenting on progress of works required to address Clean Up Notice	Stephen Cambridge
28 October 2013	Inspection of soil vapour sampling conducted at 7-Eleven located on the corner of Kororoit Creek and Millers Roads.	Nick Woodford
10 April 2014	Inspection of 7-Eleven site, specifically for Workshop area	Stephen Cambridge
4 June 2014	Inspection of Blending Area (soil management/storage area) and Kororoit Creek areas (south of Blending and south of the South Crude Tank Farm)	David Lam Ben Petrides Stephen Cambridge
28 August 2014	Site inspection and meeting with EPA and Mobil to advise on progress of Clean Up Notice requirements	David Lam Stephen Cambridge

2.4 Documents Reviewed

A large number of site assessment and monitoring reports were completed for the site, prior to the commencement of the Audit. A list of these reports is provided in **Appendix D-1**. The Auditor reviewed this list of reports, and requested a targeted selection of these reports, to enable an understanding of the pre-Audit conditions of the site, and assessment of risk where risk assessment had been conducted.

During the course of the Audit, a number of reports prepared by the site assessor, and some documents provided by Mobil, were reviewed by the Auditor and the auditor's support team. Review comments were provided on workplans and reports to Mobil and the site assessor (Golder Associates Pty Ltd). A list of the documents reviewed by the Auditor during the course of the Audit is provided in **Appendix D-2.**

3 SITE DESCRIPTION AND ENVIRONMENTAL SETTING

3.1 Site details

A summary of the site details are provided in Table 3.1.

Table 3.1 - Summary of Site Details

Site Details	Description
Site Address:	Corner of Millers and Kororoit Creek Roads, Altona, Victoria
Site Location:	The site is located approximately 10 km south-west of Melbourne CBD, on the southern side of the Westgate Freeway, Victoria. The site is split into two main areas, being the Refinery Area and the South Crude Tank Farm. The locations of these areas are shown on **Figures 1 and 2** attached.
Municipality:	Hobsons Bay City Council
Certificate of Title Details:	Lots 11 to 15 and Lots 18 to 27, on Plan LP966
Site Area:	83 hectares (Ha)
Zoning:	Special Use Zone 2 (SUZ2), under the Hobsons Bay Planning Scheme
Current Site Use:	The site is currently used for Industrial purposes (petroleum refining, storage and handling).

The site has four operational areas comprising approximately 83 Ha, with multiple boundaries and differing land uses beyond each of these boundaries.

These operational areas include:

- Processing Area
- Blending Area
- North Crude Tank Farm (NCTF)
- South Crude Tank Farm (SCTF)

The Refinery Processing Area, Blending Area and NCTF are adjacent to each other and essentially form one overall land parcel although it is acknowledged that Kororoit Creek Road exists between the processing and the Blending Areas and a rail corridor exists between the processing area and the NCTF.

The SCTF is a separate parcel of land that is surrounded by private property to the north (across Kororoit Creek Road) and west, a sporting reserve (J.T. Gray Reserve) to the east, and Kororoit Creek to the south. The SCTF area is underlain by a different geology to the other three operational areas (refer Section 3.4).

3.1.1 Refinery Processing Area

The Processing Area of the Refinery includes the following sub-areas:

- Bitumen Tankage and Load-out Area
- Processing and Refining Units
- Support Services
- Ancillary Units

3.1.2 Blending Area

The Blending Area of the refinery includes the following sub-areas:

- Blending Area Tankage
- Wastewater Treatment Facilities
- Solid Waste Management Area

3.1.3 North Crude Tank Farm (NCTF)

The NCTF includes Tanks 902, 903, 904 and 907 and a wet oil recovery tank (Tank 313). The NCTF can be broadly divided into the following sub-areas:

- Tankage – there are four large crude tanks located in the northern half of the area which have typically been in service for crude and cutback bitumen.
- Wastewater collection – wastewater collection and wet oil recovery facilities are located to the south of Tank 907.
- WAG pipeline terminal – this terminal has two key functions; to deliver crude oil to the NCTF and as a relay station for the WAG pipeline to the Shell Refinery in Geelong.
- ELGAS terminal – this terminal was developed as an LPG distribution facility to service the regional area. Operations of this terminal were ceased in 1980s, after additional LPG facilities were constructed in the south-east corner of the processing area in the 1970s.
- Open space – two open space areas are located along the southern boundary of the NCTF.

3.1.4 South Crude Tank Farm (SCTF)

The SCTF includes eight crude tanks. The details of the tanks located in the SCTF are:

- Tank 802 contains crude oil.
- Tanks 800, 801, 803 and 804 contain residual fuel.
- Tanks 805, 806 and 807 are used for storage of raw naphtha.

Additional information about the four operational areas discussed above and the site's history are presented in Section 4.

3.2 Site Setting and Surrounding Land Use

The Refinery Area (including the NCTF) covers approximately 74 ha of land and is surrounded by recreational open space, industrial, commercial and residential land. The SCTF covers approximately 9 ha of land.

Table 3.2 and 3.3 (below) summarises the adjacent land uses for each of the Refinery Area and the SCTF based on observations outlined in the Historical Operations Review (Golder, 2012c) and the State Government of Victoria planning scheme.

Table 3.2 - Surrounding Land Use for the Refinery

Direction	Land use
North	• Immediately adjacent to the northern boundary of the refinery is the Melbourne-Geelong rail line. Beyond this is a residential zone. A recreational zone exists beyond the rail line to the north of NCTF and the western part of the processing area. The recreational land includes soccer fields, Altona Lakes Golf Course and Paisley Park Reserve. Beyond the north-east corner of the processing area is vacant industrial land. Bayside Secondary College (Paisley Campus) is located approximately 1 km to the north, at the corner of Millers and McArthurs Road.
East	• To the east of the Refinery is commercial/ industrial land. In the northern section of this boundary, the Altona rail line separates the processing area from the NCTF. Further south, the rail line runs adjacent to the Blending Area boundary, separating it from the commercial and industrial land beyond. To the south-east of the Blending Area is public open space known as Altona Coastal Park which is zoned Public Conservation and Resource.
South	• Kororoit Creek and Kororoit Creek Reserve are located immediately to the south of the Blending Area. The reserve is zoned Service and Utility. Predominantly residential land, known as Seaholme, lies beyond the reserve about 300 m from the boundary. To the south-west is Cherry Lake Reserve.
West	• Millers Road is located immediately adjacent to the western boundary of the Refinery and beyond this is open space land that is currently owned by Mobil. A 7-Eleven Service Station is located on this land on the north-west corner of the intersection of Millers and Kororoit Creek Roads. On the south-west corner of the same intersection lies the Pegasus Building, an office building owned by Mobil, currently unoccupied owing to vapour risks identified to exist in relation to the Steam Cracked Naphtha plume. Beyond the Mobil land is open space known as Rowden's Swamp, which is part of the Kororoit Creek system. Further west, approximately 700 m from the boundary is a commercial and industrial area.

Table 3.3 - Surrounding Land Use for the SCTF

Direction	Land use
North	• Kororoit Creek Road and industrial/ commercial land (IN1Z) is located north of the SCTF.
East	• Immediately to the east of the SCTF is J.T. Gray Reserve (PCRZ) including Williamstown Cricket Club. Beyond this lies Jawbone Conservation Reserve at the point where Kororoit Creek meets Port Phillip Bay.
South	• Kororoit Creek and Altona Coastal Park (PCRZ) are located immediately to the south of SCTF. The land between the SCTF southern boundary and the creek appears to be zoned Special Use Zone 2. A public path (Hobson's Bay Coastal Trail) runs east west through this land.
West	• An area of industrial and commercial land (IN1Z) exists to the west, however, limited residential use has been observed within this area. The residential use area is located immediately adjacent to the boundary in Techno Park.

3.3 Sensitive Receptors

Sensitive receptors located within the vicinity of the Refinery, with respect to potentially contaminated land are presented on **Figure 2** attached and as follows:

- Residential properties:
  - Approximately 90 m north of the site (Ross Road area);
  - Approximately 320 m south of the site (Seaholme); and
  - Immediately west of the South Crude Tank Farm (Techno Park Drive area).
- Surface water features:
  - Kororoit Creek located approximately 30 m south of the Refinery at its closed point, and approximately 20 m to the south of the South Crude Tank Farm;
  - Rowden's Swamp (part of Kororoit Creek) located adjacent to Pegasus Paddock and about 450 m to the west of the Refinery boundary;
  - Cherry Lake located approximately 500 m to the south-west of the Refinery;
  - Port Phillip Bay, located approximately 1,000 m to the south south-east of the Blending Area part of the Refinery, and approximately 400 m south of the South Crude Tank Farm;
  - There are other drains surrounding the site, including Paisley Drain located approximately 250 m to the east of the North Crude Tank Farm.
- Parks and reserves:

  - Kororoit Creek Reserve: located to the immediate south of the Blending Area part of the Refinery and South Crude Tank Farm. This reserve includes an Environmental Significance Overlay under the Hobson's Bay Planning Scheme.
  - Altona Coastal Park: located to the immediate south of the South Crude Tank Farm. This reserve includes an Environmental Significance Overlay under the Hobson's Bay Planning Scheme.
  - Cherry Lake Reserve: located approximately 500 m to the south-west of the Refinery
  - J.T. Gray Reserve: is located to the immediate east of the South Crude Tank Farm.
  - S. J. Clement Reserve and Paisley Park: are located approximately 90 m to the north of the Refinery.
- Licensed groundwater extraction bores: the updated Conceptual Site Model (Golder, 2014a), states that there are 141 registered groundwater wells within a 2 km radius of the site, with twelve of these bores listed for extractive uses (and four with no registered use). Of these, no registered extraction bores (including those with no registered use), are within close enough proximity to the site to be potentially affected by existing groundwater contamination originating from the Refinery. Nevertheless, impact to groundwater is still considered to have potential to affect sensitive receptors, as the identified protected beneficial uses of groundwater require protection from groundwater contamination.

In addition to these potentially sensitive receptors, other receptors considered within this 53V Audit report, include adjacent off-site commercial/maintenance workers, including those associated with the following.

- The 7-Eleven Service Station located to the immediate west of the Refinery Processing Area on the north-west corner of Millers Road and Kororoit Creek Road.
- The Pegasus Centre located to the immediate west of the northern part of the Blending Area (currently unoccupied).
- Underground utilities surrounding the site in road reserves and utility corridors.
- Other commercial premises surrounding the site, predominantly to the east of the Refinery Area and to the west of the South Crude Tank Farm.

3.4 Geology

The Site geology and hydrogeology is described in detail in the following reports (refer to **Appendix E**):

- Hydrogeological Assessment (1 November 2013) Golder Associates 137613001-002-R-Rev0
- Altona Refinery -Groundwater Condition Report (4 February 2014), Golder Associates, 137613001-071-R-Rev1
- Altona Refinery –South Crude Tank Farm Groundwater Condition Report (20 January 2014), Golder Associates, 137613001-024-R-Rev1

An overview of the site geology from these reports is presented as follows.

The site is located at the south-eastern edge of a landscape unit known as the Werribee lava plain which developed during the late Tertiary to Quaternary periods. This plain was formed by a sequence of stacked basaltic lava flows during episodes of volcanic activity. The plain is intersected by creeks and

rivers, with the valleys of these water courses generally developed along the edges of the basalt flows (such as Kororoit Creek).

After cessation of the volcanic activity in the coastal area between Altona and Williamstown, extensive shallow marine (Port Melbourne Sand) to estuarine or mangrove type deposits (i.e. coastal swamp deposits) developed above the Newer Volcanics.

The geological units encountered on-site are presented in **Figures 10 to 17**, and in the following table.

Table 3.4 Summary of Geological Units in the Refinery Area (from Golder, 2014g)

Geological Age	Geological Unit		Description	Aquifer Classification
Quaternary	Coastal Swamp Deposits		Fine sand to silt and silty clay, often with shells	Unconfined low yielding aquifer (where sandy), porous medium. Aquitard (where clayey). Localised in extent.
	Port Melbourne Sand		Well sorted sand, shelly sand, minor silty and clayey sand	Unconfined sand aquifer, Localised in extent.
	New Volcanics		Basalt, variably weathered and fractured	Unconfined to confined fractured rock aquifer. Hydraulic parameters varying according to fracturing and weathering.
Tertiary	Upper Tertiary Deposits	Brighton Group	Variable sand and clay	Confined aquifer, porous medium. Medium yielding aquifer where sandy but aquitard where clayey
		Fyansford Formation	Silt, calcareous silt, silty clay and minor limestone	Typically aquitard
	Werribee formation		Sand, silty sand, carbonaceous clay and coal seams	Confined sand aquifer to aquitard in the coal beds encountered towards the top of the formation.

Geological Age	Geological Unit	Description	Aquifer Classification
Silurian	Melbourne Formation	Siltstone and mudstone, folded, fractured and variably weathered.	Confined fractured rock aquifer, Hydraulic parameters varying according to fracturing and weathering.

South Crude Tank Farm Area Geology

The geology in the SCTF area differs somewhat from the Refinery area, due to the location of the SCTF coinciding with the Quaternary Sediments, and the absence of the Newer Volcanics basalt in the central part of the SCTF. Subsurface geology in the SCTF consisted of fill material at isolated locations, underlain by Quaternary Sediments, which are the main lithological unit of relevance to the SCTF. Fill ranged in depth between 0.5 m to 1.0 mbgs and generally consisted of clay to sandy silty clay, with some basalt fragments. Quaternary Sediments generally consist of fine sand to sandy silty clay and silty clay, often containing shell fragments.

Residual basaltic clay was present below the Quaternary Sediments beneath the main part of the SCTF area and was encountered at depths between 4.9 mbgs and 10.7 mbgs. The upper part of this formation consists of silty clayey sand to mottled clay.

Cross sections of the South Crude Tank Farm area are presented on **Figures 12 and 13** attached.

3.5 Hydrogeology

3.5.1 Aquifer System

Multiple aquifers occur within the stratigraphic profile, however there are two relevant water table units which are identified in the site area, one being the Newer Volcanics aquifer unit covering the main part of the Refinery and the other being the Quaternary Sediments aquifer, covering localised area at the southern and eastern margins of the Refinery, and the South Crude Tank Farm. Groundwater flow within the Quaternary Sediments is considered to be a porous flow system. The Newer Volcanics is the main regional water table aquifer, without groundwater flow being within rock fractures and weathered basaltic rock.

The deeper aquifer system comprises the Tertiary Brighton Group and Fyansford deposits. This aquifer system is confined by the overlying Newer Volcanics. The following table summarises the three aquifers.

Table 3.5 Summary of Aquifer Units in Refinery Area (from Golder, 2014g)

Age	Aquifer Unit		Description	Classification
Quaternary	Quaternary Sediments		Fine sand to silt and silty clay, often with shells	Unconfined low yielding aquifer (where sandy), porous medium. Aquitard (where clayey). Localised in extent.
	Newer Volcanics		Basalt, variably weathered and fractured	Unconfined to confined fractured rock aquifer. Hydraulic parameters varying according to fracturing and weathering
Tertiary	Deeper Aquifer System	Brighton Group/Fyansford deposits	Variable sand and clay, Silt, calcareous silt, silty clay and minor limestone (Fyansford)	Confined aquifer, porous medium. Medium yielding aquifer where sandy but aquitard where clayey.

3.5.2 Groundwater Flow

From literature data, the general groundwater flow direction within the Newer Volcanics aquifer is inferred to be in a south-easterly direction, in the direction of Port Phillip Bay. Based on the groundwater gauging data, the general regional groundwater flow direction is to the east, however a number of local flow paths have been identified to the south, south-west and south-east across the Site towards Kororoit Creek.

Localised groundwater mounding has been identified in some parts of the Refinery, most likely associated with localised leakage of man-made structures such as stormwater pipes and ponds.

The hydraulic gradient is generally flat across the site, with some indication that the gradient becomes steeper towards the south, directly up-gradient of where the watertable transitions between the Newer Volcanics and the Quaternary Sediments. This steepening is inferred to indicate a reducing hydraulic conductivity around this transition zone.

Well pairs monitoring the head difference between the watertable and deeper aquifer systems at the site recorded a relatively pronounced difference in the groundwater levels, with greater heads in the deeper aquifer than the water table aquifer, indicating potential for upward groundwater flow.

3.6 Topography, Drainage and Natural Water Courses

The following discussion is reproduced from the Mobil Altona Refinery Conceptual Site Model (Golder, 2014a).

3.6.1 Surface Water Features

Regional surface water features in the proximity of the Refinery are shown in **Figure 4**. The Site is located in the catchment of Kororoit Creek, which is the nearest surface water body. This creek flows in a southerly direction along the western boundary of Pegasus Paddock before turning to the east along the southern boundaries of the Blending Area part of the Refinery, and the SCTF. Kororoit Creek is

inferred to be the main surface water body relevant to the CSM that applies in the Refinery Area and SCTF. Kororoit Creek discharges into Port Phillip Bay via Hobsons Bay and the Altona Coastal Park which is located approximately 400 m east of the SCTF.

Kororoit Creek is tidally influenced by Port Phillip Bay in the Site area. The upstream limit of tidal influence along the creek is inferred to be Rowdens Swamp (**Figure 4**) located west of Millers Road. The creek is inferred to be estuarine downstream of this point. Cherry Lake is the other dominant surface water feature within the Site area, lying approximately 1.2 km south-west of the Refinery area (on the opposite bank of Kororoit Creek). The lake is generally shallow with an average approximate depth of 1 metre. It is understood that Cherry Lake water is partially fed from active groundwater extraction from the deeper Werribee Formation aquifer.

3.6.2 Drainage Features

Regional drainage features in the proximity of the Refinery are shown in **Figure 3**.

The main surface water drainage features surrounding the site are Melbourne Water open stormwater drains. There are two major drains in the area, north of Kororoit Creek.

- Millers Road Drain is located to the west of Millers Road and in a north to south direction before discharging into the northern section of Rowden's Swamp along Kororoit Creek, upstream of the Refinery. This drain is a modified natural, unlined drain.
- Paisley Drain is located east of the Refinery and north of the SCTF. The drain transects the Williamstown industrial park and conveys water to the south-east. The drain discharges into the Paisley Challis wetland which is some 350 m east of the SCTF. This drain is man-made and concrete-lined. The wetland in turn drains into the mouth of Kororoit Creek where the creek discharges to Port Phillip Bay, some 500 m east/south-east of the SCTF.

The flow contribution of other surface water drainage features to Kororoit Creek is considered to be limited in comparison to these two main drains.

3.6.3 Kororoit Creek Hydrology

Surface water has been monitored since 2009 at seven sampling locations on Kororoit Creek, labelled KCR1 – KCR7 (Figure 18 of Golder, 2014a). In addition to these locations, three stream gauges (gauging boards) have been monitored, labelled S/G1, S/G2 and S/G3.

Recent level and flow data is available for gauging site 231104 (Brooklyn). This is the closest long-term monitoring location to the Site for flow data. The flow data indicate that the flow regime in Kororoit Creek varies considerably, with runoff strongly affected by rainfall and storm events. The base flow may be in the order of 1 to 2 ML per day. The water levels in Kororoit Creek ranged between -0.4 mAHD and 0.4 mAHD based on the data collected from the creek south of the Blending Area (i.e. surface water monitoring location SWD1). The surface water level and water quality data collected to date have confirmed that the creek is tidally influenced within the Site area. This involves the presence of a saltwater wedge at the bottom of the creek, which extends further upstream at high tide, and further downstream at low tide.

3.6.4 Surface Water Drainage from Site

The stormwater catchments at the Refinery drain from north to south, with the northern boundary of Processing Area being the top of the catchment. These catchments cover most areas of the Refinery, except for the following.

- Soil Management Area, located on the eastern boundary of the Blending Area.
- Southern half of NCTF (**Figure 4**) which is leased from Mobil (and operated) by others.

Overall, surface discharge to the surrounding environment from the Refinery is inferred likely to be limited to surface water discharge along the eastern boundary of the Blending Area (in the vicinity of the Soil Management Area) where overland flow may occur into the adjacent rail corridor.

Golder Associates has observed that a shallow, unlined, surface water drain runs along the eastern boundary of the Blending Area via the rail corridor. The drain flows south from Kororoit Creek Road, before passing east under the railway line via a set of culverts. The drain then continues to flow south between the rail corridor and Racecourse Road before discharging into Kororoit Creek.

3.6.5 Topography

In the broader area of the site, the regional topography slopes from an elevation of approximately 8 mAHD in the north-west of the Site, to less than 1 mAHD along the shore line of Port Phillip Bay to the south-east of the site (Figure 3 of Golder, 2014a).

Site topography is described as follows.

- The Refinery Area topographical surface slopes gently from an elevation of approximately 8 mAHD in the north to around 4 mAHD in the south, towards Kororoit Creek. A low-lying area with an elevation of approximately 2 mAHD exists to the east and south-east of the Refinery. This area coincides with a former coastal swamp, which has been in-filled historically. Kororoit creek lies approximately 30 m south of the Blending Area boundary.
- SCTF is relatively flat, with a gentle slope from an elevation of approximately 2 mAHD in the north to approximately 1 mAHD in the south, towards Kororoit Creek. The southern boundary of the SCTF is approximately 10-20 m from the creek.

4 SITE SOURCES OF CONTAMINATION AND CHEMICALS OF POTENTIAL CONCERN

The Site history and chemicals of potential concern (COPCs) have been investigated and described in detail in the following reports (refer to **Appendix E**):

- Summary and Findings, Historical Operations Review, Mobil Altona Refinery (December 2012), Golder Associates 097651007-389R-Rev 0, Volume 1 and 2:
- Altona Refinery - Groundwater Condition Report (4 February 2014), Golder Associates, 137613001-071-R-Rev1
- South Crude Tank Farm - Groundwater Condition Report (20 January 2013), Golder Associates, Report137613001-024-R-Rev1

An overview of the site history and COPCs from these reports is presented as follows.

4.1 Refinery Area Potential Sources of Contamination

The following provides an overview of the key potential sources identified from the historic operations at the Refinery.

Releases of chemicals to ground from the following:

- Operational tanks and activities such as tank dewatering, during product transfer and from beneath tanks.
- Piping and valving during product transfer and from beneath processing units.
- Pump bays, pits, PIG handling areas and product transfer stations.
- Load in and load out of bitumen products, bitumen cutting agents, acids and caustic solutions.
- The flare pit and elevated flare knock out drums.
- Fire training exercises.
- Waste water and sewer system that may have received refining product.
- Lubricants used to service pumps and mechanical equipment, however, it is inferred that these were of low volume and typically stored in drums.
- Seepage of untreated and treated waste water and/ or wet oil from treatment ponds and the lagoon.
- Burial of sludge from tank cleaning inside tank compounds.

The past management of sludges and contaminated soils, including infilling of land (particularly in the NCTF), has the potential to present diffuse sources of contamination to groundwater and represent a source to off-site surface waters, where the surface water run-off from these areas is not captured by the waste water treatment system.

4.2 Refinery Key Chemicals of Potential Concern

Chemicals of Potential Concern are those which are known or suspected to be present at concentrations high enough to warrant inclusion in the assessment of potential off-site risk to human

health and ecology. A more detailed review of potential COPCs has been undertaken as part of the historical operations review (Golder, 2012c) and the Updated Site Assessment Criteria (Golder, 2014d) reports. Based on this review, the following COPCs have been identified, coinciding with the main activities and products involved in operations at the Refinery.

- Total petroleum hydrocarbons (TPH) as a general indicator of hydrocarbon impact.
- Benzene, toluene, ethylbenzene and total xylenes (BTEX) as specific indicators of the presence of impact from more volatile fractions of the Refinery processes. Additional volatile organic compounds (VOCs), in particular styrene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, isopropylbenzene, n-propylbenzene, sec-butylbenzene and cis-1,2-dichloroethene are also COPCs, based on detections of these chemicals from recent groundwater monitoring events at the Refinery.
- Polycyclic aromatic hydrocarbons (PAHs) associated with bitumen, crude oil use and processing, as well as naphtha.
- Phenolic compounds as a component of crude oil and possibly naphtha.
- Chlorinated Hydrocarbon Compounds (CHCs), in particular trichloroethene, tetrachloeoethene, 1,1,2-trichloroethane and 1,2-dichloroethane.
- pH as indicator of process involving caustic or acid processes.
- Total dissolved solids (TDS) as a general indicator of saline waste water and other possible process impacts. This would be less applicable to wells located in the Kororoit Creek Reserve due to the potential tidal influence and therefore naturally higher TDS levels that are present. TDS is also important for the groundwater Segment classification and subsequent determination of the beneficial uses to be protected.
- Sulphur related to sulphur recovery.
- Hydrogen sulphide produced from the desulphurisation of jet fuel.
- Polychlorinated biphenyls (PCBs) associated with past PCB containing oils in Transformers in Substations. PCBs are considered as COPCs for soil rather than groundwater.
- Metals (consisting of arsenic, aluminium, cadmium, chromium, copper, mercury, nickel, lead, vanadium, and zinc) as indicators of processing impacts from the use of catalysts (consisting of cobalt, molybdenum platinum, rhenium) and/or produced as by-products.

Further discussion of chemicals of potential concern, with respect to the different boundary areas of the site, is presented in the risk assessment in Section 8.

4.3 South Crude Tank Farm Potential Sources of Contamination

The following provides an overview of the key potential sources identified from the historic operations at the SCTF.

Releases of contaminants to ground from:

- Operational tanks and activities such as tank dewatering, surface releases and release beneath tanks.
- Pump bays, pits, PIG handling areas, the hot oil heating system (Lirik Heater) and product transfer stations.

- Lubricants used to service pumps and mechanical equipment, however, it is inferred that these were of low volume and typically stored in drums.
- Burial of sludge from tank cleaning inside tank compounds.

4.4 South Crude Tank Farm Key Chemicals of Potential Concern

Chemicals of Potential Concern are those which are known or suspected to be present at concentrations high enough to warrant inclusion in the assessment of risks to human health and ecology. The chemicals of interest for the SCTF include the following:

- TPHs as a general indicator of hydrocarbon impact.
- BTEX as specific indicators of the presence of impact from more volatile fractions of product such as raw naphtha stored at the SCTF. Additional VOCs, in particular isopropylbenzene and npropylbenzene, are also COPCs, based on detections of these chemicals from a recent groundwater monitoring event at SCTF.
- Polycyclic aromatic hydrocarbons (PAH) associated with crude oil and raw naphtha stored at the SCTF.
- Phenolic compounds as a component of crude oil and possibly naphtha.
- Metals (consisting of arsenic, aluminium, cadmium, chromium, cobalt, copper, mercury, molybdenum, nickel, lead, platinum, rhenium, vanadium and zinc) as processing by-products that may have been stored at SCTF or impacted fill that may have been used to reclaim or grade the SCTF during its development.
- Sulphur related to sulphur recovery.

Further discussion of chemicals of potential concern, with respect to the different boundary areas of the site, is presented in the risk assessment in Section 8.

5 BENEFICIAL USES REQUIRING PROTECTION

As discussed in Section 1 of this report, the following elements were nominated to be considered as part of the Audit Scope, in order to meet the objectives of the Clean Up Notice:

- Land and aesthetics within the area described above.
- Groundwater beneath the site and beyond the site.
- Vegetation.
- Surface water receptors in the vicinity of the site.
- Air quality at and immediately adjacent the site, due to potential emissions from soil and groundwater with respect to human health.

The scope of this Audit prioritises the consideration of risk to off-site sensitive receptors, and investigations were accordingly focussed on the relevant nearby off-site areas. The term ”Beneficial Use” is defined in the Act and those beneficial uses to be protected for the various elements are set out within various State Environment Protection Policies established pursuant to the Act. Elements forming part of the site have been evaluated as noted below.

5.1 Land

The *State Environmental Protection Policy* (*Prevention and Management of Contamination of Land*) 2002 [“the Land SEPP”] sets out the regulatory framework for the prevention and management of contaminated land within the State of Victoria. The intent of this framework is to maintain and maximise (to the extent practicable) the quality of the land environment in Victoria, in order to protect its existing and potential beneficial uses.

The Land SEPP identifies and defines specific land use categories as well as a number of protected beneficial uses associated with each of the land use categories.

EPA Victoria considers that land (soil) is polluted where current and / or future protected beneficial uses for the relevant land use categories are precluded. Beneficial uses of land are considered to be precluded when relevant soil quality objectives set out in the Land SEPP for those beneficial uses have been exceeded.

Based on the off-site landuses and associated receptors considered, the beneficial uses of land requiring protection are those shaded in Table 5.1, which is a reproduction of Table 1 from the Land SEPP.

Table 5.1 - Protected Beneficial Uses of Land

Beneficial uses	Land Use						
	Parks & Reserves	Agricultural	Sensitive Use		Recreational / Open Space	Commercial	Industrial
			High Density	Other			
Maintenance of Ecosystems:-							
Natural Ecosystems	✓						
Modified Ecosystems	✓	✓		✓	✓		
Highly Modified Ecosystems		✓	✓	✓	✓	✓	✓
Human Health	✓	✓	✓	✓	✓	✓	✓
Buildings & Structures	✓	✓	✓	✓	✓	✓	✓
Aesthetics	✓		✓	✓	✓	✓	
Production of Food, Flora & Fibre	✓	✓		✓			

In accordance with the Land SEPP, the relevant beneficial uses of land that must be protected for off-site land is summarised in the following table.

Table 5.2 – Summary of Beneficial Uses of Off-Site Land

Sensitive land (residential)	Recreation/Open Space	Parks and Reserves	Commercial/Industrial
• North of the site (Ross Road area); • South of the site (Seaholme); • West of the SCTF (Techno Park Drive area).	• South of Refinery and SCTF: Kororoit Creek Reserve; • North of Refinery: SJ Clement Reserve and Paisley Park • East of SCTF (J.T. Gray Reserve).	• South of Refinery and SCTF: Kororoit Creek Reserve. As this area is subject to an Environmental Significance Overlay, the beneficial use of 'Natural Ecosystems' is considered appropriate, however production of Food, Flora and Fibre is not considered relevant for this area based on the landuse and Zoning.	• Rail and road corridors which border and divide the site. • 7-Eleven Service Station and Pegasus Centre (currently vacant) to the west of the site. • Industrial and commercial land located east and south of the NCTF and west and north of the SCTF.

5.2 Groundwater

The quality of groundwater in Victoria is protected under the *State Environmental Protection Policy Groundwaters of Victoria* 1997 ["the Groundwater SEPP"]. The stated goal of this policy is to "*maintain and where necessary improve groundwater quality sufficient to protect existing and potential beneficial uses of groundwater throughout Victoria"*.

The protected beneficial uses of groundwater are defined in Groundwater SEPP on the basis of the inherent capacity of the groundwater at the site to support specific uses (i.e. the concentration of total dissolved solids). The significance of contaminant impact upon groundwater is assessed in conjunction with the applicable beneficial use.

Table 5.3 reproduces the relevant beneficial use table from the Groundwater SEPP.

Table 5.3 – Aquifer Classification Based on Site TDS Level^

Beneficial Uses	Segments Based on TDS Range (mg/L)				
	A1	A2	B	C	D
	0 - 500	500 – 1,000	1,000 – 3,500	3,500 – 13,000	Greater than 13,000
Maintenance of Ecosystems	✓	✓	✓	✓	✓
Potable Water Supply					
- Desirable	✓				
- Acceptable		✓			
Potable Mineral Water Supply	✓	✓	✓		
Agriculture, Parks and Gardens	✓	✓	✓		
Stock Watering	✓	✓	✓	✓	
Industrial Water Use	✓	✓	✓	✓	✓
Primary Contact Recreation	✓	✓	✓	✓	(1)*
Buildings & Structures	✓	✓	✓	✓	✓

*(1) – Primary Contact Recreation is excluded on the basis that groundwater at this salinity will corrode pool pumps.

^- The above table is a reproduction of Table 2 from State Environment Protection Policy (Groundwaters of Victoria), December 1997.

The protected beneficial uses of groundwater for the main Refinery area and the South Crude Tank Farm are discussed as follows, as detailed in the Updated Conceptual Site Model (Golder, 2014a).

Refinery Area

The TDS of groundwater at the Refinery Area ranges from about 3,000 mg/L up to 22,000 mg/L, with the typical range in the order of 7,000 mg/L to 9,000 mg/L. In accordance with the Groundwater SEPP the groundwater is classified as Segment C, and the following beneficial uses are protected:

- Maintenance of ecosystems (discharge to fresh and marine aquatic ecosystems);
- Stock watering;
- Industrial water use;

- Primary contact recreation; and
- Protection of buildings and structures.

South Crude Tank Farm

The TDS of groundwater at the SCTF ranges from about 312 mg/L up to 19,800 mg/L, with the typical range in the order of 2,500 mg/L to 6,000 mg/L. The lowest TDS values can be considered anomalous, and would not represent typical groundwater quality for any extractive use. In accordance with the Groundwater SEPP the groundwater, based on the typical range of TDS values, is classified as Segment B, and the following beneficial uses are protected:

- Maintenance of ecosystems (discharge to fresh and marine aquatic ecosystems);
- Potable mineral water supply;
- Agriculture, parks and gardens;
- Stock watering;
- Industrial water use;
- Primary contact recreation; and
- Protection of buildings and structures.

Potable mineral water supply is not considered a beneficial use as the groundwater in the area as the site is not in a recognised mineral springs district.

5.3 Surface Water

The SEPP Waters of Victoria classifies Kororoit Creek under the Estuaries and Inlets segment. The protected beneficial uses under this segment are:

- Protection of aquatic ecosystems: ‘slightly to moderately modified ecosystem’.
- Primary contact recreation: bathing and swimming and secondary contact recreation (wading).
- Aesthetic enjoyment: for example visual enjoyment.
- Indigenous cultural and spiritual values. Not considered relevant with respect to potential contamination of surface waters.
- Non- Indigenous cultural and spiritual values. Not considered relevant with respect to potential contamination of surface waters.
- Aquaculture: considered to be unlikely in the vicinity of the site.
- Industrial and commercial use: considered to be unlikely in the vicinity of the site.
- Fish, crustacean and molluscs for human consumption: an unlikely but possible beneficial use in this area.

5.4 Sediment

The Auditor considers that the beneficial use of ecosystem protection that applies for soil also applies for sediment in Kororoit Creek. Sediment is present in the creek bed of Kororoit Creek, where groundwater is likely to discharge via the Newer Volcanics aquifer to the Quaternary Sediments aquifer (south of the Refinery) and from the Quaternary Sediments aquifer (south of the South Crude Tank Farm). In addition, surface water run-off from the Refinery and SCTF discharges to Kororoit Creek and is a potential source of contaminated sediment which may accumulate within Kororoit Creek. For sediments, the following beneficial uses have been considered in the 53V Audit:

- Maintenance of Ecosystems: natural and modified ecosystems.

5.5 Air

Beneficial uses of air have been considered in respect of potential off-site human health impacts from vapours arising from soil and groundwater- borne hydrocarbon impacts.

6 SITE CRITERIA

The environmental quality objectives identified in the SEPPs generally form the basis for appropriate audit criteria to assess risk to beneficial uses. Criteria for the audit have been adopted from the following:

- Environmental quality objectives prescribed by the relevant SEPPs and schedules to the SEPPs, as identified below; and
- The requirements of the Clean Up Notice.

The adopted criteria have been presented in the Updated Site Assessment Criteria Report (Golder, 2014d), as provided in **Appendix E5** to this Audit report. The adopted site assessment criteria are further discussed in Section 6.2

6.1 Relevant State environment protection policies

The activities at the Refinery should not impact the beneficial uses nominated by the SEPPs, namely:

- State environment protection policy (Groundwaters of Victoria), 1997 (SEPP GoV);
- State environment protection policy (Prevention and Management of Contaminated Land), 2002 (the 'Land SEPP');
- State environment protection policy (Waters of Victoria), 2003 (the 'SEPP (WoV)'); and
- State environment protection policy (Air Quality Management), 2001 (the 'Air SEPP').

The SEPPs describe the beneficial uses that apply to a particular geographic region or water type.

Depending on the current and likely future uses of the land, surface water and groundwater on and near the Refinery, some beneficial uses will be relevant and others may be unlikely to be realised. In the case of the Groundwater SEPP, the beneficial uses to be protected are based on level of total dissolved solids (TDS). For the Air SEPP, the beneficial uses of air relate to those that may be impacted by contaminated soil and groundwater, and will be considered as an extension of the Land SEPP assessment.

6.2 Site Assessment Criteria

An assessment and compilation of the adopted site criteria for soil, groundwater and surface water has been prepared and presented in the Updated Site Assessment Criteria Report (Golder, 2014d), as provided in **Appendix E-5** to this Audit report. Generic screening criteria have not been specifically adopted for soil vapour (air), but rather this has been addressed on scenario specific basis.

The Auditor has reviewed the adopted criteria presented in the Updated Site Assessment Criteria Report, and has accepted the use of these criteria, with the following clarifications:

- TPH criteria adopted for recreational use of groundwater were not derived to be protective of aesthetic considerations. It is likely that taste and odour thresholds are lower than those adopted and hence will be qualitative as no suitable criteria have yet been established. It is noted the Alberta Tier 1 Soil and Groundwater Guidelines were finalised in May 2014, prior to the completion of the Updated Site Assessment Criteria Report, however the TPH criteria adopted has not included the recently released criteria. The Alberta guidelines present criteria for the heavier TPH fractions F3 and F4 which will be adopted where no other criteria is available. However, on the basis that criteria

have not been developed for the protection of ecological receptors at the point of discharge to a surface water body, the Dutch Intervention Value of 0.6 mg/L for the TPH C_{10}-C_{36} will be adopted.

- Indoor air quality criteria were not directly addressed in this report however the USEPA regional screening levels were adopted as part of the soil vapour screening process. The USEPA RSLs are considered appropriate to assess chronic inhalation risks. Health risks associated with acute exposures were not addressed in this report however acute criteria for benzene developed by the ATSDR (2007) was referenced in the Q4 2013 Status of Works (Golder 2014j) and is considered appropriate. Other volatile compounds were detected in indoor or ambient air (as part of the 7-Eleven vapour assessment), however given RSL criteria derived for chronic health effects were not exceeded, acute criteria were not required for other compounds.
- Although marine criteria have been adopted for Kororoit Creek, there remains some uncertainty as to whether the creek can be considered estuarine for the entire portion down-gradient of the site. The variance in TDS and visual indicators such as plants varieties along the creek indicates freshwater criteria may be more appropriate south of the Blending Area and marine criteria south of the South Crude Tank Farm. However, given the TDS of the creek down-gradient of the site, the water is generally consistent with an estuarine environment. On this basis it is therefore agreed that the marine criteria be adopted.

7 SITE DESCRIPTION AND NATURE AND EXTENT OF CONTAMINATION

7.1 Overview of Contamination Detailed in Assessment Reports

Detailed description of the site contamination, both on-site and off-site, is provided in numerous reports (refer to **Appendix D**). Consolidated summaries of the recent soil and groundwater conditions are presented in detail in following reports:

Off-Site Soil Conditions:

- Legacy Soils Impact Assessment - Kororoit Creek Reserve, 1 April 2012, Golder Associates 097651007-428L-Rev 0
- Kororoit Creek Soil Investigation, 23 October 2012, Golder Associates 097651007-532R-Rev0
- J.T. Grey Reserve Soil Investigation, 9 January 2013, Golder Associates 097651007-591R-Rev0
- Updated Conceptual Site Model, 17 April 2014, 147613001-012-R-Rev0

On-Site and Off-Site Groundwater Conditions:

- South Crude Tank Farm Groundwater Condition Report, 20 January 2014, Golder Associates 137613001-024-R-Rev1
- Groundwater Condition Report, 4 February 2014, Golder Associates 137613001-071-R-Rev0 Altona Refinery
- Updated Conceptual Site Model, 17 April 2014, 147613001-012-R-Rev0
- Groundwater Monitoring Event Second Half 2013, 14 January 2014, Golder Associates 137613001-084-R-Rev0

Off-Site Soil Gas Conditions:

- Soil Gas Condition Report, 18 October 2013, Golder Associates 137613001-058-R-Rev0
- 7-Eleven Service Station Indoor Air Quality and Soil Gas Monitoring, 21 January 2014, Golder Associates 137613001-092-R-Rev0
- 7-Eleven Service Station Updated Conceptual Site Model, 21 May 2014, Golder Associates 147613001-010-R-Rev 1
- Utility Pit Monitoring Report 4Q13, 3 February 2014, Golder Associates 137613001-100-L-Rev 0
- Updated Conceptual Site Model, 17 April 2014, 147613001-012-R-Rev0

Off-Site Surface Water Conditions (Kororoit Creek):

- Kororoit Creek Reserve Soil Validation and Surface Water Sampling, dated 17 May 2011, Golder Associates Ref 097651007 302R Rev 2
- Groundwater Monitoring Event Second Half 2013, 14 January 2014, Golder Associates 137613001-084-R-Rev0
- Updated Conceptual Site Model, 17 April 2014, 147613001-012-R-Rev0

Off-Site Sediment Conditions (Kororoit Creek):

- Updated Conceptual Site Model, 17 April 2014, 147613001-012-R-Rev0

The scope of this Audit prioritises the consideration of risk to off-site sensitive receptors, and investigations were focussed on these areas. The on-site works were generally limited to a review of existing data, with the exception of the installation of groundwater monitoring wells for delineation purposes, and biannual monitoring of all on-site and off-site monitoring wells, as detailed in the Groundwater Quality Management Plan (Golder, 2013h).

The soil, groundwater, soil gas, surface water and sediment conditions are summarised in the following sections, with a focus on off-site and boundary areas. The site and associated off-site areas have been divided into discrete areas for the purposes of describing the environmental conditions and risk assessment. These areas are described in Table 7.1 below.

Table 7.1 – Mobil Refinery Audit Sub-Areas

Direction	Description
North of Refinery	North of the Refinery Processing area and North Crude Tank Farm. Railway/road, and residential area with parkland. Cross gradient of (generally eastward) groundwater flow direction.
West of Refinery	West of the Refinery Processing area. Roadway, open land and commercial premises. This area has been further considered in three distinct sub-areas, consisting of: 7-Eleven Service Station; Mobil Pegasus Centre building (vacant) and Pegasus paddock including the adjacent Rowden's Swamp; and the north-west paddock area. West of the Refinery is generally upgradient to cross gradient of groundwater flow directions, however with a south-westerly groundwater flow component in the Pegasus paddock towards Kororoit Creek.
South of Refinery	Kororoit Creek and Kororoit Creek Reserve are located immediately to the south of the Blending Area. Groundwater flow is generally south to south-east from the Blending Area towards Kororoit Creek. There are four former drainage lines from the Blending Area to Kororoit Creek which have been assessed for historical soil contamination.
East of Refinery	To the east of the North Crude Tank Farm and Blending Area is commercial/ industrial land. In the northern section of this boundary, the Altona rail line divides the Processing Area from the NCTF. Further south, the rail line runs adjacent to the Blending Area boundary, separating it from the commercial and industrial land beyond. Groundwater flow across the eastern boundary is generally to the east, with

Direction	Description
	a south-easterly component closer to Kororoit Creek. There is surface water drainage from the Soil Management area in the east of the Blending Area, which drains into the railway corridor, and then into Kororoit Creek.
South Crude Tank Farm	Environmental conditions associated with each of the boundaries of the SCTF are described, with a focus on the eastern boundary (bordering J. T. Gray Reserve) and the southern boundary (bordering Kororoit Creek Reserve). Groundwater flow in the SCTF area is to the south-east, towards Kororoit Creek.
Utility and Service Corridors	Subsurface utilities are present across the site, and off-site under roadways and within easements. The utilities include: water, sewers, gas, electricity, communications, stormwater and fuel pipelines. In addition, there are off-site roadway, railway and park lands owned by third parties immediately adjacent to the site. Contamination present in the vicinity of underground services and utilities is described within the other sub-areas listed within this table, however the potential risk to these receptors is discussed separately in Section 8.

7.2 Summary of Groundwater Conditions

7.2.1 LNAPL

There are four main LNAPL areas across the Audit area. These have been largely differentiated based on chemical composition of the LNAPL and source identification where feasible. The four main LNAPL areas are presented on **Figure 7** and summarised as follows:

- **Steam Cracked Naphtha LNAPL Zone:** the SCN zone covers the western part of both the Blending and Processing Areas and extends to the west beneath the Pegasus Centre building and Pegasus paddock area, and to the north-west beneath the 7-Eleven Service Station and beyond to the north-west. This is the green plume on **Figure 7**. The SCN LNAPL extent is considered to be delineated in all off-site directions, however a possible delineation gap remains along Kororoit Creek Road to the north-west of the Pegasus Centre and south-west of the 7-Eleven site, specifically north-west of monitoring bore MBB34 and south-west of GA031. The SCN LNAPL appears to be relatively stable in lateral extent, however further monitoring is required to confirm the stability of the plume.

  The SCN LNAPL originated from the 2004 release of an unknown volume of SCN from Tank 705, located at the north-west corner of the Blending Area (refer to **Figure 7**). The SCN LNAPL is typically highly aromatic and contains on average up to 20 wt% of BTEX and 0.5 wt % naphthalene. It appears to be less weathered towards the original source area.

As a result of the presence of the SCN LNAPL plume, the Pegasus Centre building, which was previously occupied by Mobil employees, was vacated in 2010, due to detection of odours and volatile gases in the basement and ground floor of the Pegasus building. This building remains closed, and Mobil conducts continuous monitoring of vapours in the basement area, with access restricted under a permit system. It is understood that Mobil is considering demolishing the building, in which case the risks and need to monitor basement spaces would change (for instance, in the event that there is no longer any basement).

The geometry of the SCN LNAPL plume is elongated in a north-south direction, approximately twice the length of its east-west extent. The SCN LNAPL does not appear to have generally moved in the direction of groundwater flow (generally easterly in the northern part of the SCN LNAPL plume, and generally south/south-westerly in the southern part of the SCN LNAPL plume. An exception to this is in the southernmost part of the SCN LNAPL plume in the Pegasus Paddock, which is elongated in the south-westerly direction towards Kororoit Creek, which is consistent with inferred groundwater flow direction. The reason for the LNAPL plume geometry is not certain, however it may be due to the profile of the basaltic clay and basalt interface in the area and/or preferential pathways for the movement of SCN LNAPL upon release. That is, the SCN LNAPL may have travelled along more permeable pathways in the fill material surrounding Millers Road and associated underground services, in addition to moving along more permeable geological pathways such as highly fractured zones and the clay/basalt interface. It is noted that in the early stages of migration following the initial release, a significant head of LNAPL would have been expected to have overridden groundwater contours in determining the direction of LNAPL migration, so correlation between LNAPL migration and groundwater gradients was not necessarily expected.

It is also noted that remediation works in the Pegasus Paddock area have been underway since 2004, and have removed approximately 137,000 litres of the SCN LNAPL and 141,000 litres of impacted groundwater from the basaltic aquifer in this area. This is also likely to have had some effect in retarding the plume movement towards Kororoit Creek.

- **Mid-Blending Area LNAPL Zone:** this LNAPL zone (shown in red on **Figure 7**) lies in the north of the Blending Area and contains LNAPL predominantly characterised by variably weathered automotive petrol mixed with varying amounts of diesel fuel and/or alkylate/aviation gasoline. This LNAPL zone does not appear to extend beyond the site boundaries.
- **Southern Blending Area LNAPL Zone:** this LNAPL zone (Shown in yellow on **Figure 7**) is present in the south of the Blending Area and contains LNAPL predominantly characterised by light distillate consistent with kerosene or jet fuel. Current monitoring data indicates that this LNAPL zone does not extend beyond the site boundaries; however it is present within 50 m of the southern boundary. There appears to be a hydraulic barrier to LNAPL migration further south, due to the presence of a groundwater mound along the southern boundary, inferred to be due to leakage of water from the stormwater holding ponds and skim lakes in this area. Biannual LNAPL mobile skimming is conducted in the Blending Area to recover LNAPL.
- **Processing Area LNAPL Zone:** this LNAPL zone (shown in grey on **Figure 7**) is present across the central and southern parts of the Processing Area and south into the Blending Area. The LNAPL is predominantly characterised by a greater proportion of fuel blending intermediate products consistent with the processing activities, compared to the Blending Area LNAPL zones. This LNAPL zone does not appear to extend beyond the site boundaries, with the exception of being inferred to be present beneath Kororoit Creek Road area and possibly to the east beneath the railway corridor between the Processing Area and the NCTF.

LNAPL has also historically been observed in the North Crude Tank Farm and in the Ross Road area to the north. The LNAPL previously observed to the north of the Refinery may have originated from off-site sources of LNAPL, north of the Ross Road area, however some contribution of hydrocarbon contamination in this area from the Refinery cannot be ruled out. LNAPL was also observed in the shallow soils associated with the 'Legacy Drainage Area' in the Kororoit Creek Reserve area to the south of the Blending Area; this is further discussed in the soil conditions section below.

7.2.2 Dissolved Petroleum Hydrocarbons

Dissolved phase petroleum hydrocarbons in groundwater are typically associated with areas close to and hydraulically down-gradient of LNAPL plumes. Dissolved phase petroleum hydrocarbons are present in the vicinity of the LNAPL plumes and in down-gradient directions in the following off-site areas.

- On the fringes of the SCN LNAPL plume
- On the southern extent of the Southern Blending Area LNAPL plume.
- To the north of the Refinery in the Ross Road area, although it is noted that there is likely to be a contribution from off-site sources in this area.
- To the south and south-east of the South Crude Tank Farm area.

An assessment of the origin of the dissolved phase Total Petroleum Hydrocarbon (TPH) concentrations reported in off-site areas was conducted, which indicates that in some areas, the TPH appears to be derived from 'biogenic' sources, which refers to organic compounds derived from naturally occurring organic material produced by plants or animals. The detected TPH may also include the polar break-down products of the microbial degradation of non-polar petroleum hydrocarbons. It is also recognised that the degradation products of TPH may also have some toxicity, and therefore the identification of biogenic TPH does not necessarily mean that there is no risk associated with these materials. Limited toxicological information is available for many of the compounds associated with the degradation of petroleum hydrocarbons. Although a limited number of studies have been published on the toxicity of degraded petroleum products, the results are generally inconclusive given the composition of the break-down products may vary depending on the conditions at each location.

Dissolved phase petroleum hydrocarbons are generally delineated off-site to below the adopted site criteria, with the exception of the southern boundary of the South Crude Tank Farm, where groundwater contamination has not been delineated in all areas. It is also noted that monitoring bores MB28 and MB44, located on the southern boundary of the SCTF, are screened below the static water level.

7.2.3 Summary of Exceedances of Beneficial Use Criteria

Summaries of the exceedances of beneficial use criteria for the different audit sub-areas are summarised in the following tables.

West of Refinery

The following COPCs have been reported in groundwater in the above the beneficial uses criteria in this area.

Table 7.2 – Exceedance of Beneficial Use Criteria for Groundwater (SCN LNAPL South-West Area)

Protected Beneficial Use	Chemical of interest exceeding assessment criteria
Maintenance of Ecosystems	pH, metals (arsenic, chromium, copper, mercury, nickel and zinc), TPH (C6-C9), TPH (C10-C36), BTEX, isopropylbenzene, naphthalene, sum of 16 common PAH parameters and 2,4-dimethylphenol
Stock Watering	TPH (C6-C9), TPH (C10-C36), BTEX and styrene
Industrial Water use	metals (manganese, nickel and mercury) TPH (C6-C9), TPH (C10-C36), BTEX, styrene, 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzne
Primary Contract Recreation	pH, metals (iron, manganese, nickel and mercy) TPH (C6-C9), TPH (C10-C36), BTEX, styrene, 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene
Building and Structures	-

Criteria exceedances in pH and metals typically occur with the hydrocarbon impacts with the exception of copper, nickel, zinc, ferrous iron and manganese. For these metals, the concentrations hydraulically downgradient of this area do not appear to differ from hydraulically upgradient areas, suggesting that these exceedances are not the result of site activities.

A conceptual site model cross section of this area is presented on **Figures 14** attached.

South of Refinery

The following COPCs have been reported in groundwater in the above the beneficial uses criteria in this area.

Table 7.3 – Exceedance of Beneficial Use Criteria for Groundwater (South of Blending Area)

Protected Beneficial Use	Chemical of interest exceeding assessment criteria
Maintenance of Ecosystems	pH, ammonia, metals (arsenic, chromium, copper, lead, nickel and zinc), TPH (C10-C36) and sum of 16 common PAH parameters
Stock Watering	arsenic, benzene and TPH (C10-C36)
Industrial Water use	pH, metals (arsenic, chromium, copper, lead, nickel and zinc), benzene and TPH (C10-C36)
Primary Contract Recreation	pH, ammonia, metals (arsenic, chromium, copper, lead, nickel and zinc), benzene, and TPH (C10-C36)
Building and Structures	-

The key groundwater contamination source relevant to the area south of Blending is the Southern Blending LNAPL zone. As noted, the potential impact of this LNAPL zone to off-site receptors is likely to be restricted by the following factors:

- Localised groundwater mounding south of the LNAPL zone, inferred to be associated with hydraulic connection with the stormwater and skim ponds;
- The depth of the western stormwater holding pond being below the depth of the water table;
- The lower hydraulic conductivity of the Quaternary Sediment aquifer associated with Kororoit Creek.

In addition, residual soil and LNAPL contamination is present in the historical drainage lines (Assessment Areas 1 to 3 and the 'Legacy Area') in Kororoit Creek Reserve to the south of the Blending Area. Contamination in these former drainage areas also represents a potential source of groundwater contamination in this area.

A conceptual site model cross section of this area is presented on **Figures 10 and 11** attached.

South-East of Refinery

COPCs have been reported in groundwater above the beneficial use criteria in this area as described in Table 7.4 below.

Table 7.4 – Exceedance of Beneficial Use Criteria for Groundwater (South-East of Blending Area)

Protected Beneficial Use	Chemical of Interest
Maintenance of Ecosystems	Metals (arsenic, chromium, copper, nickel and zinc), ethylbenzene, PAH (phenanthrene and sum of 16 common PAHs)
Stock Watering	Arsenic and benzene
Industrial Water use	Metals (arsenic, manganese and nickel), benzene and MAH (1,2,4-trimethylbenzene)
Primary Contract Recreation	Ammonia, metals (arsenic, iron, manganese and nickel), benzene, ethylbenzene, total xylene and MAH (1,2,4-trimethylbenzene)
Building and Structures	-

The main sources of groundwater contamination in the area to the south-east of the Blending Area are the Mid-Blending and Southern Blending LNAPL Zones, however there is no apparent impact from the LNAPL in these areas on groundwater conditions in the wells near the south-eastern boundary. Off-site wells did not report TPH concentrations above the laboratory limits of reporting.

East of Refinery

The following COPCs have been reported in groundwater above the beneficial use criteria in this area.

Table 7.5 – Exceedance of Beneficial Use Criteria for Groundwater (East of Refinery)

Protected Beneficial Use	Chemical of Interest exceeding assessment criteria
Maintenance of Ecosystems	Metals (arsenic, chromium, copper, mercury, nickel and zinc), TPH (C6-C9) and (C10-C36), BTEX, MAH (isopropylbenzene) and PAH (phenanthrene, sum of 16 common PAHs parameters, and naphthalene) ammonia.
Stock Watering	Arsenic, TPH (C6-C9) and (C10-C36) benzene, toluene and total xylenes
Industrial Water use	Metals (arsenic, manganese and nickel), TPH (C6-C9) and (C10-C36) benzene, toluene and total xylenes
Primary Contract Recreation	Metals (arsenic, iron, manganese and nickel), TPH (C6-C9) and (C10-C36), BTEX and ammonia
Building and Structures	-

The main inferred source of groundwater contamination in the area to the east of the Refinery Boundary is the North Crude Tank Farm, with localised contamination in groundwater in this area. Petroleum hydrocarbon groundwater contamination does not appear to extend off-site in this area. Ammonia is present in groundwater in boundary monitoring wells (MG37, GA059, GA060 and GA076) near the south-eastern boundary of the NCTF at concentrations exceeding the adopted criteria. In the *Groundwater Condition Report* (Golder, 2014f), ammonia was not identified as a Chemical of Potential Concern, however ammonia is sometimes associated with petroleum refining activities. Therefore, whilst the source of the ammonia is uncertain, the spatial extent of the ammonia may suggest a possible source in the NCTF area.

A conceptual site model cross section of this area is presented on **Figure 17** attached.

North of Refinery

COPCs have been reported in groundwater at concentrations above beneficial uses criteria in this area, including: chlorinated solvents (tetrachloroethene, trichloroethene and 1,1,2-trichloroethane), TPH (C_6-C_9) and TPH (C_{10}-C_{36}). Based on the following lines of evidence, it has been concluded that there is likely to be off-site source(s) of these chemicals in this area:

- Historical review of this area identified potential off-site sources of chlorinated hydrocarbons and TPH;
- The chemical profile of the dissolved phase contamination differs from what is reported on-site near the northern boundary of the Refinery; and
- The Ross Road area is hydraulically cross-gradient from the Refinery.

The Auditor concurs with the conclusion reached by the assessor that the chlorinated hydrocarbons are likely to be derived from off-site source(s), due to the absence of these compounds in groundwater from wells in the Refinery site. The Auditor also concurs with the conclusion that TPH in this area is also likely to have originated from off-site source(s). However due to the proximity of this area to the Refinery and the presence of aliphatic hydrocarbons in the groundwater wells to the north of Ross Road that are not fully accounted for by the chlorinated hydrocarbon concentrations, the possibility that some contribution from the Refinery to the TPH concentrations reported has occurred, cannot be ruled out. It should be noted however that the COPC concentrations in this area are not significantly elevated – the assessment of risk is further discussed in Section 8.

A conceptual site model cross section of this area is presented on **Figure 15** attached.

South Crude Tank Farm

The following COPCs have been reported in groundwater above the beneficial use criteria in this area.

Table 7.6 – Exceedance of Beneficial Use Criteria for Groundwater (South-East and South of the South Crude Tank Farm)

Protected Beneficial Use	Chemicals of Potential Concern Exceeding Criteria
Maintenance of Ecosystems	Metals (As, Cr, Cu, Ni, Zn) and TPH (C10-C36)
Agriculture Parks and Gardens	Metals (As, Fe, Mn) and TPH (C10-C36)
Stock Watering	Arsenic and TPH (C10-C36)
Industrial Water use	Metals (As, Fe, Mn) and TPH (C10-C36)
Primary Contract Recreation	Metals (As, Fe, Mn) and TPH (C10-C36)
Building and Structures	-

The groundwater contamination near the southern and south-eastern boundaries and in off-site wells in this area is characterised by TPH (C10-C36). The TPH is generally delineated, with the exception of beyond the southern boundary of the SCTF, down-hydraulic gradient of monitoring well MB44 (refer to **Figure 6** attached).

A conceptual site model cross section of this area is presented on **Figures 12 and 13** attached.

7.3 Summary of Off-Site Soil Conditions

In accordance with the Audit Scope, soil investigation works have been targeted to off-site areas where the historical review indicated that there was potential for soil contamination to exist. Six historical drainage lines were identified where soil impacts warranted consideration, four south of the Blending Area, one south of the South Crude Tank Farm, and one east of the South Crude Tank Farm. The results of assessment works in these areas are summarised in the following sections.

7.3.1 Kororoit Creek Reserve South of the Refinery

Site history review and soil investigation works in these areas identified areas of soil contamination, as presented on **Figure 8**, and summarised in the following table.

Table 7.7 – Exceedance of Beneficial Use Criteria for Soil (Kororoit Creek Reserve Area, South of Refinery Boundary)

Consideration of Maintenance of Ecosystems	
Location	**Chemical of Potential Concern exceeding assessment criteria**
Assessment Area 1	TPH (C10-C16), TPH (C16-C34), Metals (Hg, Cr*, Cu, Zn)
Assessment Area 2	TPH (C10-C16), TPH (C16-C34), Metals (Hg, Cu, Zn)
Assessment Area 3	TPH (C16-C34), Metals (Hg, Ni, Cu, Zn).
Legacy Drainage Channel	BTEX, TPH C10-C40 (sum), Total PAH, Metals (Hg, Cr, Cu*, Zn, As, Ni).
Consideration of Human Health	
Assessment Area 1	TPH (C6-C40)
Assessment Area 2	TPH (C6-C40)
Assessment Area 3	TPH (C6-C40), Pb.
Legacy Drainage Channel	BTEX, TPH (C6-C9), TPHC10-C40) (sum), PAH, Cr*

*Speciation of chromium was not undertaken during this analysis, chromium concentrations are total chromium. As such, there exists the potential for hexavalent chromium to be present at concentrations above NEPM EIL screening criterion which is defined for hexavalent chromium.

It is also noted that LNAPL was reported in the former drainage/culvert area of the 'Legacy Impact Assessment Area'. This area is shown on **Figure 8** attached.

Conceptual site model cross sections for two alignments south of the Blending Area are presented on **Figures 10 and 11** attached.

The locations of the soil sampling conducted in these areas, and the reported COPCs exceeding the adopted criteria are presented within the *Kororoit Creek Soil Investigation* Report (23 October 2012), Golder Associates 097651007-532R-Rev 0 (Figures 3 to 6 included in **Appendix E12**).

7.3.2 Kororoit Creek Reserve South of the South Crude Tank Farm

Site history review and soil investigation works in these areas identified areas of soil contamination, as presented on **Figure 8**, and summarised in the following table.

Table 7.8 – Exceedance of Beneficial Use Criteria for Soil (South of the South Crude Tank Farm)

Consideration of Maintenance of Ecosystems	
Location	**Chemicals of Potential Concern Exceeding Criteria**
Assessment Area 4	TPH (C10-C40) Metals (Hg, Cr*, Cu, Zn).
Consideration of Human Health	
Assessment Area 4	TPH (C6-C40)

*Speciation of chromium was not undertaken during this analysis, chromium concentrations are total chromium. As such, there exists the potential for hexavalent chromium to be present at concentrations above NEPM EIL screening criterion which is defined for hexavalent chromium.

A conceptual site model cross section of this area is presented on **Figures 12 and 13** attached.

7.3.3 Potential Other Areas of Soil Contamination

Off-site soil sampling was also undertaken in the J. T. Gray Reserve, located east of the South Crude Tank Farm. The J. T. Gray Reserve was historically used as a discharge point for tank bund water from Tank 806. Based on this historical information, soil sampling was conducted in the Reserve, however there were no exceedances of the adopted site criteria.

There is potential for other areas of off-site soil contamination to exist, including:

- Soil contamination associated with the SCN LNAPL release in 2004. Residual shallow soil contamination may exist adjacent to Tank 705 and may possibly extend into off-site areas, depending upon the pathways which the SCN LNAPL followed after its release. However, it is considered impractical to determine the presence of such shallow soil impacts in the immediate off-site areas, due to the lack of any noted shallow soil contamination, and discontinuity of unknown possible pathways, as well as the presence of infrastructure such as tanks, roadways and services.
- Soil contamination in the railway corridor to the immediate east of the Blending Area, where stormwater run-off from the on-site Soil Management area has been identified as occurring. Soil sampling has not been conducted in this area to assess whether soil contamination may exist in this area as a result of the Refinery operations.
- Contamination of soil is inferred to be present in the location of the off-site SCN LNAPL plume, associated with the smear zone of LNAPL occurrence. The Auditor does not consider that it is necessary to assess this separately to the groundwater contamination associated with the LNAPL and dissolved phase contamination.

7.4 Summary of Off-Site Vapour Conditions

Hydrocarbon soil vapour may migrate from on-site or off-site sources such as LNAPL, soil contamination, or significantly elevated concentrations of dissolved phase contamination. Pathways include lateral migration along permeable geological features or other preferential pathways, or vertical migration through vertical pathways. Migration may occur by advection, such as through atmospheric pumping, or diffusion gradients.

Soil vapour and indoor air vapour assessments conducted in off-site areas are discussed in the following sections.

7.4.1 Steam Cracked Naphtha LNAPL Vapour

Potential receptors associated with migration of vapours from the SCN LNAPL plume include users of the 7-Eleven Service Station, the Pegasus Building and underground utilities in the area. Hydrocarbon vapours have been reported intermittently within the Pegasus Building since 2003, including concentrations of VOCs (measured by a PID) of up to 100 ppmv in the ground floor area, and a Lower Explosive Limit (LEL) meter reading of 22% of LEL in the basement sump (Golder, 2014c). The Pegasus Building basement penetrates through the basaltic clays into the basalt rock. The pathway for migration of the vapours into the building remains uncertain but it is inferred that the basement plays a role in providing the pathway, due to the proximity to the SCN LNAPL and the absence of the overlying clay layer. As noted, the building was evacuated in 2010 due to detection of the hydrocarbon vapours, and remains vacant, with continuous LEL monitoring being conducted in the basement area. As also previously noted, demolition of the Pegasus Building is understood to be under consideration.

In late 2009, a worker reportedly observed a flash when grinding fence posts during the removal of the tennis court in the Pegasus Paddock area to the south of the Pegasus Building. This incident indicates that there is potential for accumulation of hazardous gases in confined spaces or voids.

Soil gas investigations and indoor air sampling have been undertaken at the 7-Eleven Service Station site. Hydrocarbon vapours were identified in the soil gas bores at the 7-Eleven Service Station and within indoor air. The site assessor (Golder) concluded that the hydrocarbon vapours in the shallow soil gas bores were due to an on-site source of petroleum hydrocarbons from the service station, and the indoor air concentrations were derived from ambient emissions from the refuelling area of the service station. The Auditor generally concurs with these conclusions, however due to the uncertainty associated with differentiating hydrocarbon vapours originating from SCN LNAPL from those originating from gasoline sources at the service station, and the potential for vertical migration of hydrocarbon vapours from the underlying SCN LNAPL, some contribution of SCN LNAPL vapours to the shallow soil gas concentrations reported, cannot be completely ruled out. In addition, a number of uncertainties regarding the indoor and ambient air sampling investigations at the site by Golder suggest the data is not conclusive. Further discussion on the hydrocarbon soil gas investigation is presented in Section 8.3.1.1.

Conceptual site model cross sections of these areas are presented on **Figures 14 and 16** attached.

7.4.2 Other Areas of Potential Soil Vapour

There is potential for soil vapour to be present in other areas of the site and off-site, associated with LNAPL, soil and dissolved phase hydrocarbon contamination. Mobil currently undertakes the following programs to assess and manage the condition of soil vapour in other areas of the site:

Off-site Utility Pit Monitoring: is conducted quarterly along Kororoit Creek and Millers Roads, including the monitoring of 126 accessible utility pits using a PID and LEL meter. The location of pits monitored has been within or near the inferred extent of the SCN LNAPL plume to the west of the Refinery. In general, vapours have not been detected in utility pits, with the exception of pits T6, S12 and S36 (Golder, 2014h and 2014i), which are adjacent to stormwater pits, or are actually stormwater pits inferred to potentially have a vapour pathway to the Refinery sewer system (such as via trench backfill). Two of these locations are between the Processing Area and Blending Area, and the third is

adjacent to Millers Road at the Pegasus Centre. The site assessor concluded that the vapour concentrations are likely to be locally influenced by the Refinery sewer system and not the sub surface migration of groundwater-borne hydrocarbons migrating as vapours into utilities. The Auditor considers that this conclusion is not based on sufficient evidence. It is further noted however that the pit which is closest to the SCN LNAPL area (T6) has been monitored four times since the elevated readings in September 2010 and has reported non-detects on each occasion.

Dial-Before-You-Dig (DBYD) Registration: Mobil has registered the areas of Kororoit Creek and Millers Road with DBYD, to alert third parties of the potential vapour hazards associated with conducting sub-surface works in these areas. A copy of this registration information is included in **Appendix E1**.

7.5 Summary of Off-Site Surface Water Conditions

Bi-annual monitoring of Kororoit Creek surface water has occurred since 2002 and has typically focussed on TPH, metals, phenols, PAHs and BTEX. The following COPCs have been reported above the adopted criteria: arsenic, cadmium, chromium, copper, lead, zinc, and occasionally TPH. It is noted by the Auditor that interpretation of these results is complicated by the following factors:

- Kororoit Creek was historically used as a discharge point for several large petroleum and petrochemical facilities, which are upgradient of the Mobil Refinery;
- The Creek is a receptors of stormwater run-off from a large urban and industrial area;
- There is tidal influence south of the Refinery and South Crude Tank Farm;
- The contribution of groundwater from the Refinery Area and SCTF to Kororoit Creek is orders of magnitude less than the total stream flow.

7.6 Summary of Off-Site Sediment Conditions

No specific investigation was conducted of sediment within Kororoit Creek. There is potential that historical surface water discharges along the former drainage lines, or other releases have contributed to sediment contamination of the Creek.

As a separate issue, groundwater discharge to the Creek has some minor potential to contribute to contamination in discharging groundwater impacting parts of the ecosystem within the sediment zone (benthic organisms) south of the Blending Area and south of the South Crude Tank farm.

In June 1991, EPA commissioned a study (by SKM) into sediment contamination within the Lower Kororoit Creek area. The study coincided with the connection of all major industrial polluters to trade waste sewer and as such forms a baseline assessment for when industrial wastewater discharge to Kororoit Creek ceased.

In the vicinity of the Refinery there were nine sampling locations. In general, most metals were reported below the adopted sediment criteria from this study, with the exception of mercury, which was reported at concentrations above the adopted criteria downstream of the former BP Refinery (located upstream) and the Mobil Refinery. Mercury is a by-product of crude oil refining, and mercury was also reported at concentrations above the adopted criteria in the former drainage areas south of the Blending Area.

7.7 Data Quality and Reliance

In evaluating environmental monitoring data the auditor has consider the following aspects of the environmental data gathered:

- Appropriateness of sampling and analysis procedures, for example compliance with relevant EPA guidelines, including:
    - A guide to the sampling and analysis of waters, wastewaters, soils and wastes (EPA publication 441); and
    - Groundwater sampling guidelines (EPA publication 669).
- Operating conditions at the time of the sampling.
- Training and qualifications of the person conducting the sampling/monitoring.
- Suitability of analysis processes, for example use of a laboratory that is NATA certified for that particular analysis.

The steps in the sampling and analysis process are subject to natural and inherent variability, and this can affect the results produced, and the overall quality of the data sets generated. In order to minimise the effect of this, standard procedures are used throughout for works carried out in the field, and in the laboratory. The use of such procedures represents one aspect of the quality assurance process. To measure the effectiveness of the quality assurance process, quality control samples can be tested, and other quality control tests can be conducted during the analysis of samples taken in the field.

Quality control (QC) samples and tests can be used to assess both the accuracy and the precision of the results produced.

- Measures of ACCURACY provide information on how close to the true result is the reported result. For practical reasons, measures of accuracy are usually confined to the laboratory steps in the overall process.
- Measures of PRECISION provide information on the variability in the results. Precision can be assessed as:
  "repeatability" or intra-laboratory variation– the degree of variation in a result when the same laboratory analyses a sample (or blind replicate) several times, and;
  "reproducibility" or inter-laboratory variation – the degree of variation in a result when a different laboratory separately analyses a sample.

In addition, blank samples can be used to assess whether extraneous materials and factors have contributed to the results obtained from the sampling and analysis process.

Over the time period that the environmental audit was conducted, a considerable data set of information was obtained from the site and surrounds, for soil, groundwater, surface water, and soil gas. The Auditor has conducted a targeted review of the factors affecting data quality, to determine the ability of the Auditor to rely on the data for interpretative purposes of the risk assessment. A summary of this review is provided in the following table. Where the data was considered to be critical to the outcomes of a risk assessment, a detailed assessment of the data quality was undertaken by the Auditor. This assessment is presented in Section 7.7.1.

Table 7.9 – Assessment of Data Quality Measures

Quality Control Item	Summary of Auditors Review
Appropriateness of sampling and analysis procedures	The assessors' reports confirmed that appropriate field investigation and sampling methods were adopted. The QAQC procedures for the groundwater sampling events conducted by Golder are detailed in the Mobil Altona *Groundwater Quality Management Plan,* (refer to **Appendix E9**). This Plan details the following QAQC measures which were followed during sampling of groundwater and surface waters: • Field Procedures • Data Quality Objectives • NATA Registration for analytical laboratories and methods • Quality Control Samples • Laboratory QC Samples • Sample identification and sample containers • Chain of Custody Requirements Soil and soil gas investigation works were also undertaken in accordance with an Auditor reviewed QAQC plan. All QAQC plans and executed works were considered suitable by the Auditor for data gathering and analysis for interpretative purposes.
Conditions at the time of the sampling	Ambient conditions at the time of sampling were generally not considered material to the reliance on the data. A detailed review of ambient conditions (atmospheric pressure and wind speed and direction) was conducted by the Auditor, for the soil vapour sampling and indoor air sampling undertaken at the 7-Eleven Service Station. Due to variable conditions, additional sampling events were requested to be conducted at the 7-Eleven Service Station, due to atmospheric pressure and wind direction potentially having a significant effect on soil vapour transport.
Training and qualifications of the person conducting the sampling/monitoring	Based on the site inspections conducted, and review of borelogs and field notes, the Auditor considers that all field staff used during the monitoring and sampling events were appropriately trained, qualified and experienced for the tasks they were engaged to complete.
Suitability of analysis processes	All laboratory analysis conducted in Australia was conducted by NATA certified laboratories. The limits of reporting and laboratory QAQC conducted was considered to be suitable for the purposes of the Audit. Where analysis was undertaken in the USA, further review of the data was undertaken where the data was considered critical for the risk assessment purposes. This is further discussed in Section 7.7.1.

The Auditor considers that, based on the quality controls measures implemented, and the multiple sets of monitoring data reported, that the overall dataset can be relied on for the purposes of the risk assessment. It is noted that in some isolated areas, limited monitoring data sets were available, due to the lower priority assigned to these issues, as determined during the Audit timeframe utilising the Risk Register process. Therefore in some areas additional monitoring is required to verify the findings of the assessment and provide further delineation. Where limited data is available, the Auditor has adopted a

more conservative approach to the risk assessment in that area. The recommendations of the Audit report also reflect the need for additional monitoring in some areas to refine the risk ranking.

7.7.1 7-Eleven Data Quality Review

Soil vapour and indoor air assessments provided critical data which was used to assess potential human health risks at the 7-Eleven Service Station located to the west of the Refinery. During the assessments Golder implemented Quality Assurance (QA) measures that were generally consistent with the provisions detailed in the CRC-Care technical report 23 "*Petroleum Hydrocarbon Vapour Intrusion Assessment: Australian Guidance*" (Wright 2013). Appropriate Quality Control (QC) samples were included with each batch of samples analysed and Golder provided an analysis of the QA and QC in the assessment reports.

The Auditor considers that an appropriate level of QA/QC was implemented during the assessments. However, a number of uncertainties with the data were identified and are discussed below:

- The list of volatile organic compounds included in the TO-15 analytical suite and the analysis of passive samplers is considered to be appropriate for the assessment of health risk in indoor air (particularly from benzene). However, the list of VOCs analysed provides only limited range of compounds found in SCN and these compounds are also common to petrol and diesel. The data, therefore, provides minimal evidence to differentiate the source of contaminants detected. PIANO analysis, which provides a greater range of compounds that can be used to differentiate hydrocarbon source, was only conducted on the LNAPL source.
- During indoor air and soil gas monitoring conducted in 2012, ambient air and shallow soil vapour samples reported oxygen concentrations above 50 %v/v. The analysing laboratory (Alpha Analytical) confirmed there was an issue with the oxygen analysis and that there were no other issues with the results. Although the fixed gas results from these investigations were discarded, the issue raised concern over the overall data quality of samples analysed by Alpha Analytical. The laboratory noted the TO-15 analysis was done on a different instrument and the issue would not affect these results. Further TO-15 analysis was conducted by Calscience Environmental Laboratories Inc.
- During the two rounds of soil vapour monitoring conducted in 2012, leak testing was not conducted at soil gas bore SG01 due to concerns regarding the use of helium in an enclosed space. There is potential that short circuiting of ambient air may have occurred. However, subsequent monitoring conducted in 2013 included leak testing using isopropanol which did not identify any short circuiting associated with ambient air.
- Leak testing during all rounds of soil vapour monitoring was only conducted around the well head and not the around the fittings on the canisters and flow controllers. The style of equipment used also meant that conducting a 'shut-in' test as an alternative was not possible. Therefore it cannot be determined if leaks may have been present. It is noted that large leaks would result in the canister filling very quickly rather than at a controlled rate and this was not observed, therefore significant leaks are considered unlikely to have occurred.
- Given that there is a hydrocarbon source associated with LNAPL at the groundwater interface, hydrocarbon vapour concentrations through the vadose zone would be expected to increase with depth and oxygen concentrations to decrease with depth. Soil vapour monitoring conducted in 2013 at newly installed wells SG8 (1.8 m and 2.7 m) and SG9 (1.0 m, 2.0 m and 2.9 m) showed decreased hydrocarbon and increased oxygen concentrations at the deepest probes. Whilst the

lower hydrocarbon results may be explained by a shallower soil source (although no soil sampling or PID readings were obtained to confirm this), and the increased oxygen concentrations could be explained by a preferential pathway although this was not identified, or as a result of sampling in low permeability soils. It is noted that the wells were not sealed between purging and sampling and some ambient intrusion may have been possible which would not have been identified in the leak testing. A number of uncertainties remain associated with the mid and deep soil vapour results obtained at these locations.

The Auditor considers that although there are some uncertainties with the data, the indoor air testing and shallow / sub-slab soil gas results are of adequate quality for the purpose of the assessment.

8 RISK ASSESSMENT

As detailed in Section 1.5, the scope of the Audit prioritises the consideration of risk to off-site sensitive receptors; hence investigations and risk assessment have focussed on these areas. This section of the Audit presents the detailed assessment of risk, based on the following approach.

1. Assessment of source-pathway-receptor linkages. Where a complete, or potentially complete linkage is present, the risk assessment carries through to a further stage of risk assessment, as detailed below. A potentially complete linkage may also be inferred if a site condition could reasonably be anticipated to change and result in a complete source-pathway-receptor linkage (for example, where a groundwater bore were installed for extractive use in an area where no extractive use currently occurs). Where a potential source-pathway-receptor linkage is considered not to exist and is unlikely to eventuate, that linkage will be discounted from further consideration in the risk assessment.
2. Qualitative assessment of risk in accordance with the method present in Section 2.2.4. The assessment of risk is presented in sections defined by off-site precincts or areas on the basis that the off-site areas have separately defined areal extents and separately defined source-pathway-receptors. The potential risks have been assessed for the following off-site areas:

- North of Refinery Boundary
- East of Refinery Boundary
- West of Refinery Boundary – 7-Eleven Service Station
- West of Refinery Boundary – Pegasus Building, Pegasus Paddock, and North-West Paddock
- South of Refinery Boundary
- Utility and Transport Corridors
- South Crude Tank Farm (SCTF) – Off-site Areas

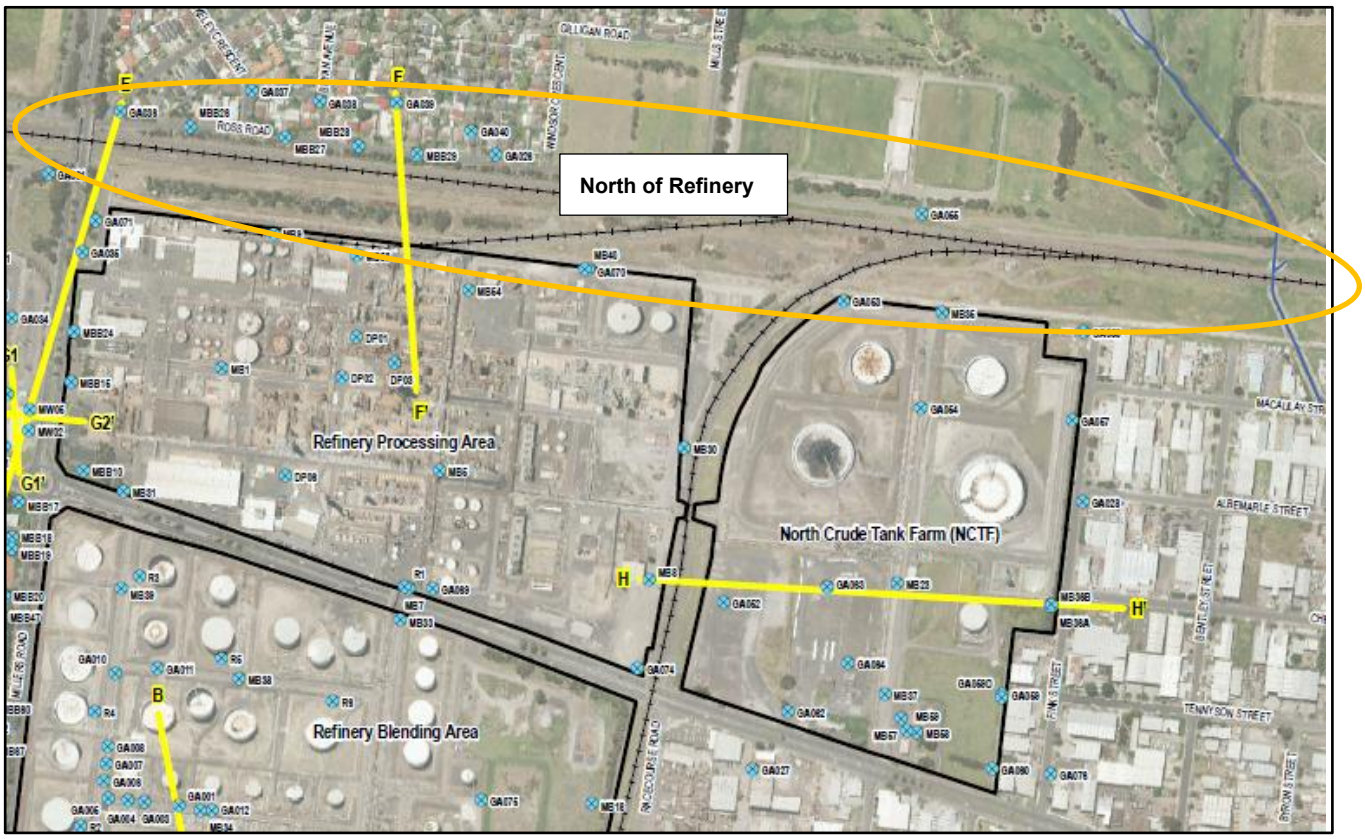
The assessment of risk also included appraisal of whether the existing contamination is likely to represent an ‘imminent environmental hazard’ to human health, the environment or third party property. Based on the information reviewed, the Auditor is of the opinion that the soil and groundwater conditions do not represent an imminent environmental hazard to off-site areas.

8.1 North of Refinery Boundary

The land to the north of the Refinery consists of the Melbourne – Geelong rail line corridor, and beyond this is a residential zone with some commercial premises. A recreational zone also is present beyond the rail line to the north of the North Crude Tank Farm. To the north east of the Processing Area is vacant industrial land and further beyond is the Bayside Secondary College (1km to the north). Underground utilities are also present in this area, including the Ross Road West Main Sewer, which is present below the watertable of the uppermost basaltic aquifer in this area.

The area to the north of the Refinery boundary is shown on **Figure 4** attached and in the image below. A cross section (F-F’) through the Processing Area and across the northern boundary is presented on **Figure 15** attached.

Plate 1 – Area to the North of the Refinery



8.1.1 Source-Pathway-Receptor Assessment

Primary Sources of Contamination

The following potential sources of contamination from the Refinery relevant to the land north of the Refinery were identified:

- North Crude Tank Farm: has been operating as an area for storage of crude oil since 1963. This area has also been used for storage of cutback bitumen from 1989 to 2011. Potential sources of contamination in this area include: storage and handling of crude oil and cutback bitumen; waste water collection and disposal; and burial of tank sludges and treated contaminated soil in tank compounds.
- Processing Area: within the main Refinery Area, the key potential sources identified include leaks and spills from the following equipment and operations:
    - Storage tank operations, including tank dewatering and product transfer;
    - Piping, valve, pit and other associated equipment;
    - Flaring equipment;
    - Fire training equipment;

  - Waste water system;
  - Servicing materials, such as lubricants and cleaners.

- Blending Area: although the Blending Area is a significant distance from the area to the north of the Refinery, the historical tank release of SCN from Tank 705 is considered relevant to the area to the north. This is due to the current (at the time of writing) SCN LNAPL plume extent, that extends north to within approximately 25 m of the northern Refinery boundary and to within approximately 100 m of residences to the north.

These broad areas contain various refinery products, intermediates and wastes which are potential sources of contamination to groundwater for the area north of the Refinery. There are a number of historical recorded spills and releases within the main Refinery Area, as documented in the *Historical Operations Review, Mobil Altona Refinery* (Golder, 2012c), however there is no single identifiable release or spill event to which the observed LNAPL current present in the Refinery Area could be attributed. Therefore the LNAPL present in this area may be due to a number of smaller leaks, spills or releases, or a larger spill/release(s) where the volume of release was not recorded or known at that time.

In addition to the potential Refinery sources, the assessment works identified the following potential off-site sources to the north:

a. Former Westgate Fuel Supplies (4 to 10 Hatherley Grove, Altona North);

b. Historical BP Fuel release in 1989 within rail corridor (north of Tank 302);

c. Former Cabot Australasia plant located north-west of the Refinery.

The specific Chemicals of Potential Concern (COPCs) relevant to the land to the north of the Refinery are presented in the following Table. These COPCs have been identified based on chemicals identified in soil and/or groundwater either at the boundary or off-site, based on analysis of a broad range of COPCs associated with the Refinery operations. Where COPCs are considered to be due to background conditions (such as some metals), or an off-site source, they have not been included in the COPC list.

Table 8.1 - Summary of Chemicals of Potential Concern for Land North of the Refinery

Possible Contaminant Sources	Chemicals of Potential Concern			
	Soil	Groundwater	Surface Water	Soil Vapour
Refinery (Bitumen area, Processing and Refining, and NCTF)	None identified	Petroleum Hydrocarbons	Not relevant to this area	None identified
Off-site areas to the north	None identified	Petroleum Hydrocarbons	Not relevant to this area	None identified

Potential Pathways and Receptors

The following potentially complete exposure pathways associated with the migration of contamination from on-site sources have been identified:

- **Groundwater**: the land to the north of the Refinery area is hydraulically across gradient from potential sources of contamination at the Refinery. Although contamination will typically migrate in the direction of groundwater flow, there is some potential for lateral migration of contamination to the north of the Refinery. Groundwater monitoring data indicates that there may be some low level hydrocarbon contamination in groundwater to the north of Ross Road, potentially due to Refinery operations. However it is difficult to distinguish between potential off-site sources of hydrocarbon contamination in this area and Refinery sources. It is also noted that groundwater monitoring bore construction details, such as the screened interval, are not known in monitoring bores MB53 and MB54.

  Chlorinated hydrocarbons have been detected in a limited number of wells to the north of Ross Road, however the chlorinated hydrocarbon impacts appear to be due to an unidentified off-site source, as these chemicals have not been reported in groundwater within the Refinery site. It is possible that the presence of LNAPL in groundwater within the Refinery boundaries has masked the presence of chlorinated hydrocarbons, as no chlorinated hydrocarbons have been detected in any on-site groundwater wells above the laboratory limits of reporting, it is considered that the chlorinated hydrocarbons reported in groundwater off-site to the north are not due to a Refinery source. Therefore chlorinated hydrocarbons are not included in Table 8.1.

  The Auditor's assessment of potentially complete exposure pathways for groundwater is presented as follows:

  - **Extraction of groundwater:** based on the nearest registered groundwater wells for extractive groundwater use (stock and domestic) being at least 0.8 km to the north-west of the Refinery, there does not currently appear to be a complete current exposure pathway for extractive use of groundwater. The protected *extractive* beneficial uses of groundwater in this area (based on TDS) are Primary Contact Recreation, Industrial Water Use, and Stock Watering. Although these beneficial uses are unlikely in this area (particularly Stock Watering and Industrial Water Use), there is some potential for extractive groundwater use to be realised in future.

    *The extractive use of groundwater to the north of the Refinery **is further considered** in the qualitative risk assessment.*

  - **Surface water discharge of groundwater:** the nearest surface water receptor in the direction of groundwater flow is the Kororoit Creek Estuary , located approximately 1 km south from the northern boundary of the refinery. Port Phillip Bay is located at the mouth of the Kororoit Creek Estuary. Based on the low levels of contamination reported in groundwater to the north of the Refinery and large distance to the nearest receptor this pathway is considered to be incomplete.

    *Surface water discharge of groundwater to the north of the Refinery **is not further considered** in the qualitative risk assessment.*

  - **Underground services:** there are shallow and deep underground services present beneath the ground surface of the land to the north of the Refinery. All identified

underground utility services are present above the standing groundwater level, with the exception of the Ross Road and Kyle Road main sewer. Therefore, there is potential for contaminated groundwater originating from the Refinery to seep into the Ross Road and Kyle Road deep sewers in this area.

*The discharge of groundwater to deeper sewer pipes to the north of the Refinery **is further considered** in the qualitative risk assessment.*

- **Underground structures:** basement car parks, cellars or other underground structures may be present in the residential area north of the site, although none have been identified. Given the standing groundwater level is approximately 5.5 mbgs, a single level basement structure or associated excavation is unlikely to intersect groundwater. Although the presence of basement structures north of the site is not known, based on the depth of groundwater, and lack of likelihood of multiple level basements in this area, direct contact exposures associated with seepage into underground structures of depths to 5 m is considered incomplete.

  *The seepage of groundwater to a one level basement or excavation to the north of the Refinery **is not considered further** in the qualitative risk assessment.*

- **Vapour**: the land to the north of the Refinery is potentially subject to lateral vapour migration from contamination in groundwater near the northern boundary of the Refinery. This is due to the presence of volatile chemicals in groundwater in the processing area and potentially associated with the Steam Cracked Naphtha (SCN) LNAPL and dissolved phase plume which is present along the western boundary of the Refinery. Based on the current groundwater conditions, vapour risk to residents or commercial premises to the north of the Refinery is considered to be low and acceptable, due to the low concentrations of dissolved phase contaminants in the monitoring wells north of Ross Road, and the current delineated extent of the LNAPL plumes, which are at least 100 m distant from the residential and commercial premises in this area.

  Currently there does not appear to be a complete exposure pathway for hydrocarbon vapours migrating from impact identified within the Refinery area. There is however only limited data to support the stability of the SCN LNAPL plume in the northern part of Millers Road. Monitoring well GA035 was first monitored in October 2012 (when no LNAPL was reported), however measureable LNAPL was not reported in this well until March 2013. This indicates that either the SCN LNAPL plume is migrating, or there is some response time between well installation and LNAPL detection, perhaps related to the method of drilling. A further delineation well, GA071, was installed further to the north, which reported concentrations of TRH and BTEX below the laboratory limits of reporting in March 2013; however this well was not accessible during the September 2013 monitoring event. It is recognised that the initial mechanism of the SCN LNAPL transport, being gravity flow under a driving head of LNAPL following the initial release, is likely to have largely dissipated due to the significant timeframe since the release occurred (over 10 years), and the removal of the primary source (i.e. repair of Tank 705). Nevertheless, the SCN LNAPL may still be partially mobile in some areas, due to other transport mechanisms, including groundwater flow (and level fluctuation) and preferential pathway transport.

  Based on the occurrence of SCN LNAPL in GA035 and the relatively short time period of monitoring of delineation well GA071, the necessity for further assessment of the potential vapour migration in

this area (associated with the potential future migration of SCN LNAPL in this area), is considered in the qualitative risk assessment.

*The migration of vapours from the SCN LNAPL plume to the north of the Refinery **is further considered** in the qualitative risk assessment.*

- **Soil:** There are two known potential incidents that may have resulted in soil contamination to the north of the Refinery. These incidents were:
    - The roof of Tank 302 was lost in high wind between 1975 and 1978, and hydrocarbons were reportedly blown onto surface soils in the rail corridor; and
    - A BP Fuel Release in 1989 in the rail corridor is known to have occurred in a similar area to the Tank 302 release.

  The exposure pathways associated with impacted soil by adult workers accessing soils within the Rail Corridor to the north of the Refinery is considered to be potentially complete. Exposure pathways associated with impacted soil are considered to be incomplete for residential/recreational land north of the rail corridor.

  *The potential exposure to contaminated soil within the rail corridor to the north of the Refinery **is further considered** in the qualitative risk assessment.*

The risk assessment for the identified source-pathway-receptors is presented in Table 8.2

Table 8.2 - Risk Assessment for Land to the North of the Refinery

Hazard Analysis					Risk Characterisation *(refer to Tables 2-2 to 2-4 for likelihood, consequence and risk definitions)*			
Risk No.	**Source**	**Environmental Element and Beneficial Use/Receptor**	**Exposure Pathway**	**Contaminants of Potential Concern**	**Likelihood**	**Consequence**	**Overall Risk Rating**	**Auditor's Summary**
1	Processing Area (Bitumen; Processing and Refining)	Groundwater: Extractive Uses (Primary Contact Recreation, Stockwatering, Industrial Use)	Exposure to contaminants in groundwater extracted north of the site	Petroleum Hydrocarbons	Rare	Medium	**Low**	In the ***Rare*** event that a groundwater extraction bore were installed in the area to the immediate north of Ross Road, then potential adverse health effects may occur as the result of the low level TPH contamination in groundwater. It is noted that although there may be a secondary source or sources of groundwater contamination in this area, the Refinery cannot be ruled out as contributing to the TPH contamination observed in this area. The potential consequences should exposure occur is considered to be ***Medium***, with potential for chronic health effects.
2.	Processing Area (ie Bitumen; Processing and Refining)	Groundwater discharge to underground services (Human Health risk to workers)	Discharge of groundwater into deeper sewers off-site to the north	Petroleum Hydrocarbons	Probable	Minor	**Low**	As the sewers along Ross Road and Kyle Road are below the water table, it is ***Probable*** that some seepage of groundwater into these sewers is occurring. However, the groundwater levels to the north of the Refinery do not indicate that groundwater drawdown is occurring in the vicinity of the sewer. Therefore seepage to sewer does not appear to be occurring at a significant rate. Potential health effects to maintenance workers are likely to be ***Minor*** due to the short exposure times and relatively low concentrations.
3	Steam Cracked Naphtha LNAPL Plume	Air (vapour): Human Health – Residents and sub-surface maintenance or construction workers	Migration of vapours from LNAPL plume to off-site indoor air and sub-surface excavations	Petroleum Hydrocarbons	Rare	Medium	**Low**	Volatile contaminants including TPH fractions, have been reported in groundwater off-site to the North of the Refinery. As such there is potential for occupants of buildings and sub-surface excavations to be exposed to contaminants in air. The current monitoring data indicates that the SCN LNAPL plume is currently sufficiently distant from the residential and commercial receptors to the north of the Refinery, to not represent a vapour risk (i.e. ***Rare***). Some uncertainty remains regarding the potential for further migration of SCN LNAPL to areas north of the Refinery; therefore a ***Medium*** consequence has been adopted.
4	Processing Area (eg Tank 302 loss)	Soil: Human Health – subsurface maintenance or construction workers	Direct contact with contaminated soil in rail reserve	Petroleum Hydrocarbons	Probable	Minor	**Low**	There is one known reported incident related to Refinery operations that may have resulted in soil contamination in the rail corridor, (the incident involving the loss of the roof of Tank 302 in high wind between 1975 and 1978 and hydrocarbons were reportedly blown onto surface soils in the rail corridor). Based on this incident, and the proximity of the rail reserve to the Refinery boundary, it is considered '***Probable***' (ie 'might occur'), that soil contamination in the rail corridor may be present. In the event that contamination was present, due to the restricted access to this area, the consequence is considered to be ***minor***.

8.1.2 Recommendations

The Auditor's recommendations, in relation to the risk assessment findings for the land north of the Refinery are presented as follows.

1. Groundwater: Extractive Uses (Primary Contact Recreation, Stockwatering, Industrial Use):

    a. Notification of groundwater extraction licensing authority that groundwater should not be used for extractive uses in the area to the immediate north of Ross Road. The area to be included in the notification shall be defined based monitoring data which indicates a potential for contamination from the Refinery, including monitoring wells MBB27 and MBB28.

    b. Ongoing monitoring in accordance with the Auditor reviewed *Mobil Altona Refinery Groundwater Quality Management Plan* (GQMP, Golder, 2013h). In addition, where monitoring well construction details are not know (such as MB53 and MB54), then further investigation to determine the well construction details, or replacement of monitoring wells, is recommended.

2. Groundwater discharge to underground services (ie Human Health risk)

    a. Notification of sewer owner of the potential to encounter low level groundwater contamination in this area, and that appropriate exposure control measures should be implemented when workers enter the sewer system.

    b. Ongoing monitoring for contaminant trend analysis and groundwater elevations in accordance with the GQMP.

3. Air (vapour): Human Health – Off site residents

    a. Installation of an additional groundwater monitoring bore in the general vicinity of (but not close to) monitoring well GA071 which is the only well delineating the northern extent of the SCN LNAPL plume between wells MBB1and MB9, which are over 300 m distant. This is to be installed as a sentinel well to assess the stability of the SCN LNAPL plume in this area.

    b. Ongoing monitoring for contaminant trend analysis and SCN LNAPL migration assessment. The GQMP is required to be updated and reviewed by an Auditor as part of the Clean Up Plan verification, to include trigger conditions and contingencies in relation to the assessment of the SCN LNAPL mobility, including the necessary response measures, if the SCN LNAPL was found to be migrating further north in this area towards residences.

4. Air (vapour): Human Health – Subsurface maintenance or construction workers

    a. Mobil to maintain the 'Dial Before You Dig' notification which provides a hazard warning to subsurface maintenance and construction workers who use the Dial Before You Dig notification service. This will continue to provide a mechanism to notify parties conducting subsurface works in this area of the potential to encounter contaminated groundwater or associated vapours. The Dial Before You Dig notification letter and plan is included in **Appendix E1**.

    b. The utility pit monitoring program to be extended to incorporate utility pits to the north of the Refinery, including all utility pits along Ross Road.

    c. Underground utility asset owners in the Ross Road area are notified of the potential to encounter low level groundwater contamination in this area, and that appropriate exposure control measures should be implemented when workers enter underground pits

8.2 East of Refinery Boundary

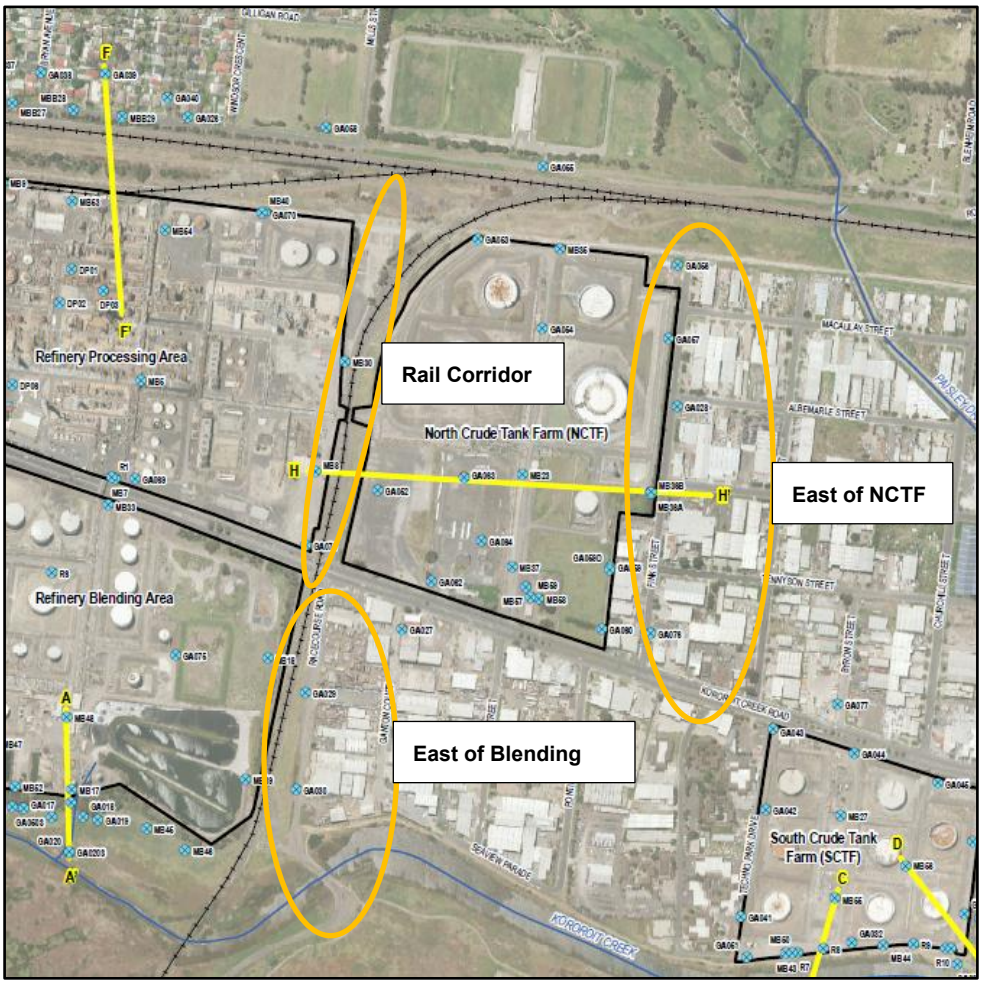
The land to the east of the Refinery boundary consists of commercial and industrial land. This includes areas adjacent to the eastern boundary of the North Crude Tank Farm Area and Blending Area. The land to the north-east consists of the Melbourne–Geelong rail line corridor; beyond this is a residential zone and recreational zone. The South Crude Tank Farm Area is located further to the south-east.

The area to the east of the Refinery boundary has been considered in three separate sub-areas consisting of:

- The rail corridor between the Processing Area and the NCTF;
- The land to the east of the NCTF; and
- The land to the east and south-east of the Blending Area.

These areas are shown on **Figure 4** attached and in the image below. A cross section (H-H') through the Processing and NCTF area is presented on **Figure 17** attached.

Plate 2 – Areas to the East of the Refinery



An open stormwater drain, Paisley Drain, is approximately 250m east of the north-east corner of the NCTF. This drain transects commercial/industrial properties to the east of the NCTF, and follows a

south-easterly flow path and discharges to the mouth of Kororoit Creek, east of J.T. Gray Reserve. It is believed that an historical depression/drainage swale existed between the NCTF and SCTF as an overflow area from Paisley Drain. Underground utilities are also present in this area, including the Kyle Road Trunk Sewer which is located below the watertable of the uppermost basaltic aquifer in this area (refer to Figure 21 of the Conceptual Site Model, Golder 2014a, as included in **Appendix E** of this Audit report).

8.2.1 Source-Pathway-Receptor Assessment

The following potential sources of contamination from the Refinery, relevant to the area east of the Refinery boundary, were identified:

a. North Crude Tank Farm Tankage: has been in operation since around 1963. Four tanks are located in the northern half of the North Crude Tank Farm (NCTF) area. These tanks have been used for the storage of crude oil and cutback bitumen.

b. North Crude Tank Farm Wastewater Collection Facilities: located to the south of the crude tanks, this facility has been used to collect stormwater and wastewater from the NCTF. This wastewater has historically been collected in a central pit and then transferred to sewer in the Processing Area via an above ground pipeline. The facility was upgraded in the 1990s to incorporate a Wet Oil Recovery tank.

c. WAG Pipeline Terminal: has been in operation since 1970 and is used to deliver crude oil to the NCTF. It is also used as a relay station for the WAG Pipeline to the Shell Refinery in Geelong.

d. ELGAS Terminal: has been in operation since 1956 and is used as an LPG terminal which services the regional area. The ELGAS Terminal receives LPG from the refinery.

e. Blending Area Tankage: has been in operation since 1953. The tanks receive product from the Processing Area for temporary storage prior to blending or transfer off-site as a final product. Potential sources of contamination in this area include leaks and spills related to the storage and handling of crude oil and petroleum products, release of wastewater, tank dewatering and sludge removal, and leakages from the wastewater system.

f. Solid Waste Management Area: located in the north-east part of the Blending Area has historically been used for the management of soils and sludges. This has included the use of sludge drying beds. Buried soil and sludge material is present along the eastern edge of the Solid Waste Management Area.

g. Processing Area: within the main Refinery area, the key potential sources identified include leaks and spills from the following equipment and operations:

    - Storage tank operations, including tank dewatering and product transfer;
    - Piping, valve, pit and other associated equipment;
    - Flaring equipment;
    - Fire training equipment;
    - Waste water system;
    - Servicing materials, such as lubricants and cleaners.

These broad areas contain various refinery products, intermediates and wastes which are potential sources of contamination to the area east of the Refinery boundary.

A number of historical tank releases have occurred within the Blending Area, Processing area and North Crude Tank Farm area, as detailed in the *Historical Operations Review, Mobil Altona Refinery* (Golder, 2012c), a copy of which is included in **Appendix E10**. The most significant spills reported (based on the magnitude of the volume of release), are listed as follows and shown on **Figure 7** attached:

- Release of Steam Cracked Naphtha (SCN) from Tank 705 in 2004 due to a hole in the base of the tank (release volume unknown, but possibly more than 300,000 L);
- Release of unleaded petrol from Tank 809 in 2010 (30,000 L);
- Release of unleaded petrol from Tank 501 in 1998 (60,000 L);
- Release of diesel from the No. 2 Pump Skid House located near the north-west corner of the waste water treatment lagoons (64,000 L); and
- The potential for historical slow leaks in the area of the pipe rack along G Street due to the pipe flanges, which were subsequently replaced.

There were numerous other releases reported, however the volumes were either smaller or not recorded.

In addition to the potential Refinery sources, the assessment works identified the following potential off-site sources to the east:

a. Industrial and commercial land within the Williamstown Industrial area to the east of the site due to the various light industrial land uses in this area.

b. The area to the east of the site reclaimed coastal marshlands, there is potential for waste materials to have been used for landfilling and reclamation activities in this area

The specific Chemicals of Potential Concern (COPCs) relevant to the land to the east of the Refinery are presented in the following Table. These COPCs have been identified based on chemicals identified in soil and/or groundwater either at the boundary or off-site, based on analysis of a broad range of COPCs associated with the Refinery operations. Where COPCs are considered to represent background conditions (such as metals), or an off-site source, they have not been included in the COPC list.

Table 8.3 - Summary of Chemicals Potential of Concern for Land East of the Refinery

Possible Contaminant Sources	Chemicals of Potential Concern			
	Soil	Groundwater	Surface Water	Soil Vapour
Refinery North Crude Tank Farm Area (Eastern boundary)	Not relevant to this area	• Petroleum Hydrocarbons • Ammonia	Not relevant to this area	• Petroleum Hydrocarbons • Ammonia
Refinery Processing Area (Eastern boundary near rail corridor)	Not relevant to this area	• Petroleum Hydrocarbons (LNAPL)	Not relevant to this area	• Petroleum Hydrocarbons
Refinery Blending Area (Eastern boundary)	Petroleum hydrocarbons in Solid Waste Management Area (potential, not confirmed).	• Petroleum Hydrocarbons	Petroleum hydrocarbons due to run-off from Solid Waste Management Area (potential, not confirmed).	• Petroleum Hydrocarbons

Potential Pathways and Receptors

The following potentially complete exposure pathways for the migration of contamination from on-site sources have been identified:

- **Groundwater**: the land to the east of the Refinery area is generally across or down gradient from potential Refinery sources of contamination. Site investigations identified LNAPL in the Processing Area and Blending Area which is a potential secondary source of groundwater impact to the off-site areas to the east, given the generally easterly groundwater flow in this part of the site and surrounds. There is a south-easterly groundwater flow pattern in the southern portion of the site, indicating potential for the LNAPL beneath the Processing Area and Blending Area to be a source of groundwater impact in the off-site area to the east of the Blending Area. The LNAPL plumes are not considered to extend to off-site areas to the east, with the exception of possible LNAPL extending beyond MB8 beneath a part of the nearby rail corridor, where it divides the Processing Area and the North Crude Tank Farm. Associated dissolved phase hydrocarbons have been reported in groundwater near the eastern boundaries of the NCTF and Blending Area. Groundwater contamination is delineated off-site to the east of the Blending Area (GA029 and GA030), with off-site monitoring wells reporting petroleum hydrocarbon concentrations in groundwater below the laboratory limits of reporting. A minor exceedance of the adopted ammonia criterion is noted to be present off-site in groundwater this area (GA030).

  Groundwater monitoring wells near the south-eastern boundary of the NCTF reported ammonia and benzene above the adopted criteria, and this is not delineated off-site to the east. It is noted

that the benzene concentration is only marginally above the adopted criterion and the source of the ammonia is not known.

The Auditor's assessment of potentially complete exposure pathways for groundwater is presented as follows:

- **Extraction of groundwater:** no registered extractive groundwater wells have been identified within 1 km east of the eastern boundary of the Refinery site (hydraulically downgradient), including both NCTF and Blending Area boundaries. Although some LNAPL is potentially present beneath the rail corridor between the Processing Area and the NCTF, extractive use of groundwater in the rail corridor is considered highly unlikely. As such there does not currently appear to be a complete exposure pathway for extractive use of groundwater. The protected *extractive* beneficial uses of groundwater in this area (based on TDS) are Primary Contact Recreation, Industrial Water Use, and Stock Watering. Although the beneficial uses of groundwater are unlikely to be realised in this area, there is some potential for them to be realised in future, and as such, one or more of the beneficial uses may be precluded based on the benzene and ammonia concentrations reported in the vicinity of the south-eastern portion of the North Crude Tank Farm and the ammonia concentrations reported in groundwater off-site to the east of the Blending Area.

  *The extractive use of groundwater to the east of the Refinery **is further considered** in the qualitative risk assessment.*

- **Surface water discharge of groundwater east of NCTF:** along the easterly groundwater flow path in the northern portion of the site the nearest surface water receptor is Paisley Drain located approximately 250m from the north-east corner of the NCTF area. The drain discharges to the mouth of Kororoit Creek to the south-east of the site. Groundwater contamination does not extend to the vicinity of the Paisley Drain, and therefore, impacted groundwater is inferred not to migrate to the drain. As such groundwater discharge to Paisley Drain is considered to be an incomplete pathway.

  *Surface water discharge of groundwater to the east of the Refinery **is not further considered** in the qualitative risk assessment.*

- **Surface water discharge of groundwater:** groundwater migrating along the south-easterly flow path from the eastern portion of the Blending Area and south-eastern portion of the Processing Area potentially discharges to Kororoit Creek, located to the south-east from the Blending Area eastern boundary. There are three off-site groundwater monitoring wells located along the south-easterly flow path between the eastern boundary of the Blending Area and Kororoit Creek. Hydrocarbons have not been detected in these off-site wells above the laboratory limits of reporting. It is noted that although BTEX, TPH $C_6 – C_9$ and TPH $C_{10} – C_{36}$ have been reported in groundwater at concentrations exceeding the adopted criteria on the eastern boundary of the Blending Area (monitoring wells MB018 and GA075 in the solid waste management area), this pathway is not considered to be complete, due to the absence of contamination in the off-site wells in this area. Ammonia was reported at a concentration marginally above the adopted criteria in GA030, located off-site to the south-east of the Blending Area, however this is not considered to be significant, due to the low concentrations reported and the distance to Kororoit Creek.

  *Surface water discharge of groundwater to the east and south-east of the Refinery **is not further considered** in the qualitative risk assessment.*

- **Excavations**: given depth to groundwater in the off-site areas to the east of the NCTF (approximately 2 mbgs), there is potential for sub-surface excavation works beyond 2 mbgs to intercept groundwater with ammonia contamination.

  *The discharge of groundwater to sub-surface excavations the east of the Refinery **is further considered** in the qualitative risk assessment.*

- **Underground services:** there are shallow and deep underground services present beneath the ground surface of the land to the east of the Refinery. Underground utility services are present above the groundwater standing water level, with the exception of shallow and deep sewers located in the off-site areas to the east of the NCTF and Blending Area. These sewers are located approximately 15 m from the north-eastern boundary of the NCTF area and approximately 40 m from the eastern boundary of the Blending Area. Therefore, there is a potential for contaminated groundwater originating from the Refinery to seep into sewers, in particular the Kyle Road deep sewers.

  *The discharge of groundwater to deeper sewer pipes to the east of the Refinery **is further considered** in the qualitative risk assessment.*

- **Vapour**: the land to the East of the NCTF is potentially subject to lateral vapour migration from contamination in groundwater near the eastern boundary of the NCTF. Ammonia has been reported in groundwater monitoring wells near the eastern boundary of the NCTF and Blending Area. The volatile chemicals have not been reported in the off-site wells to the east, with the exception of ammonia. There is considered to be a potentially complete (ammonia) vapour inhalation exposure pathway for human receptors in commercial/industrial slab on ground buildings and sub-surface excavations to the east of the site.

  *The migration of vapours from groundwater to the east of the Refinery **is further considered** in the qualitative risk assessment.*

- **Soil:** There is considered to be potential for soil in the off-site areas to the east to be impacted as a result of surface water run-off from the Refinery site. The eastern boundary of the NCTF is unbunded, so there is potential for surface water to run off onto adjacent land. However, Fink Street is at a higher elevation than the site, so surface water from the Refinery is unlikely to impact the commercial/industrial land to the east. The eastern boundary of the Blending Area and Soil Management Area is also unbunded, so there is potential for off-site soils to be impacted by surface water run-off. Soils in the adjacent rail corridor may be impacted from surface water run-off but any impacts are unlikely to extend to the commercial/industrial land further east as the rail line is at a higher elevation than the Refinery site. There have not been any soil assessments conducted to confirm whether or not surface water run-off has impacted off-site soils.

  Soil exposure pathways are considered to be incomplete for the commercial/industrial land to the east of the NCTF and Blending Areas on the basis of land elevation. However, are potentially complete for receptors within the utility corridors directly adjacent to the eastern boundary of the NCTF and Blending Area.

  *The potential exposure to contaminated soil within the utility corridors to the east of the Refinery **is further considered** in the qualitative risk assessment for the Utility and Transport Corridors area (Section 8.5). The potential exposure to contaminated soil within the commercial/industrial land to the east of the Refinery **will not be further considered** in the qualitative risk assessment*

The risk assessment for the identified source-pathway-receptors is presented in Table 8.4.

Table 8.4- Risk Assessment for the area East of the Refinery boundary

Hazard Analysis					Risk Characterisation *(refer to Tables 2-2 to 2-4 for likelihood, consequence and risk definitions)*			
Risk No.	**Source**	**Environmental Element and Beneficial Use/Receptor**	**Exposure pathway**	**Contaminants of Potential Concern**	**Likelihood**	**Consequence**	**Overall Risk Rating**	**Auditor's Summary**
1	Processing Area, NCTF and Blending Area	Groundwater Extractive Uses (Primary Contact Recreation, Stock Watering, Industrial Use)	Exposure to contaminants in extracted groundwater	• Ammonia • Petroleum Hydrocarbons	Rare	Medium	**Low**	In the ***Rare*** event that groundwater extraction bores were installed in the off-site areas to the east, potential adverse health effects may occur. Ammonia and TPH fractions have been reported at concentrations above adopted criteria for extractive uses near the eastern boundary of the NCTF. The potential consequences should exposure occur is considered to be ***Medium***, associated with chronic health effects.
2	Processing Area, NCTF and Blending Area	Groundwater discharge to sub-surface excavations – Human Health	Exposure to contaminants in groundwater intercepted during excavation	• Ammonia • Petroleum Hydrocarbons	Probable	Negligible	**Low**	It is considered ***Probable*** that future sub-surface excavation works to the east of the Refinery could intercept groundwater, due to the depth of groundwater being less than 2 m. Potential health effects to sub-surface excavation workers who come in direct contact with contaminated groundwater are likely to be ***Negligible*** due to the short exposure times and relatively low concentrations. An overall risk rating of ***Low*** has been determined.
3	NCTF and Blending Area	Groundwater discharge to underground services (i.e. sewers) – Human Health	Exposure to contaminants in groundwater discharge to underground utility pits	• Ammonia	Probable	Minor	**Low**	It is considered ***Probable*** that contaminated groundwater from the Refinery may discharge to underground sewers to the east of the site, given the close proximity to the eastern site boundary and the depth to groundwater in this area (approximately 1 mAHD) which is above the invert levels of the off-site sewers in this area (-0.34 to 1.02 mAHD). Potential health effects to maintenance workers are likely to be ***Minor*** due to the short exposure times and relatively low concentrations of COPCs.
4	NCTF and Blending Area	Air (vapour): Human Health	Migration of vapours from groundwater plume (indoor air, outdoor air and sub-surface excavations)	• Ammonia	Not Likely	Minor	**Low**	Volatile contaminants have been reported in groundwater near the eastern site boundary, with ammonia in off-site areas to the east. Therefore, there is potential for occupants of buildings and workers within sub-surface excavations to be exposed to contaminants in soil vapour. However, a semi-quantitative risk assessment (Golder, 2014a) indicated that adverse health effects due to vapour inhalation were ***Not Likely*** to occur given the expected attenuation during migration through the vadose zone and mixing with fresh outdoor air. Should adverse health effects occur they are expected to be ***Minor***.

8.2.2 Recommendations

The Auditor's recommendations, in relation to the risk assessment findings for the land east of the Refinery are presented as follows.

1. Groundwater beneficial uses of Primary Contact Recreation and Maintenance of Ecosystems:

    a. The beneficial uses of groundwater which are precluded based on the ammonia concentrations are Primary Contact Recreation (aesthetics) and Maintenance of Ecosystems. Neither of these beneficial uses are likely to be realised to the immediate east of the NCTF. However, the Clean Up Notice requires delineation of contamination, and, currently, the source and spatial extent of ammonia in groundwater to the east and south-east of the NCTF is not known, therefore further investigation into possible source(s) of in this area is required. Depending on the outcome of that investigation, further direct assessment of ammonia impact may be warranted.

    b. Ongoing monitoring in accordance with the Auditor reviewed *Mobil Altona Refinery Groundwater Quality Management Plan* (Golder, 2013h).

    c. LNAPL is inferred to extend beneath a part of the rail corridor where the rail corridor divides the Processing Area and the North Crude Tank Farm (to the east of MB8). LNAPL extent is delineated to the east, where LNAPL is absent within the NCTF. Management measures should assume LNAPL is present within this part of the rail corridor.

8.3 West of Refinery Boundary

The land west of the Refinery boundary beyond Millers Road is Mobil-owned. The Mobil-owned land includes a service station, currently leased to 7-Eleven, the Pegasus Centre (a former Mobil administration building), the Pegasus Paddock (south and south-west of the Pegasus Centre) and the North-West Paddock (north-west of the 7-Eleven service station). Beyond the Mobil-owned land is Rowden's Swamp and Kororoit Creek.

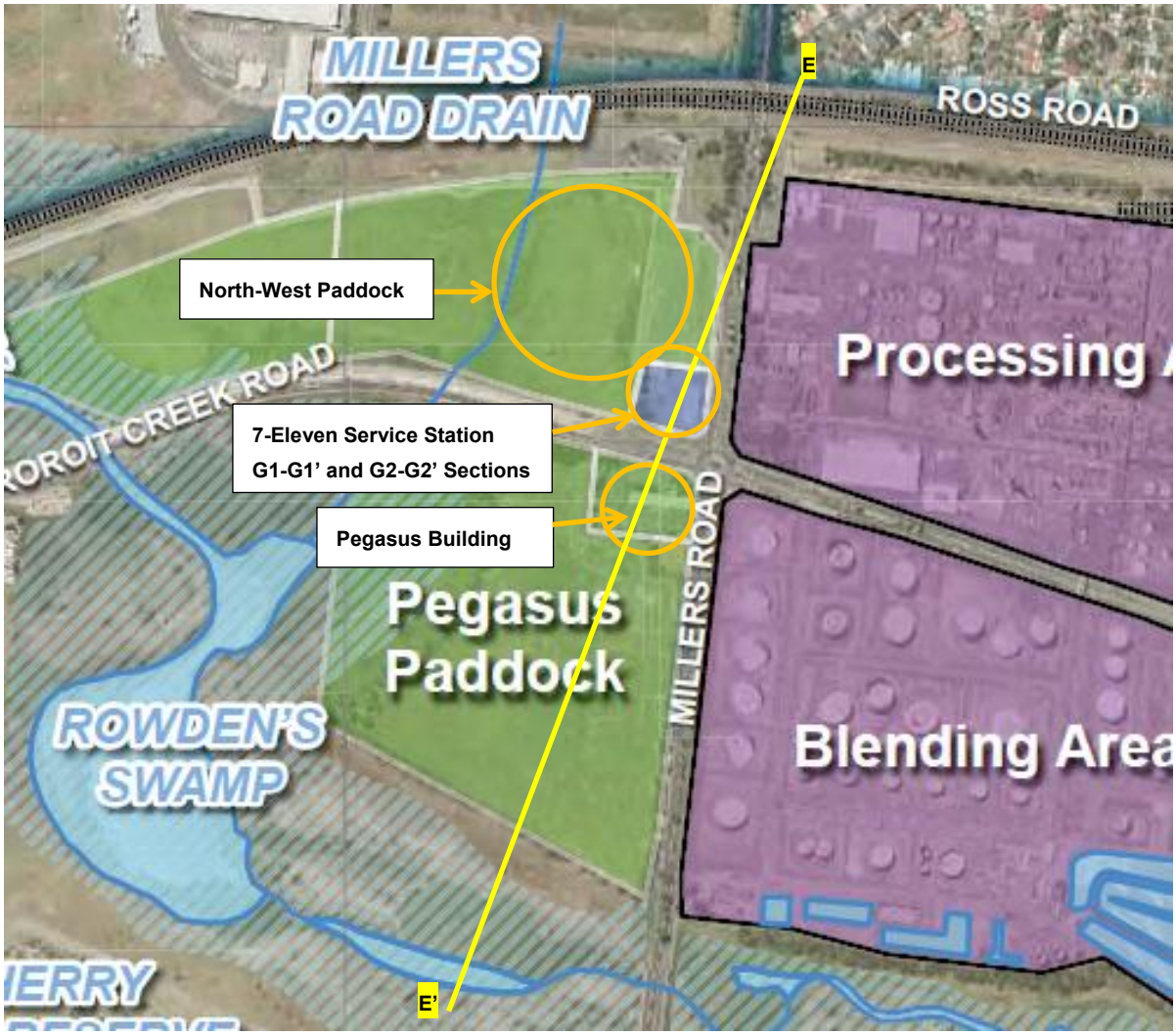
The 7-Eleven Service Station is an operational retail petroleum service station with an associated carwash and mechanics workshop. The assessment of risk associated with the 7-Eleven Service Station is presented in Section 8.3.1.1.

The Pegasus Centre was a former commercial building with a basement area. The Pegasus Centre was evacuated due to the identification of hydrocarbon vapours within the building and is now disused. The remainder of the Mobil-owned land is open space land with some areas used for parking. A cluster of pipework from the processing area emerges from beneath Millers Road to the north of the 7-Eleven Service Station and runs above ground to the north and then west along the boundary of the North-West paddock. Rowden's Swamp and Kororoit Creek lie within a recreational/public open space area which is zoned as Service and Utility. The assessment of risk associated with the Mobil-owned land is presented in Section 8.3.2.

Although the area to the west of the Refinery may be affected by primary sources of contamination originating from both the Processing area and the Blending Area, the critical contamination source is considered to be the Steam Cracked Naphtha Plume which underlies a significant portion of the area.

These areas are shown on Plate 3 below and **Figures 2 and 4** attached. Relevant cross sections (E-E', G1-G1' and G2-G2'), are presented on **Figures 14 and 16** attached.

Plate 3 – Areas to the West of the Refinery



8.3.1 7-Eleven Service Station

8.3.1.1 7-Eleven Service Station Source-Receptor-Pathway Assessment

Sources of Contamination

Steam Cracked Naphtha

Environmental investigations conducted by URS and Golder (refer to Appendices D and E) at the 7-Eleven Service Station have confirmed the presence of an LNAPL plume beneath the 7-Eleven Service Station site, with measurable thicknesses of LNAPL being detected in all on-site groundwater monitoring wells (MW01 to MW05, MBB9 and GA084, at 0.32 m to 0.64 m thickness). Based on the groundwater investigations conducted by Golder, the inferred extent of the LNAPL plume covers the entire 7-Eleven site (refer **Figure 7**), and a dissolved phase hydrocarbon plume is present in the groundwater beneath the LNAPL.

LNAPL fingerprinting was conducted in 2011, with LNAPL samples collected from MW01 to MW05 and MBB9 being submitted for analysis to Newfields Environmental Forensics Practise LLC (Golder,

2012a). In addition, samples from a further 33 groundwater wells associated with the Refinery were also submitted for analysis. Newfields concluded that the LNAPL samples from the 7-Eleven Service Station comprised Steam Cracked Naphtha (SCN) and variation in constituent ratios as compared to samples collected closer to Tank 705 (the release point) was likely to be due to water washing and volatilisation of the SCN since the release occurred (circa 2003).

Newfields also identified that samples collected from wells MW02, MW03 and MW05 contained elevated levels of alkylated PAHs and that this indicated the samples partly comprised diesel. Newfields commented that the concentrations of certain compounds indicative of a diesel product were higher in these samples than in fresh SCN LNAPL. They therefore concluded that this indicated the differences are unlikely to be from ageing and more likely to be a result of separate diesel source. Golder identified MW02, MW03 and MW05 as being down-gradient of fuel storage infrastructure associated with the use of the site as a service station. No diesel fuel was identified in samples from MW01, MW04 and MBB9.

Further LNAPL fingerprinting of a sample collected from GA084 was conducted in September 2013. Newfields concluded that the sample was comprised of a typical SCN with trace amounts of distillate fuel (i.e. diesel) and that this was comparable to samples collected from MW02, MW03 and MW05.

Petroleum Storage and Dispensing Infrastructure (Off-site)

Other potential sources of contamination at the 7-Eleven Service Station include the current and historic petroleum storage and dispensing infrastructure associated with the site use as a service station and mechanics workshop. There are currently seven underground storage tanks, eight bowsers, a triple interceptor trap and associated fuel pipework at the 7-Eleven Service Station; the tanks were identified as being installed between 1986 and 1990. Historical records indicate a further 10 storage tanks may have existed at the site, installed between 1960 and 1971. The locations of the historical storage tanks are not known.

Whilst the petroleum storage and dispensing infrastructure associated with 7-Eleven Service Station are not primary sources associated with the Refinery, they have the potential to be confounding sources of contamination comprising many constituents that are also found in SCN. Diesel identified in LNAPL samples may be due to spills and/or releases associated with the operation of a service station.

Environmental investigations conducted by URS identified petroleum hydrocarbon impacts in soil samples collected during the installation of MW01, MW02 and MW03 and from a soil bore adjacent to the USTs in the north west of the site. However the contaminant concentrations were reported as being below the adopted investigation criteria. Most of the impacts were reported to be at depths of approximately 5 mbgs and could potentially be associated with an LNAPL smear zone; shallower impacts identified at 2.4 mbgs are more likely to be associated with spills and/or releases associated with the operation of a service station.

Ambient air investigations were conducted by 2012 and in 2013 (Golder, 2013b, 2013c and 2014b), and identified the presence of low molecular weight petroleum hydrocarbons in outdoor air collected at the 7-Eleven Service Station. Samples collected in 2012 were analysed by Newfields, who identified that the contaminants reported in ambient air samples were indicative of uncombusted gasoline and diesel, the most likely source being the dispensing infrastructure.

Chemicals of Potential Concern

The specific Chemicals of Potential Concern (COPCs) relevant to the land to the west of the Refinery are presented in the following Table. These COPCs have been identified based on chemicals identified in groundwater off-site, based on analysis of a broad range of COPCs associated with the Refinery operations. Where COPCs are considered to be due to background conditions (such as some metals), or an off-site source, they have not been included in the COPC list.

Table 8.5: Summary of Chemicals of Potential Concern for Land West of the Refinery

Possible Contaminant Sources	Chemicals of Potential Concern			
	Soil	Groundwater	Surface Water	Soil Vapour
Tank 705 SCN LNAPL release	SCN	SCN	None identified	None identified
Vapour partitioning from the SCN plume	None identified	None identified	None identified	SCN

The chemicals of potential concern at the 7-Eleven Service Station comprise the constituents of SCN. Of primary concern is benzene, which is considered to have both high toxicity as well as being highly mobile (in terms of environmental fate and transport). Other major constituents include olefins (such as 1-pentene, 2-methyl-1-butene, cis- & trans-2-pentene and 1-hexene), aromatics (such as toluene and styrene) and paraffins (n-pentane) and isoparaffins (isopentane).

Potential Receptors

Based on the extent of the groundwater contamination and the identified potential future land uses, receptors were considered to be:

- Commercial workers employed at the 7-Eleven Service Station and associated mechanics workshop;
- Maintenance workers and contractors employed at the 7-Eleven Service Station and associated mechanics workshop conducting subsurface works; and
- Site visitors to the 7-Eleven Service Station and associated mechanics workshop.

Chronic daily exposures are generally considered to represent more significant risk potential than transient exposure to occasional visitors of the site. On the basis of exposure frequency and duration, the above receptors are considered to present the highest chronic intake and dose in a descending order (highest for commercial workers and lowest for site visitors).

Potential Pathways

Groundwater

Except for groundwater monitoring wells installed at the 7-Eleven Service Station as part of the environmental investigations, no groundwater bores were identified, indicating no existing potential for groundwater extraction. However, there is potential that a groundwater extraction bore could be installed in the future, although this is unlikely, given the availability of a reticulated water supply.

No surface water discharge areas are present on the 7-Eleven Service Station property and the depth to groundwater is in the order of 6 mbgs, limiting the potential for direct contact exposures.

- *The extractive use of groundwater at the 7-Eleven Service Station **is considered** in the qualitative risk assessment.*
- *Surface water discharge of groundwater at the 7-Eleven Service Station **is not further considered** in the qualitative risk assessment.*
- *Direct contact with in-situ groundwater at the 7-Eleven Service Station **is not further considered** in the qualitative risk assessment.*

Vapour

Volatilisation followed by vapour intrusion and subsequent inhalation exposure was identified as being the most likely exposure route for the identified receptors to the SCN impacts.

Golder identified the most likely migration pathway would consist of the following stages:

- *Partitioning of vapours from the SCN LNAPL plume.*
- *Vertical migration of the vapour through fractures in the basalt rock or cracks or fissures in the basaltic clays into overlying permeable fill material*.
- *Vertical and lateral migration of vapours through permeable fill material and around subsurface infrastructure and /or areas where infrastructure has been historically located, but has since been infilled.*
- *Lateral migration of vapour into:*
    - *The Sales Building via:*
        - *Cracks or gaps in the forecourt concrete slab and the building concrete apron; and*
        - *Utility entry points into the building;*
    - *The workshop via:*
        - *Cracks or gaps in the concrete slab; and*
        - *Utility entry points into the building*
    - *Underground utilities and below ground structures.*

Soil vapour sampling was undertaken in September and November 2012, and in October 2013 and provides information relevant to the vapour migration pathways. The most significant concentrations of benzene were detected at soil gas bore SG7 in the north of the site, close to the existing tanks and at soil gas bore SG9 in the east of the site where the clay layer is relatively thin.

Hydrocarbon impact was generally identified as being more prevalent with depth, indicative of a deeper source; however, the distribution of certain contaminants (such as butane and hexane) in nested bores SG8 (to the west of the Sales Building) and SG9 was observed to be higher in the bores at ~2 mbgs than in the bores at ~3 mbgs. This may be indicative of soil sources shallower than 3 mbgs (ie associated with the 7-Eleven site), or preferential pathways intersecting the bores at 2 mbgs, or as a result of difficulties in collecting samples from within the deeper more competent clay.

Newfields analysed samples collected in September and November 2012 and concluded that soil vapour in the deeper bores was indicative of a gasoline source showing higher concentrations of isoparaffins and lower concentrations of paraffins, olefins, aromatics and naphthenes. On this basis, Newfields concluded that the samples from the deeper soil vapour bores show there is a break in the source-receptor-pathway for SCN vapour.

As individual chemicals will have markedly different mobility through the capillary fringe and vadose zone, and will also degrade at different rates, constituent ratios are likely to change as migration occurs. In addition, Golder considers that soil gas from soil gas bores SG7 and SG9 are from an SCN source; however these samples appear to have similar constituent ratios to other soil gas samples that Newfields claim to be from a gasoline source. The Auditor acknowledges that the work conducted by Newfields and Golder based on constituent ratios provides some evidence that a distillate fuel (ie diesel from the 7-Eleven site) may be the primary source of vapour in the deeper bores; however, this does not rule out a contribution from the Steam Cracked Naphtha LNAPL.

Sub-slab vapour bores SG1, SG3 and SG5 are located beneath the Sales Building, adjacent to the north of the Sales Building and on the eastern boundary of the site respectively. Soil vapour samples from the sub-slab bores were identified by Newfields as being compositionally similar to ambient air samples from the service station.

This is supported by oxygen concentrations in sub-slab bores in the October 2013 investigation, which reported oxygen at ambient concentrations. The sub-slab vapour results point to the potential for air exchange between the ambient air and sub-slab air to exist. High levels of oxygen beneath the slab also indicate a good potential for aerobic degradation of hydrocarbons to be occurring in the shallow subsurface, and this could explain the significant reduction of vapour concentrations in sub-slab bores compared to deeper soil vapour bores.

The ambient air investigation conducted by Golder also provides information relevant to the vapour migration pathways. The initial investigation, conducted in September 2012, identified hydrocarbons were present in indoor air and in general were present at concentrations comparable to outdoor air. The compounds analysed did not provide any evidence as to whether SCN was a likely contributing source.

During the second investigation, conducted in conjunction with the soil vapour assessment in late September 2012, indoor air samples were sent to Newfields for analysis. Newfields identified the constituent ratios to be indicative of a gasoline source. However, this does not provide definitive evidence that the indoor air contaminant concentrations were solely from a gasoline source, as many of the volatile hydrocarbons are also known to be present in SCN which may therefore also have contributed.

During the third investigation, sampling was conducted inside and outside the Sales Building for a period of two weeks using Radiello passive samplers (Golder, 2014b). The results identified that the concentrations of contaminants within the Sales Building were generally stable and reflected those measured outside. Three spikes in the indoor air contaminant concentrations were identified; the days on which the spikes occurred correlated with days of falling barometric pressure, a situation which can lead to increased vapour flux into a building. A spill incident on the 7-Eleven site was also noted to have occurred on the day which showed the largest spike. The incident was reported as a spill of petrol on the forecourt area and one of the 7-Eleven operators was reported to have cleaned it up. It is uncertain whether this may have introduced gasoline vapours into the Sales Building and affected the indoor air results, as the ambient sampler positioned outside the Sales Building entrance did not record an increase. With the exception of the day on which the petrol spill was recorded, the increase in

indoor air concentrations above background is unlikely to result in a significant acute inhalation health risk to workers or visitors of the Sales Building.

Based on a review of the current and historical plans for the service station, Golder identified five preferential pathways through which vapour migration may occur into the Sales Building:

- Through backfilled historical UST pits H6 and H7) which are potentially connected to historical vent lines and an infilled open drain beneath the Sales Building;
- Through backfilled historical UST pits (H1-H4, H8 and H9) which are potentially connected to historical vent lines and an infilled open drain beneath the Sales Building;
- Through backfilled historical UST pit (H5) which is potentially connected to an infilled open drain beneath the Sales Building;
- Through fill surrounding UST C7 and associated pipework which are potentially connected to a historical transpiration bed beneath the Sales Building;
- Through backfilled historical UST pit (H10) which is potentially connected to electrical conduits leading to the Sales Building;

The potential preferential vapour pathways are depicted in **Figure 16**.

Golder concluded that the SCN vapour pathway into the Sales Building is incomplete based on the following:

- Contaminants identified in ambient air, indoor air, sub-slab vapour and some soil vapour is indicative of a gasoline source (from the 7-Eleven Service Station) rather than SCN;
- The competency (ie 'tightness') of the clay in the eastern portion of the site limits the migration of SCN vapours.

Based on the evidence presented above the Auditor considers there is insufficient data to fully eliminate SCN as a contributing factor to the indoor air contamination identified within the Sales Building. The Auditor acknowledges however that the contribution from SCN (if present) is likely to be low.

Golder concluded that there is a potentially complete vapour pathway linkage from the SCN LNAPL into indoor air within the workshop building and into underground utilities and structures.

- *The migration of vapours from the SCN LNAPL plume into the 7-Eleven Sales Building **is considered** in the qualitative risk assessment.*
- *The migration of vapours from the SCN LNAPL plume into the Workshop associated with the 7-Eleven Service Station **is considered** in the qualitative risk assessment.*
- *The migration of vapours from the SCN LNAPL plume into underground utilities and structures associated with the 7-Eleven Service Station **is further considered** in the qualitative risk assessment.*

8.3.1.2 7-Eleven Service Station Qualitative Risk Assessment

The risk assessment for the identified source-pathway-receptors is presented in Table 8.6.

Table 8.6 - Risk Assessment for 7-Eleven Service Station

Hazard Analysis					Risk Characterisation *(refer to Tables 2-2 to 2-4 for likelihood, consequence and risk definitions)*			
Risk No.	**Source**	**Environmental Element and Beneficial Use/Receptor**	**Exposure Pathway**	**Contaminants of Potential Concern**	**Likelihood**	**Consequence**	**Overall Risk Rating**	**Auditors Summary**
1	Steam Cracked Naphtha LNAPL Plume	Groundwater: Extractive Uses (PCR, Stockwatering, Industrial)	Exposure to contaminants in extracted groundwater	Petroleum Hydrocarbons	Rare	Significant	**High**	Given the likely on-going land use as a petroleum service station and the presence of a reticulated water supply, the likelihood of groundwater being utilised for beneficial uses is considered to be ***rare***. Groundwater in the area of the Refinery falls into Segment C under the SEPP for Groundwaters of Victoria, based on the measured TDS. The protected beneficial uses of groundwater relevant to human health therefore include Stock Watering, Primary Contact Recreation and Industrial Water Use. Should groundwater extraction be realised in the future on the 7-Eleven Service Station site the potential consequences are considered to be ***significant***.
2	Steam Cracked Naphtha LNAPL Plume	Air (vapour): Human Health – Commercial Workers and Visitors of the 7-Eleven Sales Building	Migration of vapours from LNAPL plume to indoor air	Petroleum Hydrocarbons	Not likely	Minor	**Low**	Indoor air investigations conducted by Golder indicate that vapour intrusion into the 7-Eleven Sales building is likely to be limited. Based on the monitoring conducted in September 2013, it is considered that the rate of vapour intrusion may be higher during periods of falling barometric pressure; atmospheric pressure drops are likely to occur at regular frequencies. Taking into consideration the previously recorded vapour intrusion into the Pegasus building, and the reported vapour intrusion into steel post at ground level in the Pegasus Paddock, it is considered probable that SCN vapours could migrate through clay to the surface in the 7-Eleven area. However, based on the investigation works conducted, and the apparent absence of a significant pathway into the 7-Eleven buildings, it is consider ***Not Likely***, that vapour intrusion would occur under the current building construction and operating conditions. The indoor air concentrations of contaminants detected within the Sales Building during the investigations conducted by Golder were not considered to represent a chronic health risk to workers in a commercial setting or to visitors of the site. However, thorough exposure modelling has not been conducted and some variation of indoor air concentrations may occur over time. It is acknowledged that there is sufficient evidence to conclude that the majority of indoor air vapours are likely to be as a result of air exchange with outdoor air with only a small contribution from soil vapour. Furthermore the contribution of SCN to vapours beneath the building is also considered to be low, and likely to be due to the thicker basaltic clay layer present in this area of the site. It is therefore concluded that whilst there is potential for the pathway to be complete, the contribution of SCN to indoor air vapour at the 7-Eleven Service Station (under its current building configuration) is low and the consequences of this are ***minor***.

Hazard Analysis					Risk Characterisation *(refer to Tables 2-2 to 2-4 for likelihood, consequence and risk definitions)*			
Risk No.	**Source**	**Environmental Element and Beneficial Use/Receptor**	**Exposure Pathway**	**Contaminants of Potential Concern**	**Likelihood**	**Consequence**	**Overall Risk Rating**	**Auditors Summary**
3	Steam Cracked Naphtha LNAPL Plume	Air (vapour): Human Health – Commercial Workers and Visitors of the 7-Eleven Mechanics Workshop.	Migration of vapours from LNAPL plumes to indoor air	Petroleum Hydrocarbons	Probable	Negligible	**Low**	The conceptual site model indicated that there was a potentially complete pathway for the volatilisation and subsequent vapour intrusion into the indoor air of the mechanics workshop. No preferential vapour migration pathways were identified and no sumps pits or subsurface structures were identified in the workshop. However, it was identified that the thickness of the basaltic clays in the north west corner of the site was less than in other areas of the site. Based on the reduced thickness of clay in this area, and the increased likelihood of preferential pathways due to the older age of the building, it is considered to be ***Probable*** that some vapour intrusion could occur. The indoor air investigations conducted by Golder did not include sampling from within the mechanics workshop. Three large doors are present at the front of the workshop to allow cars inside which would provide a significantly higher air exchange through the workshop than in a typical commercial building. The door openings would also prevent a negative pressure developing within the building a result of air extraction. As with the Sales Building, there is sufficient evidence to conclude that the presence of indoor air vapours would likely be a result of workshop activities or air exchange with outdoor air, with only a small contribution from soil vapour. It is therefore concluded that whilst there is potential for the pathway to be complete, the contribution of SCN to indoor air vapour at the 7-Eleven Workshop (under its current building configuration), is very low and the consequences of this are considered ***negligible***.
4	Steam Cracked Naphtha LNAPL Plume	Air (vapour): Human Health – Subsurface Maintenance Workers	Migration of vapours from LNAPL plume to air within a trench, utility or sub-surface structure	Petroleum Hydrocarbons	Likely	Significant	**High**	Soil vapour sampling conducted by Golder identified that there is hydrocarbon vapour present in the vadose zone across a significant portion of the audit area. It is considered ***almost certain*** that an underground utility or subsurface maintenance trench would be subject to a degree of vapour intrusion. Although the contaminant concentration of soil vapour in the areas surrounding a trench has the potential to be significantly higher than that detected in the sub-slab vapour samples, this would be off-set by a greatly increased air exchange rate and reduced exposure time, depending upon the depth of the excavation. It is therefore concluded that the potential consequence of vapour intrusion into an underground utility or trench which is occupied by a maintenance or construction worker could be ***Severe*** if appropriate health and safety controls were not in place.

8.3.1.3 7-Eleven Service Station Recommendations

The Auditor's recommendations, in relation to the risk assessment findings for the 7-Eleven Service Station site, are presented as follows:

1. Groundwater: Extractive Uses:

a. Mobil implements a process which ensures that no extractive groundwater bores are installed on its land (other than monitoring or remediation bores), including Mobil land leased to 7-Eleven. It is recommended that this forms part of the *Mobil Altona Refinery Groundwater Quality Management Plan* (Golder, 2013h). As part of issuing a Bore Construction Licence, the relevant authority (Southern Rural Water) requires the land owner's consent. Therefore, Mobil is able to control this process by not granting its approval for extractive bore construction licence application on the land affected by the SCN LNAPL. It should be noted that it is considered unlikely that the installation of a groundwater bore for extractive beneficial uses (such as Primary Contact Recreation or Stockwatering) would be contemplated in this area, given the landuse setting and the availability of reticulated water supply in the area.

b. Ongoing monitoring in accordance with the Auditor reviewed *Mobil Altona Refinery Groundwater Quality Management Plan* (Golder, 2013h) to assess the SCN LNAPL plume stability and trends in concentrations of COPCs in the areas of dissolved phase contamination.

c. In accordance with Clause 18 of the *State Environment Protection Policy (Groundwaters of Victoria)* (State Government of Victoria, 1997), where NAPL is present in an aquifer, it must be removed unless the Authority (ie EPA), is satisfied that there is no unacceptable risk posed to any beneficial use by the NAPL. Currently, the NAPL is considered to represent a risk to the beneficial uses of groundwater, such as the extractive uses of Primary Contact Recreation and Stockwatering, and also represent a risk to the beneficial uses of land, such as workers who may occasionally conduct subsurface construction or maintenance works at the 7-Eleven Service Station. Notwithstanding that the beneficial uses of groundwater are unlikely to be realised, and the risks to subsurface workers can be controlled through appropriate health and safety procedures, remediation of groundwater to remove the SCN LNAPL to the extent practicable is considered necessary to comply with Clause 18 of the SEPP.

2. Air (vapour): Human Health – Commercial Workers

a. Further assessment of vapour risk within the 7-Eleven mechanics workshop.

b. Additional vapour monitoring at the Sales Building and in the Workshop for chemicals of potential concern and comparison to the Health Screening Levels. It is recommended that a minimum of an additional two monitoring events is conducted, to assess the variation in sub-ground vapour conditions due to changing weather and sub-surface conditions. The further monitoring program is to be documented in the Auditor verified Clean Up Plan.

3. Air (vapour): Human health and explosive hazards – Subsurface maintenance or construction workers

a. The occupant of the 7-Eleven Service Station site, and any other relevant underground utility asset owners at the 7-Eleven Service Station site, to be notified of the potential to encounter hydrocarbon vapours in this area, and that appropriate exposure control measures should be implemented when workers are conducting sub-surface maintenance or construction works, or

when conducting any above ground 'hot works' that may generate an ignition source (for example, fence post grinding).

8.3.2 Pegasus Building, Pegasus Paddock and North-West Paddock

The area to the west of the Refinery is underlain by the SCN LNAPL which is inferred to have resulted from the SCN release from Tank 705. This area is associated with SCN contamination potentially migrating off-site to the west, south-west, and north-west.

8.3.2.1 Primary Sources of Contamination

The groundwater contamination to the west of the site is the SCN LNAPL zone from the SCN release in around 2004, as discussed in detail in Section 7.2.1. The SCN zone covers the western part of both the Blending and Processing areas and extends to the west beneath the Pegasus and North-west paddocks, including under public areas such as Millers Road and Kororoit Creek Road. This zone originates from the release of an unknown volume of SCN from Tank 705 at the north-west corner of the Blending Area. The primary source (Tank 705) was emptied and repaired.

Dissolved phase impacts are present at the immediate periphery of the SCN LNAPL zone. Based on the monitoring wells where the SCN LNAPL has been present, and those where the SCN LNAPL has been absent over time, it appears that the SCN LNAPL plume and dissolved phase plume are not expanding.

The following potential sources of contamination were identified for this area:

1). Tank 705 SCN LNAPL release

2). Vapour partitioning from the SCN plume

The associated COPCs for this area are the same as detailed for the 7-Eleven Service Station site, as presented in Section 8.3.1.

8.3.2.2 Potential Pathways and Receptors

Pathways that may potentially cause impacted groundwater in this area to come into contact with receptors include:

d. Extraction of groundwater.

e. Discharge to surface water.

f. Vapour migration to indoor air and pits/utilities.

g. Vapour migration to indoor air at the Pegasus Centre.

h. Vapour migration to outdoor air.

These potential pathways are discussed in more details as follows.

Groundwater

Extraction of Groundwater

The closest registered groundwater well for extractive use (i.e. stock watering, domestic supply, irrigation) is more than 2 km from the western boundary of the Refinery (Golder, 2014f). There does not

currently appear to be a complete exposure pathway for extractive groundwater use. The protected extractive beneficial uses of groundwater in this area (based on TDS) are Primary Contact Recreation, Industrial Water Use and Stock Watering. Although these beneficial uses may be considered to be unlikely in this area, there is some potential for other beneficial uses of groundwater in this area to be realised in the future.

The extractive use of groundwater in the Pegasus Paddock and North-West Paddock areas ***is further considered*** in the qualitative risk assessment.

Direct Contact with Groundwater

The approximate depth to groundwater reported in monitoring wells in the Pegasus Paddock was 4.5 mbgs (northern part) and 2.5 mbgs (southern part) and in North-West Paddock approximately 5 mbgs. There is a potential pathway for impacted shallow groundwater and soil vapour to impact maintenance and/or construction workers conducting sub-surface works.

The direct contact with groundwater due to excavation in the Pegasus Paddock and North-West Paddock ***is further considered*** in the qualitative risk assessment.

Groundwater Discharge to Kororoit Creek

LNAPL and dissolved phase impacts are unlikely to impact Kororoit Creek based on the following.

a. Based on the monitoring well network present in the Pegasus Paddock, the SCN LNAPL is located approximately 200 m from Kororoit Creek at its closest point, and the dissolved phase groundwater contamination associated with the SCN plume is conservatively estimated to be no closer than 100 m from Kororoit Creek, and could be up to 200 m distant.

b. A review of the SCN LNAPL presence in monitoring wells over time, and the groundwater chemistry data indicates that the groundwater contamination is delineated and does not appear to be migrating further towards Kororoit Creek.

Although discharge of contaminated groundwater associated with the SCN plume to Kororoit Creek is unlikely, there remains some residual risk that migration in future towards Kororoit Creek could occur, therefore this ***is further considered*** in the qualitative risk assessment.

Vapour

Hydrocarbon odours were reported in indoor air at the Pegasus Centre on 19 February 2010. It was considered likely that the vapour intrusion into the building was due to vapours partitioning from the SCN plume, migrating through fractured rock and natural clays into the more permeable subgrade material beneath the building.

Golder assessed the potential inhalation risks to onsite commercial workers from vapours identified within the Pegasus Centre (Golder, 2010). Concentrations of benzene and 1,2,4-trimethylbenzene in indoor air were found to exceed published guidance for protection of human health over chronic timescales. All staff were evacuated from the Pegasus Centre by 23 July 2010.

The pathway for vapour migration to outdoor air in the north-west and Pegasus paddock is considered complete, however due to the likely exposure time and dilution of vapour by wind, the potential exposure risk is considered to be low for adult workers occupying these outdoor areas.

The pathway for vapour migration to underground utilities, pits and surface voids is also considered complete. Although infrequent, the magnitude of vapours previously recorded above 10 ppm_v in utility

pits surrounding the Refinery indicates that there is a potential ongoing risk to adult maintenance workers accessing underground utilities or conducting hot works on structures that extend below the ground surface in land to the west of the Refinery.

The migration of vapours from the SCN plume ***is further considered*** in the qualitative risk assessment.

The risk assessment for the identified source-pathway-receptors is presented in Table 8.7.

Table 8.7 - Risk Assessment for the Pegasus Centre, Pegasus Paddock and North-West Paddock

Hazard Analysis					Risk Characterisation *(refer to Tables 2-2 to 2-4 for likelihood, consequence and risk definitions)*			
Risk No.	**Source**	**Environmental Element and Beneficial Use/Receptor**	**Exposure pathway**	**Contaminants of Potential Concern**	**Likelihood**	**Consequence**	**Overall Risk Rating**	**Auditors Summary**
1	SCN LNAPL Plume	Groundwater: extractive uses	Exposure to contaminants in extracted groundwater	Petroleum hydrocarbons	Rare	Medium	**Low**	In the ***Rare*** event that a groundwater extraction bore was installed in the area to the immediate west of Millers Road, then potential adverse health effects may occur as a result of the SCN LNAPL plume and associated dissolved phase plume at the immediate periphery of the SCN LNAPL zone. The potential consequences should exposure occur is considered to be ***Medium***, with potential for chronic health effects.
2	SCN LNAPL Plume	Groundwater: Maintenance of Ecosystems and Primary Contact Recreation at point of discharge (Kororoit Creek)	Discharge of groundwater in Kororoit Creek	Petroleum hydrocarbons	Rare	Significant	**Low**	As the SCN LNAPL plume is greater than ~100m from Kororoit Creek and the groundwater chemistry infers that the SCN LNAPL plume is delineated and stable, it is considered ***Rare*** that groundwater contaminants would discharge to Kororoit Creek under the current conditions. Should discharge of contaminated groundwater occur, the potential impacts/consequences to ecological and human receptors are considered to be ***Significant*** given the chemistry of the SCN having a significant toxicity profile.
3	SCN LNAPL Plume	Groundwater: Human health – adult maintenance workers	Excavations intercepting groundwater	Petroleum hydrocarbons	Probable	Significant	**High**	It is considered ***Probable*** that future sub-surface excavation works in the Pegasus Paddock could intercept contaminated groundwater, as the water table sits at approximately 2.5 mbgs in the southern part of the Pegasus Paddock. Potential health effects to sub-surface excavation workers who come in direct contact with contaminated groundwater are likely to be ***Significant*** due to the high volatility and toxicity of the SCN LNAPL.
4	SCN LNAPL Plume	Air (vapour) Human health	Migration of vapours from LNAPL plumes (Pegasus Centre/Indoor Air)	Petroleum hydrocarbons (benzene and 1,2,4-trimethylbenzene)	Almost Certain	Significant	**Very High**	Indoor air investigations conducted by Golder indicate that vapour intrusion into the Pegasus Centre has occurred. Based on the monitoring conducted in 2010 concentrations of 1,2,4-trimethylbenzene and benzene in indoor air were found to exceed the published guidance for protection of human health over chronic timescales. Thus it is ***Almost Certain*** that human receptors could be exposed to unacceptable concentrations of vapours if the building were occupied. Potential health effects associated with vapour inhalation are likely to be ***Significant***.
5	SCN LNAPL Plume	Air (vapour) Human health	Migration of vapours from LNAPL plumes (Pegasus and Northwest Paddocks/Outdoor Air)	Petroleum hydrocarbons (benzene and 1,2,4-trimethylbenzene)	Probable	Negligible	**Low**	The pathway for vapour migration to outdoor air in the North-west and Pegasus paddocks is considered ***probable***, however due to the likely exposure time and dilution of vapour by outdoor air, the potential exposure risk is considered to be ***negligible*** for adult workers occupying these outdoor areas.
6	SCN LNAPL Plume	Air (vapour) Human health	Migration of vapours from LNAPL plumes to underground utilities (including backfill and structures extending below the ground)	Petroleum hydrocarbons (benzene and 1,2,4-trimethylbenzene)	Likely	Significant	**High**	Soil vapour sampling conducted by Golder identified that there is hydrocarbon vapour present in the vadose zone across a significant portion of the site. It is considered ***Likely*** that an underground utilities or subsurface maintenance trench would be affected by vapour intrusion. Potential health effects associated with vapour inhalation are likely to be ***Significant***

8.3.2.3 Key Areas of Uncertainty and Recommendations

The Auditor's recommendations, in relation to the risk assessment findings in the area to the west of the Refinery are presented as follows:

1. Groundwater extractive uses:

    a. Mobil to implement a process which ensures that no extractive groundwater bores are installed on its land (other than monitoring or remediation bores). It is recommended that this forms part of the *Mobil Altona Refinery Groundwater Quality Management Plan* (Golder, 2013h). As part of issuing a Bore Construction Licence, the relevant authority (Southern Rural Water) requires the land owner's consent. Therefore, Mobil is able to control this process by not granting its approval for extractive bore construction licence application on the land affected by the SCN LNAPL. It should be noted that it is considered unlikely that the installation of a groundwater bore for extractive beneficial uses (such as Primary Contact Recreation or Stockwatering) would be contemplated in this area, given the landuse setting and the availability of reticulated water supply in the area.

    b. Ongoing monitoring in accordance with the Auditor reviewed *Mobil Altona Refinery Groundwater Quality Management Plan* (Golder, 2013h) to assess the SCN LNAPL plume stability and trends in concentrations of COPCs in the areas of dissolved phase contamination.

    c. In accordance with Clause 18 of the *State Environment Protection Policy (Groundwaters of Victoria)* (State Government of Victoria, 1997), where NAPL is present in an aquifer, it must be removed unless the Authority (EPA) is satisfied that there is no unacceptable risk posed to any beneficial use by the NAPL. Currently, the NAPL is considered to represent a risk to the beneficial uses of groundwater, such as the extractive uses of Primary Contact Recreation and Stockwatering, and also represent a risk to the beneficial uses of land, such as workers who may occasionally conduct subsurface construction or maintenance works in the Pegasus Paddock or North-West Paddock. Notwithstanding that the beneficial uses of groundwater are unlikely to be realised, and the risks to subsurface workers can be controlled through appropriate health and safety procedures, remediation of groundwater to remove the SCN LNAPL to the extent practicable is considered necessary to comply with Clause 18 of the SEPP.

2. Air (vapour): Human Health and Explosive Hazards – Subsurface maintenance or construction workers

    a. Mobil to maintain the 'Dial Before You Dig' notification which provides a hazard warning to subsurface maintenance and construction workers who use the Dial Before You Dig notification service. This will continue to provide a mechanism to notify parties conducting subsurface works in this area of the potential to encounter contaminated groundwater or associated vapours. The Dial Before You Dig notification letter and plan is included in **Appendix E1**.

    b. Continue with monitoring of utility pits in areas previously monitored. Preparation of a program of continuous utility pit monitoring for a period of one month (in order to cover a range of atmospheric conditions) in utility pits in the vicinity of the Pegasus Building, where elevated vapours have been previously recorded. The objective of the monitoring is to provide data on utility pit vapour ingress over an extended period, in addition to the short time period monitoring currently conducted. This program is to be documented in the Clean Up Plan.

c. Underground utility asset owners in the Millers Road area are notified of the potential to encounter vapour contamination in this area, and that appropriate exposure control measures should be implemented when workers enter underground pits.

d. A possible delineation gap remains in groundwater near Kororoit Creek Road to the north-west of the Pegasus Centre and south-west of the 7-Eleven site, specifically north-west of monitoring bore MBB34 and south-west of GA031. Further delineation bores are required in this area to address this data gap.

8.4 South of Refinery Boundary

The land to the south of the Refinery boundary consists of the Kororoit Creek Reserve and Kororoit Creek immediately to the south of the Blending Area. Kororoit Creek Reserve is a recreational/public open space area which is zoned as Public Use - Service and Utility.

Residential land exists beyond Kororoit Creek, approximately 300 m from the Refinery boundary. Public open space is present to the west/south-west of Kororoit Creek Reserve including Rowden's Swamp and Cherry Lake Reserve (see **Figure 3** attached). The Altona Coastal Park is located to the east of Kororoit Creek Reserve; this area is zoned as Public Conservation and Resource. The Hobson's Bay Planning Scheme includes an Environmental Significance Overlay for the Kororoit Creek Reserve. The ESO defines the southern reaches of the creek as having 'high ecological value'.

Four historic drainage channels have been identified in the Kororoit Creek Reserve area (see **Figure 8** attached). These former drainage channels are associated with the Refinery site and were used to discharge wastewater from the Refinery's wastewater treatment facility, into Kororoit Creek up until 1991. These historic drainage channels are depressions formed due to the filling in of drains or open swale drains.

The area to the immediate south of the Blending Area is shown on **Figures 2 and 4** attached and in the image below. Cross sections (A-A' and B-B'), of this area are presented on **Figure 10 and 11** attached.

Plate 4 – Areas to the South of the Refinery

8.4.1 Source-Pathway-Receptor Assessment

Primary Sources of Contamination

The following potential sources of contamination from the Refinery relevant to the area south of the Refinery boundary were identified.

- Blending Area Tankage: has been in operation since 1953. The tanks receive product from the Processing Area for temporary storage prior to blending or transfer off-site as a final product. Potential sources of contamination in this area include leaks and spills related to the storage and handling of crude oil and petroleum products, release of wastewater, tank dewatering and sludge removal, and leakages from the wastewater system.
- Wastewater Treatment Facilities: located along the southern boundary of the Blending Area, this facility is used to recover waste oil from the wastewater stream for reprocessing and to manage and treat wastewater and stormwater to meet off-license discharge requirements. Potential sources of contamination including seepage of untreated and treated wastewater, surface water run-off and waste oil from treatment ponds. Between 1949 and 1991 there were four wastewater discharge points between the wastewater treatment facility and Kororoit Creek. These former drainage areas

are shown on **Figure 8** attached. Since 1991 treated wastewater has been discharged to sewer under a trade waste agreement.

- Solid Waste Management Area: located in the north-east part of the Blending Area has historically been used for the management of soils and sludges. This has included the use of sludge drying beds. Buried soil and sludge material is present along the eastern edge of the Solid Waste Management Area.

These broad areas contain various refinery products, intermediates and wastes which are potential sources of contamination to the area south of the Refinery boundary.

A number of historical product releases have occurred within the Blending Area include the following (as shown on **Figure 7** attached):

- Release of Steam Cracked Naphtha (SCN) from Tank 705 in 2004 due to a hole in the base of the tank (release volume unknown, but possibly more than 300,000 L);
- Release of unleaded petrol from Tank 809 in 2010 (30,000 L);
- Release of unleaded petrol from Tank 501 in 1998 (60,000 L);
- Release of diesel from the No. 2 Pump Skid House located near the north-west corner of the waste water treatment lagoons (64,000 L); and
- The potential for historical slow leaks in the area of the pipe rack along G Street due to the pipe flanges, which were subsequently replaced.

There were numerous other releases reported, however the volumes were either smaller or not recorded. The release of SCN from Tank 705 is not considered to be relevant to the area south of the Refinery and has been discussed separately, with respect to Kororoit Creek, in Section 8.3.2.

Uncontained releases of wastewater from the wastewater treatment plant also occurred in 1995 and 2011; this resulted in discharges of wastewater to Kororoit Creek. These releases impacted on surface soils within the Kororoit Creek Reserve Area at that time. It was estimated that a total of 900 m^2 of soil has been impacted by hydrocarbons in this area, which was subsequently remediated by Mobil and the vegetation rehabilitated. During the course of these remediation works, a former drainage line from the wastewater treatment area was uncovered, with soil contamination evident. This lead to the further investigation of the four former drainage lines in this area, including historical aerial photograph review and soil and groundwater investigation works.

The specific Chemicals of Potential Concern (COPCs) relevant to the land to the south of the Refinery are presented in the following Table. These COPCs have been identified based on chemicals identified in soil and/or groundwater either at the boundary or off-site, based on analysis of a broad range of COPCs associated with the Refinery operations. Where COPCs are considered to be due to background conditions (such as some metals), or an off-site source, they have not been included in the COPC list.

Table 8.8 - Summary of Chemicals of Potential of Concern for Land South of the Refinery

Possible Contaminant Sources	Chemicals of Potential Concern			
	Soil	Groundwater	Surface Water	Soil Vapour
Blending Area – Petroleum product storage and transfer, and LNAPL present in the southern part of the Blending Area.	• Petroleum Hydrocarbons	• Petroleum Hydrocarbons	• Petroleum Hydrocarbons	• Petroleum Hydrocarbons
Wastewater treatment plant	• Petroleum Hydrocarbons	• Petroleum Hydrocarbons • Ammonia	• Petroleum Hydrocarbons • Ammonia	• Petroleum Hydrocarbons
Former wastewater drainage lines in Kororoit Creek Reserve (ie Legacy areas)	• Petroleum Hydrocarbons • Metals (mercury, chromium, copper, lead, nickel, zinc)	• Petroleum Hydrocarbons	• Petroleum Hydrocarbons	• Petroleum Hydrocarbons

Potential Pathways and Receptors

The following potential complete exposure pathways for the migration of contamination from on-site sources have been identified:

- **Groundwater**: the land to the south of the Refinery area is down gradient of potential sources of contamination at the Refinery. Site investigations have identified LNAPL in the southern Blending Area which is a potential source of contamination to the area to the south of the Refinery. The LNAPL in the Southern Blending Area zone is considered to be predominantly light distillate petroleum (consistent with kerosene or jet fuel) and has been observed within 50 m of the southern boundary of the Blending Area. Groundwater monitoring has identified low level TRH (C_{10} – C_{36}) contamination in groundwater in the Kororoit Creek Reserve area directly south of the Refinery boundary, but north of the Creek. This is inferred to be associated with the Refinery operations given that TRH C_{10} – C_{36} has been reported above the adopted assessment criteria in monitoring wells located along the southern boundary of the Blending Area. In addition to petroleum hydrocarbons, other chemicals of potential concern, including PAHs, arsenic, chromium, copper, iron, lead, manganese, nickel, zinc and ammonia, have also been identified in groundwater in the southern Blending Area.

  A groundwater mound is present in the vicinity of the stormwater impoundment pond, as shown on **Figure 5a** attached. It appears that this groundwater mound is acting as a hydraulic barrier to the

transport of contaminated groundwater from the southern part of the Blending Area to Kororoit Creek. The mound is inferred to be caused by the localised increase in water infiltration associated with the pond system. This mound causes a localised reversal of inferred flow directions which are generally towards the creek. Some petroleum hydrocarbon contamination is present in groundwater beneath Kororoit Creek Reserve, however it appears to be limited, and does not extend at significant concentrations to monitoring wells which are closest to the Creek.

The Auditor's assessment of potentially complete exposure pathways for groundwater is presented as follows:

- **Extraction of groundwater:** no registered extractive use groundwater (wells have been identified within 1km to the south and south-east of the southern boundary of the Refinery (i.e. hydraulically downgradient). As such there does not currently appear to be a complete exposure pathway for extractive use of groundwater. The protected extractive beneficial uses of groundwater in this area (based on TDS) are Primary Contact Recreation, Industrial Water Use, and Stock Watering. Although these beneficial uses may be considered to be unlikely in this area (particularly Stock Watering and Industrial Water Use), there is some potential for them to be realised in future.

  *The extractive use of groundwater to the south of the Refinery **is further considered** in the qualitative risk assessment.*

- **Discharge of groundwater to surface water:** the nearest surface water receptor in the direction of groundwater flow is the Kororoit Creek, located approximately 20 to 40 m from the southern boundary of the Refinery. Site investigations have identified impacted groundwater from the Refinery may potentially discharge to Kororoit Creek, however the concentrations and rate of discharge to Kororoit Creek are likely to be low, based on the groundwater monitoring well results and the expected low hydraulic conductivity of the alluvial sediments surrounding Kororoit Creek. A number of aquifer tests have been carried out at the Site and these provide an indication of local scale, bulk hydraulic conductivity values for the aquifer systems of interest. Results from testing of the Newer Volcanics aquifer indicated hydraulic conductivity values ranging from approximately 9×10^{-4} m/day to 46 m/day (URS, 2007 & 2009). The lowest values were reported along Kororoit Creek to the south of Blending Area, and the higher values in the Pegasus Paddock area.

  The chemical signature of the petroleum hydrocarbons detected in groundwater along the southern boundary of the Refinery is consistent with weathered lube/waste oil. The chemical signature of hydrocarbons in groundwater further downgradient in the off-site area differs and is indicative of biogenic material which may be attributed to naturally occurring organic matter or degradation of petroleum hydrocarbons.

  *Groundwater discharge to surface water to the south of the Refinery **is further considered** in the qualitative risk assessment.*

- **Excavations**: given depth to groundwater in the Kororoit Creek Reserve area ranges from approximately 1.0 to 2.5 mbgs there is potential for excavation works to intercept impacted groundwater.

*The seepage of groundwater into subsurface trenches or excavations to the south of the Refinery **is further considered** in the qualitative risk assessment.*

- **Underground services:** based on the underground services plans provided to the Auditor in the assessors report (Golder, 2014a), there does not appear to be any underground services in the Kororoit Creek Reserve area to the south of the Blending Area. Therefore this pathway is considered to be incomplete, due to absence of a receptor.

  *The discharge of groundwater to underground service trenches to the south of the Refinery **will not be further considered** in the qualitative risk assessment.*

- **Vapour**: volatile chemicals (including TPH C_{10} – C_{14}, xylenes and ammonia) have historically been reported in groundwater within the Kororoit Creek Reserve Area, thus there is potential for vapour migration through the vadose zone. No buildings are present within the Kororoit Creek Reserve Area, and impacted groundwater is not expected to migrate beyond Kororoit Creek to the area where the nearest buildings (residential dwellings) are located (approximately 300m south). There is a potentially complete vapour inhalation exposure pathway for human receptors in sub-surface excavations and outdoor air.

  *The migration of vapours from groundwater plume to the south of the Refinery **is further considered** in the qualitative risk assessment.*

- **Soil:** the soil within the Kororoit Creek Reserve Area is impacted with hydrocarbons and metals including chromium, copper, mercury and zinc, which is considered to be due to the historical drainage channels for wastewater discharge to Kororoit Creek. The direct soil contact pathway is considered to be potentially complete for recreational users, adult workers and ecological receptors within the Kororoit Creek Reserve Area. The impacted soil is a potential source of contamination to Kororoit Creek via leaching through the vadose zone, or via surface run-off of sediments during high rainfall events.

  *The potential exposure to contaminated soil within the Kororoit Creek Reserve Area to the south of the Refinery **is further considered** in the qualitative risk assessment.*

- **Stormwater and Wastewater**: stormwater and wastewater is considered to be contained within the boundaries of the Refinery and then discharged to sewer, thus unlikely to migrate off-site to the south. However, it is known that wastewater from the Refinery was historically discharged to Kororoit Creek via four drainage channels thus may have impacted on this surface water body. It is also acknowledged that there have been at least two uncontained releases of wastewater from the Wastewater Treatment Facility which have resulted in discharges to Kororoit Creek.

  *Surface water discharge of wastewater to the south of the Refinery **is not further considered** in the qualitative risk assessment, as this is considered to be beyond the scope of the 53V Audit. Refinery operations such as wastewater management and infrastructure management (eg tank integrity testing) are beyond the scope of the Audit, and are addressed under the Mobil Refinery Operational and Integrity Management System (OIMS).*

The risk assessment for the identified source-pathway-receptors is presented in Table 8.9.

Table 8.9 - Risk Assessment for the area South of the Refinery boundary

Hazard Analysis					Risk Characterisation *(refer to Tables 2-2 to 2-4 for likelihood, consequence and risk definitions)*			
Risk No.	**Source**	**Environmental Element and Beneficial Use/Receptor**	**Exposure pathway**	**Contaminants of Potential Concern**	**Likelihood**	**Consequence**	**Overall Risk Rating**	**Auditors Summary**
1	Blending Area	Groundwater Extractive Uses	Exposure to contaminants in extracted groundwater	Petroleum Hydrocarbons Ammonia	Rare	Medium	**Low**	In the ***Rare*** event that a groundwater extraction bore were installed in the Kororoit Creek Reserve Area potential adverse health effects may occur. The potential consequences should exposure occur is considered to be ***Medium***, with potential for chronic health effects.
2	Blending Area	Surface Water due to groundwater discharge into Kororoit Creek – aquatic ecological receptors	Exposure to contaminants in surface water of Creek as a result of groundwater discharge	Petroleum Hydrocarbons Ammonia	Probable	Minor	**Low**	Based on the understanding of the hydrogeology at the site it is almost certain that groundwater from the southern Blending Area discharges to Kororoit Creek. Although petroleum hydrocarbon concentrations decrease towards the Creek, it is considered ***Probable*** that groundwater contaminants would be discharging to the Creek with groundwater. Ecological risks directly related to contaminants in the water column are likely to be low given the expected groundwater to surface water dilution factor. Any adverse effects to surface water receptors are likely to be ***Minor*** and restricted to a small localised area.
3	Blending Area	Sediment due to groundwater discharge into Kororoit Creek – aquatic ecological receptors	Exposure to contaminants in sediment of Creek as a result of groundwater discharge	Petroleum Hydrocarbons Ammonia	Probable	Medium	**Medium**	Based on the understanding of the hydrogeology at the site it is almost certain that groundwater from the southern Blending Area discharges to Kororoit Creek. Although petroleum hydrocarbon concentrations decrease towards the Creek, it is considered ***Probable*** that groundwater contaminants would be discharging to the Creek with groundwater. Adverse effects to ecological receptors are most likely to occur in the benthic and littoral zones due to contamination of groundwater within sediments, and possibly the resulting accumulation of contaminants in sediments. Site investigation works to date have not included assessment of sediment quality. Ecological risks directly related to sediment are considered to be ***Medium*** as the current extent of sediment contamination (if any) due to the Refinery operations is not known.
4	Blending Area	Surface water in Kororoit Creek – Recreational Users	Exposure to contaminants in surface water and sediment of Creek as a result of groundwater discharge	Petroleum Hydrocarbons Ammonia	Not likely	Negligible	**Very Low**	Based on the understanding of the hydrogeology at the site it is considered almost certain that groundwater from the southern Blending Area discharges to Kororoit Creek. The likelihood of recreational use of this part of Kororoit Creek however is considered to be ***Not Likely***. Any adverse health effects are likely to be ***Negligible*** given the relatively low concentrations of contaminants and short exposure times.
5	Blending Area	Groundwater discharge to sub-surface excavations – Human Health	Exposure to contaminants in groundwater intercepted during excavation	Petroleum Hydrocarbons Ammonia	Not likely	Minor	**Low**	It is considered probable that future sub-surface excavation works in the Kororoit Creek area would intercept contaminated groundwater, however it is noted that deeper excavations in this area are ***Not Likely***. Potential health effects to sub-surface excavation workers who come in direct contact with contaminated groundwater are likely to be ***Minor*** due to the short exposure times and relatively low concentrations based on current site conditions and groundwater flow.

Hazard Analysis					Risk Characterisation *(refer to Tables 2-2 to 2-4 for likelihood, consequence and risk definitions)*			
Risk No.	**Source**	**Environmental Element and Beneficial Use/Receptor**	**Exposure pathway**	**Contaminants of Potential Concern**	**Likelihood**	**Consequence**	**Overall Risk Rating**	**Auditors Summary**
6	Blending Area	Air (vapour): Human Health	Migration of vapours from groundwater plume (outdoor air and sub-surface excavations)	Petroleum Hydrocarbons Ammonia	Not Likely	Minor	**Low**	Based on current site conditions and groundwater flow, the presence of volatile groundwater contaminants beneath the Kororoit Creek area indicates there is a potential sub-surface excavation workers and recreational users may be exposed to contaminants in air. However, a semi-quantitative risk assessment completed by Golder indicated that adverse health effects due to vapour inhalation were ***Not Likely*** to occur given the expected attenuation during migration through the vadose zone and mixing with fresh outdoor air. Should adverse health effects occur they are expected to be temporary (***Minor***).
7	Blending Area (historical discharges and LNAPL and soil contamination in former drainage lines)	Surface water and sediment: Aquatic ecological receptors	Migration of contaminants from legacy areas to surface water and sediments in Kororoit Creek	Petroleum hydrocarbons and metals (mercury, copper, zinc, nickel, chromium)	Probable	Medium	**Medium**	Due to the potential for residual soil contamination associated with former wastewater discharges to the Creek, and residual contamination in soil in the Kororoit Creek Reserve former drainage lines, there is potential for this soil contamination to adversely affect the creek sediments and surface waters. The degree of leaching and transport of the residual soil contamination to the sediments and surface waters of Kororoit Creek is however not known, and therefore a likelihood ranking of ***Probable*** has been adopted. If transport of residual soil contaminants to the Creek were occurring, this is likely to be occurring at a low rate, and as such it is considered that only ***Medium*** ecological effects could occur.

8.4.2 Recommendations

The Auditor's recommendations, in relation to the risk assessment findings for the land south of the Refinery are presented as follows:

1. Groundwater extractive uses:

a. Notification of groundwater extraction licensing authority that groundwater should not be used for extractive uses in the area to the immediate south of the Refinery area, between the southern Refinery boundary and Kororoit Creek.

b. Ongoing monitoring in accordance with the Auditor reviewed *Mobil Altona Refinery Groundwater Quality Management Plan* (Golder, 2013h). The GQMP is required to be updated and reviewed by the Auditor as part of the Clean Up Plan verification, to include trigger conditions and contingencies in relation to the groundwater mound near the southern boundary of the Blending Area, including consideration of the likelihood of LNAPL mobilisation in the event that the groundwater mound dissipated, and the necessary response measures, such as remediation of the LNAPL in this area.

2. Groundwater discharge to sub-surface excavations (ie Human Health risk)

a. Notification of the land manager for Kororoit Creek Reserve of the potential to encounter groundwater contamination in this area (ie between the southern boundary of Blending and Kororoit Creek), and that appropriate exposure control measures should be implemented when workers are conducting sub-surface excavation works.

b. Alternatively conduct further site-specific human health risk assessment to determine the need for risk management controls.

3. Discharges into Kororoit Creek (maintenance of ecosystems)

a. Further assessment of the potential ecological risks to Kororoit Creek associated with discharges of contaminants in groundwater, surface run-off water and mobilisation of soil contaminants. This should include investigation of the contaminants in Creek sediments (from either groundwater discharge or contaminated sediment transport) from Refinery and potential risks to benthic organisms.

b. Remediation of soil and LNAPL present in four former drainage areas in Kororoit Creek Reserve.

4. Soil: Direct contact (Maintenance of ecosystems, Human Health)

a. As per recommendation 3b, remediation of soil and LNAPL present in four former drainage areas in Kororoit Creek Reserve.

8.5 Utility and Transport Corridors

Subsurface utilities are present across the site, and off-site under roadways and within easements. The utilities include: water, sewers, gas, electricity, communications, stormwater and fuel pipelines. In addition, there are off-site roadway, railway and park lands owned by third parties immediately adjacent to the site.

Underground utilities are a potential conduit for contaminant migration and a point at which adult workers who maintain these utilities can be exposed to contaminants including vapours. The known utilities have been identified and mapped, with the exception of stormwater drainage plans which are not provided by DBYD.

In addition to underground services, there is potential that contamination originating from the Refinery to be present in off-site service corridors, such as railway and road reserves, although contamination in these areas has not been identified.

8.5.1 Source-Pathway-Receptor Assessment

Primary Sources of Contamination

The following potential sources of contamination from the Refinery relevant to Utility and Transport Corridors were identified:

- SCN LNAPL: as this LNAPL extends off-site under Kororoit Creek and Millers Road, there is potential for this LNAPL to volatilise into underground services and pits. In addition, there is potential for workers conducting excavations in road reserves or other public off-site areas to be exposed to SCN vapours.
- Processing area LNAPL: this LNAPL is inferred to extend underneath Kororoit Creek Road, and therefore there is potential for this LNAPL to volatilise into underground services and pits. In addition, there is potential for workers conducting excavations in road reserves or other public off-site areas to be exposed to LNAPL vapours.
- Railway corridors: there is potential for site sourced contamination to be transported into Railway Corridors, such as from the Soil Management area to the east of the Blending Area.

The specific Chemicals of Potential Concern (COPCs) relevant to the Utility and Transport Corridors are presented in the following Table. These COPCs have been identified based on chemicals identified in soil and/or groundwater either at the site boundary or off-site, based on analysis of a broad range of COPCs associated with the Refinery operations. Where COPCs are considered to be due to background conditions (such as some metals), or an off-site source, they have not been included in the COPC list.

Table 8.10 - Summary of Chemicals of Potential Concern for Utility and Transport Corridors

Possible Contaminant Sources	Chemicals of Potential Concern			
	Soil	Groundwater	Surface Water	Soil Vapour
LNAPL Plumes	None identified	Petroleum hydrocarbons Ammonia	None identified	Petroleum hydrocarbons Ammonia
Residual soil contamination in on-site areas	None identified, however potentially petroleum hydrocarbons associated with contaminated soil and tank sludges	Petroleum hydrocarbons	None identified	None identified

Potential Pathways and Receptors

The following potential complete exposure pathways for the migration of contamination from on-site sources and groundwater contamination in off-site areas have been identified:

- **Groundwater**:
    - there are shallow and deep underground services present beneath the ground surface of the land to the north of the Refinery. All identified underground utility services are present above the groundwater standing water level, with the exception of the Ross Road and Kyle Road main sewer and the sewer to the immediate east of the NCTF. Therefore, there is potential for contaminated groundwater originating from the Refinery to be seeping into the deep sewers in these areas.
    - there is potential for groundwater to discharge into deep excavations during maintenance or construction works in service corridors. This may impact on receptors through direct contact with contaminated groundwater.

      *The discharge of groundwater into underground services and trenches during excavation works **is further considered** in the qualitative risk assessment.*
- **Vapour**: there is potential for vapours from LNAPL plumes to migrate into underground utilities and/or deep excavations during maintenance or construction works in service corridors.

  *The migration of vapours from the LNAPL plumes **is further considered** in the qualitative risk assessment.*
- **Soil:** there is potential for soil contamination to migrate from the Soil Management area into the Railway Corridor to the east of the Refinery boundary in this area. Furthermore there is potential for

surface water from the Refinery site to migrate off-site (due to run-off) and impact on soil in utility corridors adjacent to the site boundaries, particularly where the site boundaries are not bunded.

*The potential exposure to contaminated soil within the rail corridor to the east of the Refinery, and subsequent impact to Kororoit Creek **is further considered** in the qualitative risk assessment.*

The risk assessment for the identified source-pathway-receptors is presented in Table 8.11.

Table 8.11 - Risk Assessment for the Utility and Transport Corridors

Hazard Analysis					Risk Characterisation *(refer to Tables 2-2 to 2-4 for likelihood, consequence and risk definitions)*			
Risk No.	**Source**	**Environmental Element and Beneficial Use/Receptor**	**Exposure pathway**	**Contaminants of Potential Concern**	**Likelihood**	**Consequence**	**Overall Risk Rating**	**Auditors Summary**
1	LNAPL (excluding SCN LNAPL which is presented separately in Table 8.7)	Groundwater: Human health – adult maintenance workers	Excavations intercepting groundwater	Petroleum hydrocarbons	Probable	Minor	**Low**	Based on the depth to groundwater and the depth of services generally being above the groundwater standing water level, it is generally considered Not Likely that this event would occur, except were services are present below the groundwater table, such as to the north and east of the site, where deeper sewers exist. In these areas is it considered ***Probable*** that this would occur. In the event that discharge of groundwater occurred in these areas, the consequences are considered to be ***Minor***, due to the low contaminant concentrations to the north and east of the Refinery.
2	LNAPL (excluding SCN LNAPL which is presented separately in Table 8.7)	Air (vapour) Human health – adult maintenance workers	Migration of vapours through underground utilities (including backfill)	Petroleum hydrocarbons	Probable	Significant	**High**	The utility pit monitoring data generally indicates that vapour migration into utility pits and services unlikely. However, given the short duration which utility pit monitoring occurs, and the potential for vapour migration into conduits and backfilled trenches which cannot be monitored, it is considered to be ***Probable*** that this event could occur. If the event did occur without any occupational exposure controls, the consequences could be ***Significant.***
3	Contaminated soil and sludge in Solid Waste Management area	Soil: Human health – adult maintenance workers (Railway Corridor to east of Blending)	Direct contact exposure for maintenance workers in railway corridor	Petroleum hydrocarbons, metals	Probable	Minor	**Low**	The extent of soil contamination migrating from the Soil Management area to the Railway corridor in this area is currently unknown, therefore it is conservatively assumed that this 'might occur' (i.e. ***Probable***). However the potential consequence of this occurring, with respect to human health in this area, is expected to be ***Minor***
4	Contaminated soil and sludge in Solid Waste Management area	Surface water: maintenance of ecosystems	Sediment run-off to surface water body (Kororoit Creek) from Railway Corridor	Petroleum hydrocarbons, metals	Not likely	Minor	**Low**	The extent of soil contamination migrating from the Soil Management area to the Railway corridor, and possibly from that point into Kororoit Creek, is currently unknown, however based on a site inspection of the drainage of this area conducted by the Auditor, it is considered ***Not Likely***. The surface topography, degree of vegetation and distance from the area in which soils are managed to the off-site railway corridor area, suggests very limited potential for significant sediment run-off. The potential consequence of this occurring, with respect to ecosystem protection in this area, is considered to be ***Minor***.

8.5.2 Key Areas of Uncertainty and Recommendation

The Auditor's recommendations, in relation to the risk assessment findings for the Utility and Transport Corridors are presented as follows:

1. Groundwater: Human health – adult maintenance workers:

a. Mobil to maintain the Dial-Before-You-Dig registration of potentially hazardous areas for third parties conducting sub-surface works;

b. Notify utility owners in the area of the potential for human health hazards to exist in the vicinity of the Refinery. The area covered by the notification needs to include all off-site areas where LNAPL is present, or dissolved phase contamination above the adopted criteria, including a suitable buffer distance. This should be documented in the Clean Up Plan.

c. Ongoing monitoring in accordance with the Auditor reviewed *Mobil Altona Refinery Groundwater Quality Management Plan* (Golder, 2013h).

2. Air (Vapour): Human health – adult maintenance workers:

a. As per recommendation 1a;

b. As per recommendation 1b;

c. As per recommendation 1c.

d. Periodic monitoring of utility pits to be continued, in areas previously monitored. Prepare a program of continuous utility pit monitoring for utility pits in the vicinity of the Pegasus Building, where elevated vapours have been previously recorded. The objective of the monitoring is to provide data on utility pit vapour ingress over an extended period, in addition to the short time period monitoring currently conducted. This program is to be documented in the Clean Up Plan.

e. Investigation to establish whether the utility pits previously identified with elevated VOC concentrations have any vapour pathway connection to the Refinery sewer system, as indicated by the site assessor. This will provide further information on the source of the utility pit vapours reported in these pits, and whether these pits represent a higher risk of vapour intrusion.

8.6 South Crude Tank Farm (SCTF) Off-site Areas

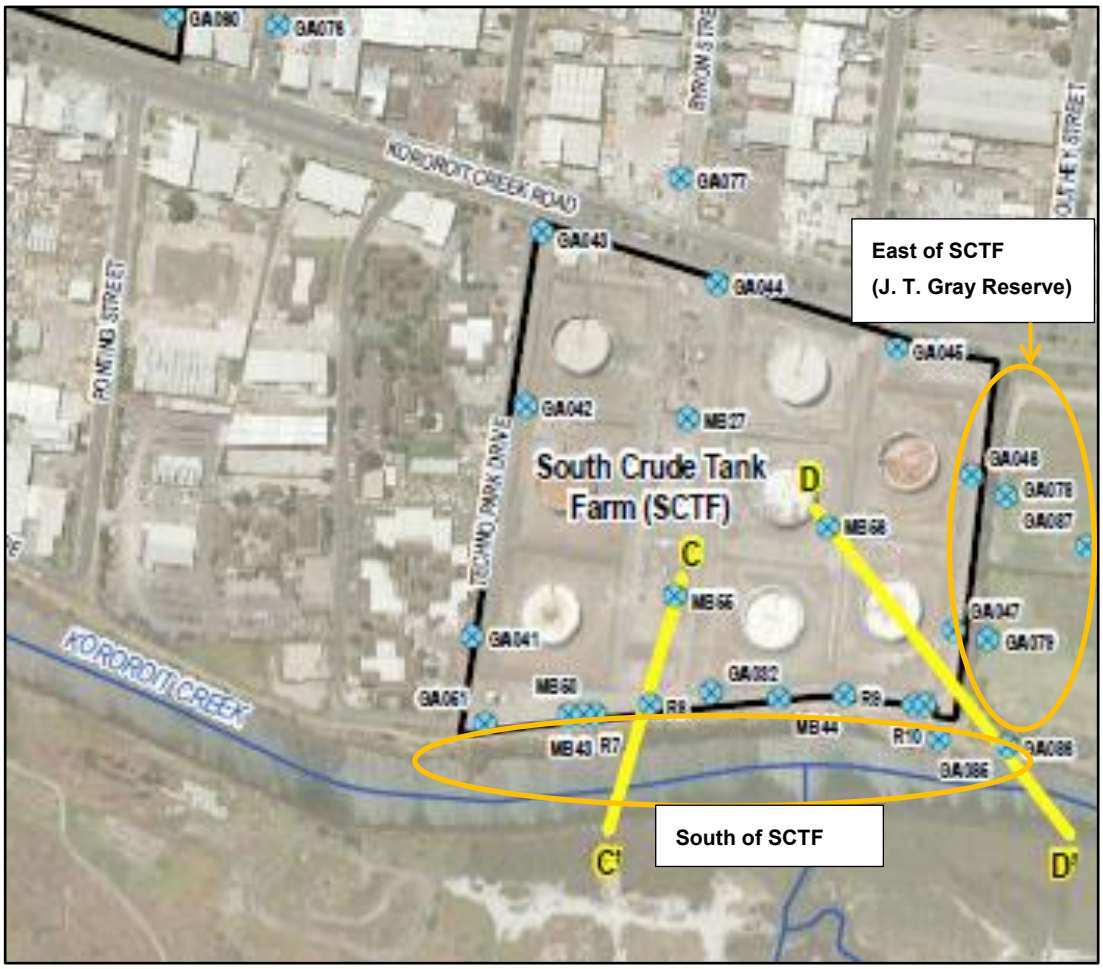
The SCTF covers approximately 8 ha of land and is surrounded by mixed land use including recreational open space, industrial, commercial and to a lesser extent, residential uses.

The SCTF is situated near the estuary of Kororoit Creek which flows in an easterly direction approximately 20 m south of the southern SCTF boundary. The Creek discharges into Port Phillip Bay approximately 400 m east of the SCTF. The tank farm at SCTF was built on a flood plain that has been in-filled.

Immediately to the north of the SCTF is Kororoit Creek Road and beyond Kororoit Creek Road is industrial and commercial land. To the east is J.T. Gray Reserve and to the west Techno Park, an area of industrial and commercial land. Residential land is located immediately adjacent to the western boundary of Techno Park. The land located between the southern boundary of the SCTF and Kororoit Creek is occupied by a public path, which runs east-west. The land between the path and Kororoit Creek consists of undeveloped land owned by Melbourne Water. South of Kororoit Creek lies the Altona Coastal Park.

SCTF is shown on **Figures 2, 4 and 6** attached and in the image below. Two cross sections (C-C' and D-D') through the SCTF area are presented on **Figures 12 and 13** attached.

Plate 5 – SCTF Off-Site Areas of Interest



8.6.1 Primary Sources of Contamination

The SCTF has operated as a crude tank farm since 1953 when the Refinery was upgraded in order to produce its first transport fuels. Eight new tanks were constructed at the SCTF (800 to 807). The tanks were operated as crude oil tanks from 1953 to around 1969. From around 1970, only Tank 802 was retained as a crude tank for crude shipments delivered by sea, while the other tanks were converted to either residual fuel (Tank 800, 801, 803 and 804) or raw naphtha storage (Tank 805, 806 and 807). The SCTF is still operated in this manner. The following potential sources of contamination from the SCTF were identified:

a. Product Storage within Tank Compounds.
b. Evidence of release and observations of TPH impacts in soil have been reported in tank bunds. Evidence of releases includes:

c. The burial of sludge from tank cleaning in all tank bunds (AGC Woodward-Clyde, 1991).

d. The observations of a pit described as containing hydrocarbon and water in the north-west corner of Tank 803 compound (AGC, 1991).

e. A reported release of approximately 4,000 L of naphtha in 2000.

f. Product Transfer.

The crude oil is transferred from crude shipments to SCTF via an underground pipeline. The pipeline enters the SCTF from Churchill Street, north of SCTF. Residual fuels and raw naphtha are supplied to SCTF by underground pipelines, which run from the Refinery to the north-west corner of the SCTF, along Kororoit Creek Road. These areas were indicated to have surface spills and releases involving products historically stored at the SCTF, including raw naphtha.

Following the construction of the tank farm, rainwater from tank roofs, tank dewatering activities and bund drainage was directed to an open central spoon drain. This spoon drain bisected the tank farm in a north-south direction and discharged into Kororoit Creek. A soil assessment conducted by Golder in the vicinity of the spoon drain outlet into Kororoit Creek indicated the presence of metals and TPH impacts in soils (Golder, 2012b). Originally, bunded areas for all tanks discharged into the central spoon drain, with the exception of Tank 806 which discharged via a valved outlet located to the east of the SCTF, adjacent to J.T. Gray Reserve.

The wastewater collection system was upgraded in the early 1990s and from 1995 onwards, tank dewatering and tank compound water was collected in a central pit and transferred via an underground pipeline to the main Refinery wastewater treatment plant in the Blending Area.

The specific Chemicals of Potential Concern (COPCs) relevant to the South Crude Tanks Farm are presented in the following Table. These COPCs have been identified based on chemicals identified in soil and/or groundwater either at the boundary or off-site, based on analysis of a broad range of COPCs associated with the SCTF operations. Where COPCs are considered to be due to background conditions (such as some metals), or an off-site source, they have not been included in the COPC list.

Table 8.12: Summary of Chemicals of Potential Concern for SCTF Area

Possible Contaminant Sources	Chemicals of Potential Concern			
	Soil	Groundwater	Surface Water	Soil Vapour
Product Storage within Tanks Compounds Within bunded areas of Tanks 801, 804 and 806	Petroleum Hydrocarbons	Petroleum Hydrocarbons	None identified	None identified
Product Transfer Including pipe tracks, pipelines and associated installations	Petroleum Hydrocarbons	Petroleum Hydrocarbons	None identified	None identified
Ancillary and Support Services Including process activities, storm water and wastewater management, and the former drainage area into Kororoit Creek	Petroleum Hydrocarbons and metals (mercury, chromium, copper, and zinc)	Petroleum Hydrocarbons	Petroleum Hydrocarbons	None identified

8.6.2 Potential Pathways and Receptors

The following potentially complete exposure pathways for the migration of contamination from on-site sources have been identified:

Groundwater: there are two groundwater flow patterns relevant to the off-site areas around the SCTF, including a south-easterly flow pattern and a southerly flow pattern. J.T. Gray Reserve is located hydraulically down gradient to the south-east whilst Kororoit Creek is located down gradient to the south. Both of these areas could be impacted by contaminated groundwater from the site. Petroleum hydrocarbons have been reported in groundwater beneath the SCTF including along the south-eastern boundary of the site. TPH fractions C_{10}-C_{36} have been reported in off-site wells GA085 and GA086 and chemical fingerprinting indicated the impact is likely to be biogenic material. It is also noted that monitoring bores MB28 and MB44, located on the southern boundary of the SCTF, are screened above the static water level.

The Auditor's assessment of potentially complete exposure pathways for groundwater is presented as follows.

- **Extraction of groundwater:**

  The closest registered groundwater well for extractive use (stock watering, domestic supply, irrigation) is located 1.3 km to the east of the SCTF. There does not currently appear to be a complete exposure pathway for extractive groundwater use. The protected extractive beneficial uses of groundwater in this area (based on TDS) are Primary Contact Recreation, Industrial Water Use and Stock Watering. Although these beneficial uses are considered unlikely in this area, there is some potential for the beneficial uses of groundwater in this area to be realised in the future. Refer

to Section 4.6 of the SCTF Groundwater Condition Report (Golder, 2013e) report for a summary on groundwater usage and registered groundwater bores.

*The extractive use of groundwater at the SCTF is **further considered** in the qualitative risk assessment.*

- **Groundwater discharge to surface water:** the nearest surface water receptor in the direction of groundwater flow is the Kororoit Creek estuary located approximately 20m to the south of the southern boundary of the SCTF. Site investigations have identified that impacted groundwater from the SCTF may potentially discharge to Kororoit Creek along both the southerly and south-easterly groundwater flow paths. Beneath the SCTF area the groundwater contamination is considered to be predominately weather crude in the south eastern portion of the site and along the southern boundary chemical signature of the hydrocarbons is indicative of biogenic material.

  *Surface water discharge of groundwater to the south of the SCTF **is further considered** in the qualitative risk assessment.*

- **Excavations**: given depth to groundwater in the off-site areas of the SCTF has been reported to be in the vicinity of 1.6 mbgs there is potential for excavation works to intercept impacted groundwater. It is noted that the concentrations of contaminants groundwater wells along the SCTF boundary are relatively low and below the adopted Primary Contact Recreation criteria.

  *The discharge of groundwater to excavations in the SCTF area **is further considered** in the qualitative risk assessment.*

- **Underground services**: a shallow sewer is present in Kororoit Creek Road along the northern boundary of the SCTF which is positioned below the standing groundwater level. A stormwater drain located along the eastern boundary of the SCTF is also positioned below the standing groundwater level. There is potential for contaminated groundwater originating from the SCTF to be seeping into these underground utilities.

  *The discharge of groundwater to underground services in the vicinity of the SCTF **is further considered** in the qualitative risk assessment.*

Vapour: the land surrounding the SCTF is potentially subject to lateral vapour migration from contaminated in groundwater beneath the SCTF area. Semi-volatile chemicals have been reported in groundwater in this area, thus there is considered to be a potentially complete vapour inhalation exposure pathway for human receptors in sub-surface excavations and utility pits. It is noted however that the petroleum hydrocarbon contamination in this area is generally greater than C9 chain length, and therefore the vapour risk is considered to be lower than in the main Refinery area.

*The migration of vapours from groundwater in the vicinity of the SCTF **is further considered** in the qualitative risk assessment.*

Soil: Two soil investigations associated with the SCTF have been undertaken targeting historical surface water discharge areas including:

- Discharge of surface water collected in the central spoon drain south of the SCTF boundary which discharged towards Kororoit Creek (Golder Associates 2012b, *Kororoit Creek Soil Investigation, Mobil Altona Refinery*, Reference 097651007-532-R-Rev0 dated 23 October 2012).

- Discharge of stormwater and tank dewatering from Tank 806 compound into the adjacent J.T. Gray Reserve (Golder Associates 2013f, J.T. Gray Reserve Soil Investigation, Mobil Altona Refinery, Reference 097651007-591-R-Rev0, January 2013).
- Ecological soil screening criteria have been exceeded for TPHs, mercury and copper at some of the investigation locations targeting impacts associated with the central spoon drain and Kororoit Creek. In addition historic tank water from Tank 806 and storm water from the SCTF compound was discharged into the J.T. Gray Reserve, east of the SCTF. Thus there is potential for recreational users, adult workers and ecological receptors in the Kororoit Creek Reserve areas to be exposed to impacted soil. The impacted soil is also a potential secondary source of impact to Kororoit Creek. For the J.T. Gray Reserve the soil data indicates that the potential risks to human health receptors and ecological receptors is considered to be low as concentrations of TPH, BTEX and naphthalene were reported below the laboratory limits of reporting.
- *The potential exposure to soil within Kororoit Creek Reserve are **further considered** in the qualitative risk assessment, whilst the potential exposure to soil within J. T. Gray reserve is **not further considered.***

Sediments: Historical information indicates that surface water collected in the central spoon drain from bunded areas of tanks and other infrastructure, was discharge to the creek. Furthermore there is potential for contamination in soils within the Kororoit Creek Reserve area to be mobilised and discharge to Kororoit Creek as a result of surface water run-off. This has the potential to result in contamination of sediments within Kororoit Creek and thus adverse effects to aquatic/riparian ecosystems and recreational users of the creek.

*The potential exposure to sediments within Kororoit Creek **is further considered** in the qualitative risk assessment.*

The risk assessment for the identified source-pathway-receptors is presented in Table 8.13.

Table 8.13 - Risk Assessment for the SCTF off-site areas

Hazard Analysis					Risk Characterisation *(refer to Tables 2-2 to 2-4 for likelihood, consequence and risk definitions)*			
Risk No.	**Source**	**Environmental Element and Beneficial Use/Receptor**	**Exposure pathway**	**Contaminants of Potential Concern**	**Likelihood**	**Consequence**	**Overall Risk Rating**	**Auditors Summary**
1	South Crude Tank Farm Hydrocarbons	Groundwater: extractive uses	Exposure to contaminants in extracted groundwater	Petroleum hydrocarbons	Rare	Minor	**Very Low**	In the ***Rare*** event that a groundwater extraction bore was installed in the area in the immediate vicinity of the SCTF potential adverse health effects may occur as a result of the low level TRH contamination in groundwater. The potential consequences should exposure occur is considered to be ***Minor*.**
2	South Crude Tank Farm Hydrocarbons	Groundwater discharge to surface waters: Maintenance of Ecosystems and Primary Contact Recreation (Kororoit Creek)	Exposure to contaminants in surface water of Creek as a result of groundwater discharge	Petroleum hydrocarbons	Probable	Minor	**Low**	Based on the understanding of the hydrogeology at the site it is almost certain that groundwater from the SCTF discharges to Kororoit Creek. Although petroleum hydrocarbon concentrations decrease towards the Creek, it is considered ***Probable*** that groundwater contaminants would be discharging to the Creek with groundwater. Ecological risks directly related to contaminants in the water column are likely to be low given the expected groundwater to surface water dilution factor. Any adverse effects to surface water receptors are likely to be ***Minor*** and restricted to a small localised area.
3	South Crude Tank Farm petroleum hydrocarbons in groundwater	Sediment due to groundwater discharge into Kororoit Creek – aquatic ecological receptors	Exposure to contaminants in sediment of Creek as a result of groundwater discharge	Petroleum hydrocarbons	Probable	Medium	**Medium**	Based on the understanding of the hydrogeology at the site it is almost certain that groundwater from the SCTF discharges to Kororoit Creek. Although petroleum hydrocarbon concentrations decrease towards the Creek, it is considered ***Probable*** that groundwater contaminants would be discharging to the Creek with groundwater. Adverse effects to ecological receptors are most likely to occur in the benthic and littoral zones due to accumulation of contaminants in sediments. Site investigation works to date have not included assessment of sediment quality. Ecological risks directly related to sediment are considered to be ***Medium*** as the current extent of sediment contamination (if any) due to the SCTF operations is not known.
4	South Crude Tank Farm petroleum hydrocarbons in groundwater	Groundwater: underground services	Discharge of groundwater into shallow sewers/stormwater	Petroleum hydrocarbons	Not likely	Minor	**Low**	The shallow stormwater drain runs along the eastern boundary of the SCTF. It is inferred that the drain or sections of the backfill material may be intercepting the watertable only when it is at its highest. Thus it is considered ***Not Likely*** that contaminated groundwater will be discharged to the stormwater drain and the potential consequences ***Minor***.
5	South Crude Tank Farm Hydrocarbons	Air (vapour) Human health	Migration of vapours from dissolved phase contamination in groundwater (Outdoor and Indoor Air and sub-surface excavations)	Petroleum hydrocarbons	Rare	Minor	**Very Low**	Given the presence of semi-volatile groundwater contaminants beneath the SCTF area there is potential for workers in excavations to be exposed to contaminants from soil vapour. The current monitoring data indicates that the TPH C_{10}-C_{36} impacts derived from the SCTF are sufficiently distant from the residential and commercial receptors to the surrounding land, to not represent a vapour risk (i.e. ***Rare***). There is no LNAPL in monitoring wells at SCTF and the absence of the more volatile TPH C_6-C_{10}

Hazard Analysis					Risk Characterisation *(refer to Tables 2-2 to 2-4 for likelihood, consequence and risk definitions)*			
Risk No.	**Source**	**Environmental Element and Beneficial Use/Receptor**	**Exposure pathway**	**Contaminants of Potential Concern**	**Likelihood**	**Consequence**	**Overall Risk Rating**	**Auditors Summary**
								fraction and BTEX along the northern and western boundaries, the potential for soil vapour to accumulate within the utility pits and the backfill of the utility pits is considered ***Rare*****.** This is supported by a semi-quantitative risk assessment completed by Golder which indicated that there was likely to be sufficient attenuation of vapours in the vadose zone. Should adverse health effects occur they are expected to be ***Minor***,
6	South Crude Tank Farm Hydrocarbons	Soil: Human health – adult workers, recreational users	Direct contact with contaminated soil in Kororoit Creek Reserve	Petroleum hydrocarbons	Probable	Minor	**Low**	It is considered ***Probable*** that sub-surface maintenance workers, recreational users and ecological receptors will come in direct contact with contaminated soil with the Kororoit Creek Reserve. Based on the soil concentrations reported, any adverse effects to human or ecological receptors are likely to be relatively ***Minor***.
7	South Crude Tank Farm – Residual soil contamination in Assessment Area 4	Soil/Sediment: aquatic and riparian ecosystems	Mobilisation of contaminated soil to sediments in Kororoit Creek	Petroleum hydrocarbons	Probable	Medium	**Medium**	There is potential for soil contaminants in the Kororoit Creek Reserve area are to be mobilised and discharged to the Creek as a result of surface run-off (i.e. due to rainfall events) or leaching. Thus is it is considered ***Probable*** that ecological receptors may be exposed to contaminants associated with the residual soil impact. Any adverse effects are likely to be ***Medium*** however it is noted that due to the small area of residual soil contamination, any adverse effects would be localised.

8.6.3 Key Areas of Uncertainty and Recommendations

The Auditor's recommendations, in relation to the risk assessment findings for the SCTF are presented as follows:

1. Groundwater: Extractive Uses (PCR, Stock watering, Industrial):

a. Notification of groundwater extraction licensing authority that groundwater should not be used for extractive uses in the area to the immediate south of the SCTF, between the southern and south-eastern SCTF boundary and Kororoit Creek.

b. Ongoing monitoring in accordance with the Auditor reviewed *Mobil Altona Refinery Groundwater Quality Management Plan* (Golder, 2013h).

2. Groundwater discharge to Kororoit Creek

- Further data required to understand interaction and potential for preferential flow pathways, along SCTF southern boundary (MB44, GA085 and GA086). Additional data required includes off-site groundwater bore(s) to the south of MB44, and an assessment of the flux of contaminant movement from groundwater to sediments and surface waters of Kororoit Creek. The following investigations could assist in understanding the interaction between groundwater (and contamination) and the creek:
    - Survey the morphology and surface water level in the creek.
    - Assess hydraulic gradients within the creek beds.
    - Assess the magnitude of short and longer term creek and groundwater level fluctuations.
    - Installation of a surface water gauging station.

b. Monitoring bores MB28 and MB44, located on the southern boundary of the SCTF, are screened below the static water level. The depth to groundwater below ground surface is approximately 1.2 m in these wells, therefore it is considered practical to replace these groundwater bores with the well screened across the water table.

3. Discharges into Kororoit Creek (maintenance of ecosystems)

a. Further assessment of the potential ecological risks to Kororoit Creek associated with discharges of contaminants in groundwater, surface run-off water and mobilisation of soil contaminants. This should include investigation of the accumulation of contaminants in Creek sediments from Refinery and potential risks to benthic organisms.

b. Remediation of soil present in the former drainage area (Assessment Area 4) in Kororoit Creek Reserve.

4. Soil: Direct contact (Maintenance of ecosystems, Human Health)

a. As per recommendation 3b, remediation of soil present in the former drainage area in Kororoit Creek Reserve.

9 AUDIT CONCLUSIONS AND RECOMMENDATIONS

The Final Clean Up Notice included the following requirement with respect to the Section 53V Environmental Audit:

Clause 3.2 - By 1 October 2014, you must submit to EPA an environmental audit report, prepared in accordance with section 53V of the Act by an EPA-appointed environmental auditor, that:

(a) delineates the extent of any contamination beyond the boundary of the premises caused by past or current industrial processes, activities or wastes;

(b) specifies the risk of any possible harm or detriment to beneficial uses of the environment; and

(c) recommends measures to reduce risks to beneficial uses to acceptable levels, or, where risks cannot be determined, measures to determine risks.

The Audit has been conducted in accordance with the agreed Audit Scope, based on the requirements of Clause 3.2 of the Clean Up Notice. The scope of this Audit has prioritised the off-site sensitive receptors first, and investigations were focussed on these areas. On-site works were limited mainly to a review of existing data and review of ongoing routine monitoring data (such as biannual groundwater monitoring events), in the context of assessing risks to off-site receptors when considering the source-pathway-receptor model.

Investigation and assessment works were targeted in high priority areas where risk mitigation measures are to be implemented, or where risk mitigation measures were already in place at the commencement of the Audit. The purpose of prioritising risks was to ensure that risks to beneficial uses were managed during the Audit process, where considered necessary, rather than waiting for the Audit completion. This process was managed by establishing a Risk Register, which was prepared by the assessor at the Auditor's request, and included prioritisation of key off-site issues, such as the Steam Cracked Naphtha Light Non-Aqueous Phase Liquid (SCN LNAPL) plume.

In consideration of the Clean Up Notice requirements and the Audit Scope, the following conclusions and recommendations are presented.

9.1 Delineation of extent of contamination beyond the site boundary

9.1.1 Delineation of Soil Contamination

Off-site soil contamination has been identified in two scenarios:

1. Smear zone soil contamination; and

2. Off-site soil contamination in former drainage areas.

In addition, sediment contamination in Kororoit Creek has been identified as a potential issue, based on the proximity of soil contamination in the former drainage areas to the Creek, and a historical study done on Kororoit Creek by EPA (SKM, 1991).

Each of these scenarios is discussed as follows.

Smear Zone Soil Contamination

Soil contamination associated with the off-site migration of chemicals through a groundwater pathway, for example, the Steam Cracked Naphtha Light Non Aqueous Phase Liquid (LNAPL) plume, is present in some off-site areas. The presence of LNAPL at the water table results in the adsorption of chemicals

to the soil in and around that depth, where soil such as clay is present either above the fractured basalt, or clay infill within the fractures of the rock. This soil contamination is likely to be present to a similar lateral extent as the LNAPL, and may also be present over a vertical interval where fluctuations in groundwater levels occur with time, referred to as the 'smear zone'. The soil contamination associated with the smear zone has not been addressed separately to the LNAPL contamination, and as such, delineation of smear zone soil contamination is discussed under the 'Delineation of Groundwater Contamination' section of this report.

Off-site soil contamination in former drainage areas

Soil investigation works have been targeted to off-site areas where the historical review indicated that there was potential for soil contamination to exist from overflows of potentially contaminated water in drainage lines exiting from different parts of the site. Six historical drainage lines were identified, with four being south of the Blending Area, one south of the South Crude Tank Farm, and one to the east of the South Crude Tank Farm in J. T. Gray Reserve. Soil contamination exceeding the adopted criteria for the beneficial uses of land: 'Maintenance of Ecosystems' and 'Human Health' were reported for the four former drainage lines to the south of the Blending Area (Assessment Areas 1 to 3 and the 'Legacy Drainage Channel'), and the former drainage line to the south of the South Crude Tank Farm (Assessment Area 4). No soil contamination above the adopted criteria was reported in J. T. Gray Reserve. Soil contamination reported in these areas appears to be generally associated with the former drainage lines as identified from historical aerial photographs, site records and intrusive site investigation works (soil and groundwater sampling).

Soil contamination in the former drainage areas is considered to be delineated with the following exceptions:

- Assessment Area 1: this is the western-most former drainage line to the south of the Blending Area. Delineation is not complete to the north and south of the identified soil contamination areas and to the north-west of the assessment area. Soil contamination in these directions (if present) is likely to be associated with the former drainage alignment, with the possible exception of the north-west, where soil contamination was reported approximately 10 m from the former drainage channel. Soil contamination at the locations sampled is delineated with depth, with soil contamination extending to the top of basaltic rock in the northern part of this area.
- Assessment Area 2: this is the second most western former drainage line to the south of the Blending Area. Delineation is not complete to the north and south of the identified soil contamination areas and partially to the west and north-east. Soil contamination in these directions (if present) is likely to be associated with the former drainage alignment, with the possible exception of the north-east and west, where soil contamination was reported approximately 5 to 10 m from the former drainage channel. Soil contamination at the locations sampled has been delineated with depth.
- Assessment Area 3: this area lies to the south of the Blending Area. Delineation is not complete to the south-east and south-west of the identified soil contamination area towards Kororoit Creek. Soil contamination in these directions (if present) may be associated with the former drain flows, however given the close proximity to Kororoit Creek; other off-site sources (upstream of Kororoit Creek) of contamination are also possible. Soil contamination at the locations sampled has been delineated with depth.
- Legacy Area: this area is the eastern-most former drainage line to the south the Blending Area. Delineation is complete in all directions. Soil contamination at the locations sampled has been

delineated with depth, with soil contamination extending to the top of basaltic rock in the northern part of this area.

- Assessment Area 4: this area lies to the south of the South Crude Tank Farm (SCTF). Delineation is not complete to the south-east and south-west of the identified soil contamination area towards Kororoit Creek. Soil contamination in these directions (if present) may be associated with the former drain flows, however given the close proximity to Kororoit Creek, other off-site sources (upstream of Kororoit Creek) of contamination are also possible. Soil contamination at the locations sampled has not been delineated with depth, due to groundwater inflow to the boreholes being reported.

Sediment in Kororoit Creek

There is also potential for sediment contamination along Kororoit Creek due to historical activities which could lead to contaminated sediment transport, and possible contribution of contamination from groundwater discharge into sediments associated with the creek. Sediment contamination (if present) is not delineated, however it is noted that in June 1991 EPA commissioned a study (by SKM) into sediment contamination within the Lower Kororoit Creek area. In general most metals were reported below the adopted sediment criteria from this study, with the exception of mercury, which was reported at concentrations above the adopted criteria downstream of the former BP Refinery (located upstream) and the Mobil Refinery. Some mercury contamination in soil was also reported in the former drainage assessment legacy areas, therefore there remains some potential for contamination associated with Kororoit Creek sediments to exist.

Where soil contamination is not delineated, recommendations to address these areas have been prepared, as presented in Section 9.2.1.

9.1.2 Delineation of Groundwater Contamination

Groundwater contamination, including both Light Non-Aqueous Phase (LNAPL), and dissolved phase is considered to be delineated, to below the adopted criteria, in all off-site directions, with the exception of the following areas:

- To the south of the South Crude Tank Farm, towards Kororoit Creek, for petroleum hydrocarbons (TRH C_{10} to C_{36} fraction);
- Within the Rail Corridor between the Processing Area and the NCTF, where (because of access difficulties limiting access in the rail corridor) LNAPL is inferred to extend offsite beyond the eastern boundary of the Processing Area beyond monitoring well MB8.
- A potential delineation gap for the SCN LNAPL extent remains for groundwater near Kororoit Creek Road to the north-west of the Pegasus Centre and south-west of the 7-Eleven site, specifically north-west of monitoring bore MBB34 and south-west of GA031.
- To the east/south-east of the North Crude Tank Farm, for ammonia.

An extensive groundwater monitoring well network has been installed on-site and in off-site areas to monitor and assess groundwater. Further discussion on delineation of groundwater contamination is presented as follows.

Light Non-Aqueous Phase Liquid

There are four main LNAPL areas across the Audit area. These have been largely differentiated based on chemical composition of the LNAPL and source identification where feasible. The four main LNAPL areas are presented on **Figure 7** attached, and summarised as follows:

- **Steam Cracked Naphtha LNAPL Zone:** the SCN zone covers the western part of both the Blending and Processing areas and extends to the west beneath the Pegasus Building and paddock area, and to the north-west beneath the 7-Eleven Service Station and beyond to the north-west. The SCN LNAPL extent is considered to be delineated in all off-site directions and appears to be relatively stable in lateral extent.
- **Mid-Blending Area LNAPL Zone:** this LNAPL zone lies in the north of the Blending Area and contains LNAPL predominantly characterised by variably weathered automotive petrol mixed with varying amounts of diesel fuel and/or alkylate/aviation gasoline. This LNAPL zone does not appear to extend beyond the site boundaries.
- **Southern Blending Area LNAPL Zone:** this LNAPL zone is present in the south of the Blending Area and contains LNAPL predominantly characterised by light distillate consistent with kerosene or jet fuel. Current monitoring data indicates that this LNAPL zone does not extend beyond the site boundaries; however it is present within 50 m of the southern boundary.
- **Processing Area LNAPL Zone:** this LNAPL zone is present across the central and southern parts of the Processing Area and south into the Blending Area. The LNAPL is predominantly characterised by a greater proportion of fuel blending intermediate products consistent with the processing activities, compared to the other Blending Area LNAPL zones. This LNAPL zone does not appear to extend beyond the site boundaries, with the exception of being inferred to be present beneath Kororoit Creek Road area and possibly to the east of the Processing Area beneath the railway corridor.

LNAPL has also historically been observed in the North Crude Tank Farm and in the Ross Road area to the north. There is potential for off-site sources of LNAPL to the north of the Ross Road area, however some contribution of hydrocarbon contamination in this area from the Refinery cannot be ruled out. LNAPL was also observed in the shallow soils associated with the 'Legacy Drainage Area' in the Kororoit Creek Reserve area to the south of the Blending Area, however it is noted that LNAPL has not been reported in groundwater monitoring wells in this area, so the LNAPL is expected to be localised.

Monitoring bores MB28 and MB44, located on the southern boundary of the SCTF, are screened below the static water level. Therefore, there is potential for LNAPL to be present in this area.

Dissolved Phase Groundwater Contamination

Dissolved phase petroleum hydrocarbons in groundwater are typically associated with locations hydraulically down-gradient of the LNAPL plumes, and within the groundwater immediately adjacent to the LNAPL. Dissolved phase petroleum hydrocarbons are present in the vicinity of the LNAPL plumes and in down-gradient directions in the following off-site areas:

- Beyond the fringes of the SCN LNAPL plume;
- Beyond the southern extent of the Southern Blending Area LNAPL plume; and
- To the north of the Refinery in the Ross Road area, although it is noted that there is likely to be a contribution from off-site sources in this area.

In addition, there is dissolved phase petroleum hydrocarbon contamination in groundwater to the south and south-west of the South Crude Tank Farm area. Groundwater monitoring data also indicates that ammonia above the adopted criteria to the south-east of the North Crude Tank Farm and to the south-east of the Blending Area, possibly associated with wastewater treatment facilities to the south-east of the Blending area. The source of the ammonia to the south-east of the North Crude Tank Farm is not known.

An assessment of the origin of the dissolved phase Total Petroleum Hydrocarbon (TPH) concentrations reported in off-site areas was conducted, which indicates that in some areas, the TPH appears to be derived from 'biogenic' sources, which refers to organic compounds derived from naturally occurring organic material produced by plants or animals. The detected TPH may also include microbial degradation of petroleum hydrocarbons (non-polar) to polar break-down compounds. It is also recognised that the degradation products of TPH may also have some toxicity, and therefore the identification of biogenic TPH does not necessarily mean that there is no risk associated with these materials. Limited toxicological information is available for many of the compounds associated with the degradation of petroleum hydrocarbons. Although a limited number of studies have been published on the toxicity of degraded petroleum products, the results are generally inconclusive given the composition of the break-down products vary depending on the conditions at each location.

Dissolved phase petroleum hydrocarbons are delineated off-site to below the adopted site audit criteria, with the exception of the southern boundary of the South Crude Tank Farm, where groundwater contamination has not been delineated towards Kororoit Creek (between monitoring well MB44 and Kororoit Creek).

Where groundwater contamination is not delineated, recommendations to address these areas have been prepared, as presented in Section 9.2.1.

9.2 Risk Assessment Findings and Measures to Reduce Risks or Further Assess Risks

The site assessment works completed by the assessment consultants on behalf of Mobil have been used to assess the potential risks to receptors associated with contaminants inferred to be associated with the site. This has included comparison of reported concentrations against the adopted site assessment criteria, and documenting the Source-Pathway-Receptor Models for the different areas of the site. Where a complete, or potentially complete, Source-Pathway-Receptor linkage is considered to be present, a qualitative risk assessment has been conducted. This has also been conducted for areas where currently there is not a complete linkage, but where there is a protected beneficial uses of land or groundwater which may be subject to risk at some point in the future (for example, groundwater extraction). In some cases, the potential for protected beneficial uses to be realised in these off-site areas is low or very low (for example, groundwater extraction), and this likelihood is reflected in the risk assessment ranking assigned.

The assessment of risk also included appraisal of whether the existing contamination is likely to represent an 'imminent environmental hazard' to human health, the environment or third party property. Based on the information reviewed, the Auditor is of the opinion that the soil and groundwater conditions do not represent an imminent environmental hazard to off-site areas.

The potential risks to receptors have been further characterised using a qualitative risk-based approach, adapted from the HB436:2013 *Risk Management Guidelines (*Standards Australia, 2013).

This has been used to *'specify the risks of any possible harm or detriment to beneficial uses of the environment'* as required in the Clean Up Notice issued by EPA.

The specific methodology used to assess the risks for each of the different off-site areas involved the following approach.

- Definition of the beneficial uses of land, groundwater and surface water requiring protection.
- Identification of the chemicals of potential concern (COPC).
- Definition of the source-pathway-receptor model to identify the complete and potentially complete exposure pathways to be carried forward for further assessment. Incomplete exposure pathways (where there was also little likelihood of a future complete pathway) were not subject to the further risk assessment process.
- Characterisation of the potential risk, according to the likelihood and consequence matrix, for each of the complete and potentially complete exposure pathways identified for each beneficial use. The potential risks have been determined as the *inherent risk,* that is, without consideration of risk management control measures, in order to ensure that the importance of any mitigation measures is recognised. In some cases, Mobil have existing remediation or management control measures in place to reduce or manage risks. Where this is the case, these have been noted in the risk assessment.
- Determination of the need for, and where needed nature of, risk management measures.
- Documentation of uncertainties in the risk assessment.

The approach adopted for characterizing the potential risks has been based on consideration of the likelihood of a deleterious outcome occurring, and the potential consequences (a measure of severity) should the event occur. The level of risk for each potential event was then determined by combining the likelihood and consequence to rank the potential risk as very low, low, medium, high or very high according to a risk ranking matrix. This definition of event likelihood and consequences, and risk ranking has been adapted from HB436:2013 *Risk Management Guidelines (*Standards Australia, 2013) and EPA Publication 1321.1 (2010) '*Licence Assessment Guidelines, Guideline for Using a Risk Management Approach to Assess Compliance with Licence Conditions'.*

Based on this approach, an assessment of risk has been described for the protected Beneficial Uses of soil, groundwater, air, surface water and sediment. The risk assessment rankings and measures to reduce risk to acceptable levels, or further determine risks, in order of priority (highest risk ranking to lowest) are presented in the following Table.

In the context of protection of beneficial uses, the following response measures are recommended:

- Very high: immediate action is required.
- High: priority management required to address risk.
- Medium: some management of risk required.
- Low: generally can be managed by standard operating procedures, such as monitoring or administration; however is some cases further active management, such as remediation may be necessary, however it will be of a lower priority to implement.
- Very low: generally, no action is required.

Based on these response measures, only ‘Very High’, ‘High’, ‘Medium’ risks are included in Table 9.1, with the exception of ‘Low’ risks that require specific management measures. ‘Low’ risk and ‘Very Low’ risks that do not require any specific remediation or management measures are not included in Table 9.1, as they are not considered to be relevant to the requirements of the Clean Up Notice.

It should also be noted that some of the Risk Treatment measures are common to different parts of the site and different risk scenarios. The Risk Treatment measures have been listed for all identified risks in Table 9.1, however where Risk Treatment measures are common to various risks or off-site areas, they have been consolidated into one recommendation in Section 9.2.1 below.

Table 9.1: Risk Assessment and Risk Treatment Summary

Environmental Segment and Beneficial Use	Source and Exposure Pathway	Risk Ranking	Auditor's Summary of Risk Ranking	Risk Treatment Summary
Air (vapour) Human health	Steam Cracked Naphtha LNAPL Migration of vapours from SCN LNAPL plume to indoor air at the Pegasus Building	Very High	Indoor air investigations conducted by the site assessor indicate that vapour intrusion into the Pegasus Centre has occurred. Based on the monitoring conducted in 2010, concentrations of 1,2,4-trimethylbenzene and benzene in indoor air were found to exceed the published guidelines for protection of human health over chronic exposure timescales. Whilst air vent sealing works appear to have prevented the detection of vapours since the earlier detections, as noted the risks are considered in the absence of such measures, in order to recognise the potential for a concern to occur. Thus it is considered ***Almost Certain*** that human receptors would be exposed to unacceptable concentrations of vapours if the building were occupied (and the mitigating vent sealing was not maintained). Potential health effects associated with vapour inhalation are likely to be ***Significant***.	• Currently, the Pegasus Building is not occupied and there is continual air space monitoring in the basement, although it is understood that demolition of the building is being contemplated, which would clearly change any requirement for risk treatment. Mobil controls access to this building under a permit system. Therefore, with continuation of the current management controls (access and monitoring) the risk should remain low for human health exposure to SCN vapours, unless and until the building is demolished. • SCN LNAPL and dissolved phase contamination to be remediated to the extent practicable to reduce risks of vapour migration to enclosed spaces.
Air (vapour): Human Health – Subsurface Maintenance Workers	Steam Cracked Naphtha LNAPL Migration of vapours from LNAPL plumes to air within a trench, utility or sub-surface structure	High	Soil vapour sampling conducted by Golder identified that there is hydrocarbon vapour present in the vadose zone across a significant portion of the audit area, although utility pit monitoring has detected limited vapours. It is considered ***likely*** that an underground utility or subsurface maintenance trench would be subject to vapour intrusion. Although the contaminant concentration in soil vapour in the areas surrounding a trench has the potential to be significantly higher than that detected in the sub-slab vapour samples, this would be off-set by a greatly increased air	• Mobil to maintain the 'Dial Before You Dig' hazard identification registration for off-site areas. • Notification of utility owners of potential hazards of working in underground service trenches or pits. • SCN LNAPL and dissolved phase contamination to be remediated to the extent practicable to reduce risks. • A potential delineation gap for the SCN LNAPL extent remains in groundwater near Kororoit

Environmental Segment and Beneficial Use	Source and Exposure Pathway	Risk Ranking	Auditor's Summary of Risk Ranking	Risk Treatment Summary
			exchange rate and reduced exposure time, depending upon the depth of the excavation. It is therefore concluded that the potential consequence of vapour intrusion into an underground utility or trench which is occupied by a maintenance or construction worker could be ***Significant*** if appropriate health and safety controls were not in place.	Creek Road to the north-west of the Pegasus Centre and south-west of the 7-Eleven site, specifically north-west of monitoring bore MBB34 and south-west of GA031. Further delineation bores are required in this area to address this data gap.
Groundwater: Human health and explosive risk – subsurface maintenance or construction workers	SCN LNAPL Plume Excavations intercepting groundwater	High	It is considered ***Probable*** that future sub-surface excavation works in the Pegasus Paddock could intercept contaminated groundwater, as the water table sits at approximately 2.5 mbgs in the southern part of the Pegasus Paddock. Potential health effects to sub-surface excavation workers who come in direct contact with contaminated groundwater are likely to be ***Significant*** due to the high volatility and toxicity of the SCN LNAPL.	• Mobil to maintain the 'Dial Before You Dig' notification which provides a hazard warning to subsurface maintenance and construction workers who use the Dial Before You Dig notification service. • Notification of utility owners of potential hazards of working in underground service trenches or pits. • SCN LNAPL and dissolved phase contamination to be remediated to the extent practicable, to reduce risks of vapour migration to enclosed spaces.
Air (vapour) Human health – adult maintenance workers	LNAPL (excluding SCN LNAPL which is addressed separately) Migration of vapours through underground utilities (including backfill)	High	The utility pit monitoring data generally indicates that vapour migration into utility pits and services is unlikely. However, given the short duration over which utility pit monitoring occurs, and the potential for vapour migration into conduits and backfilled trenches which cannot be monitored, it is considered to be ***Probable*** that this event could occur. If the event did occur without any occupational exposure controls,	• Mobil to maintain the Dial-Before-You-Dig registration of potentially hazardous areas for third parties conducting sub-surface works; • Notify utility owners in the area of the potential for human health hazards to exist in the vicinity of the Refinery. The area covered by the notification needs to include all off-site areas where LNAPL is

Environmental Segment and Beneficial Use	Source and Exposure Pathway	Risk Ranking	Auditor's Summary of Risk Ranking	Risk Treatment Summary
			the consequences could be ***Significant.***	present, or dissolved phase contamination above the adopted criteria, including a suitable buffer distance. This is to be documented in the Clean Up Plan. • Ongoing monitoring in accordance with the Auditor-verified *Mobil Altona Refinery Groundwater Quality Management Plan* (Golder, 2013h), which may be amended or replaced subject to auditor endorsement. • Continue with periodic monitoring of utility pits in areas previously monitored. Prepare a program of continuous utility pit monitoring for utility pits in the vicinity of the Pegasus Building, where elevated vapours have been previously recorded. The intention is to have continuous monitoring over a period sufficient to capture significant low-pressure atmospheric conditions at least once. • Investigate whether the utility pits previously identified to have elevated Volatile Organic Compound (VOC) concentrations, have any vapour pathway connection to the Refinery sewer system, as suggested by the site assessor (such as via intersecting trench backfill). This will provide further information on the source of the utility pit vapours reported in these pits, and whether these pits represent a significant risk of vapour intrusion.

Environmental Segment and Beneficial Use	Source and Exposure Pathway	Risk Ranking	Auditor's Summary of Risk Ranking	Risk Treatment Summary
Sediment due to groundwater discharge into Kororoit Creek – aquatic ecological receptors	Exposure to contaminants in sediment of Creek as a result of groundwater discharge south of Blending Area	Medium	Based on the understanding of the hydrogeology at the site it is almost certain that some groundwater from the southern Blending Area discharges to Kororoit Creek. Although petroleum hydrocarbon concentrations decrease towards the Creek, it is considered ***Probable*** that groundwater contaminants would be discharging to the Creek with groundwater. Adverse effects to ecological receptors are most likely to occur in the benthic and littoral zones due to accumulation of contaminants in sediments. Site investigation works to date have not included assessment of sediment quality. Ecological risks directly related to sediment are considered to be **Medium** as the current extent of sediment contamination (if any) due to the Refinery operations is not known.	• Further assessment of the potential ecological risks to Kororoit Creek associated with discharges of contaminants in groundwater to sediments of Kororoit Creek. This should include investigation of the accumulation of contaminants in Creek sediments from Refinery and potential risks to benthic organisms. • Ongoing monitoring in accordance with the Auditor verified Mobil Altona Refinery Groundwater Quality Management Plan (Golder, 2013h).
Surface water and sediment: Aquatic ecological receptors	Migration of contaminants from legacy areas to surface water and sediments in Kororoit Creek	Medium	Due to the potential for residual soil contamination associated with former wastewater discharges to the Creek, and residual contamination in soil in the Kororoit Creek Reserve former drainage lines, there is potential for this soil contamination to adversely affect the creek sediments and surface waters. The degree of leaching and transport of the residual soil contamination to the sediments and surface waters of Kororoit Creek is however not known, and therefore a likelihood ranking of ***Probable*** has been adopted. If transport of residual soil contaminants to the Creek were occurring, this is likely to be occurring at a low rate, and as such it is considered that only ***Medium*** ecological effects could occur.	• Management/remediation of soil contamination present in four former drainage areas in Kororoit Creek Reserve, including the LNAPL in the former drainage line of the 'Legacy Area' south of the Blending Area. • Further assessment of the potential ecological risks to Kororoit Creek associated with discharges of contaminants in groundwater, surface run-off water and mobilisation of soil contaminants. This should include investigation of the accumulation of contaminants in Creek sediments from Refinery and potential risks to benthic organisms.

Environmental Segment and Beneficial Use	Source and Exposure Pathway	Risk Ranking	Auditor's Summary of Risk Ranking	Risk Treatment Summary
Sediment due to groundwater discharge into Kororoit Creek – aquatic ecological receptors	South Crude Tank Farm petroleum hydrocarbons in groundwater Exposure to contaminants in sediment of Creek as a result of groundwater discharge	Medium	Based on the understanding of the hydrogeology at the site it is almost certain that some groundwater from the SCTF discharges to Kororoit Creek. Although petroleum hydrocarbon concentrations decrease towards the Creek, it is considered ***Probable*** that groundwater contaminants are discharging to the Creek in groundwater. Although mixing in the water column would be likely to mitigate ecological risks risks within the water column, adverse effects to ecological receptors could occur in the benthic and littoral zones due to groundwater contaminants that could affect benthic organisms within the sediment zone. Site investigation works to date have not included assessment of emergent groundwater quality within sediments. Ecological risks associated with groundwater discharge to sediments are considered to be **Medium**.	• Further data required to understand interaction and potential for preferential flow pathways, along SCTF southern boundary (MB44, GA085 and GA086). Additional data required includes off-site groundwater bore(s) to the south of MB44, and an assessment of the flux of contaminant movement from groundwater to sediments and surface waters of Kororoit Creek. • Further assessment of the potential ecological risks to Kororoit Creek associated with discharges of contaminants in groundwater to sediments of Kororoit Creek. This should include investigation of the accumulation of contaminants in Creek sediments from Refinery and potential risks to benthic organisms.
Soil/Sediment: aquatic and riparian ecosystems	South Crude Tank Farm – Residual soil contamination in Assessment Area 4 Mobilisation of contaminated soil to sediments in Kororoit Creek	Medium	There is potential for soil contaminants in the Kororoit Creek Reserve area are to be mobilised and discharged to the Creek as a result of surface run-off (i.e. due to rainfall events) or leaching. Thus is it is considered ***Probable*** that ecological receptors may be exposed to contaminants associated with the residual soil impact. Any adverse effects are likely to be ***Medium*** however it is noted that due to the small area of residual soil contamination, any adverse effects would be localised.	• Remediation of soil present in the former drainage area (Assessment Area 4) in Kororoit Creek Reserve.

Environmental Segment and Beneficial Use	Source and Exposure Pathway	Risk Ranking	Auditor's Summary of Risk Ranking	Risk Treatment Summary
Air (vapour): Human Health – Commercial Workers and Visitors of the 7-Eleven Sales Building	Steam Cracked Naphtha LNAPL Plume Migration of vapours from LNAPL plume to indoor air (7-Eleven Sales Building)	Low	Indoor air investigations conducted by Golder indicate that vapour intrusion into the 7-Eleven Sales building is likely to be limited. Based on the monitoring conducted in September 2013, it is considered that the rate of vapour intrusion may be higher during periods of falling barometric pressure; atmospheric pressure drops are likely to occur at regular frequencies. Taking into consideration the previously recorded vapour intrusion into the Pegasus building, and the reported vapour intrusion into steel post at ground level in the Pegasus Paddock, it is considered probable that SCN vapours could migrate through clay to the surface in the 7-Eleven area. However, based on the investigation works conducted, and the apparent absence of a significant pathway into the 7-Eleven buildings, it is considered ***Not likely***, that vapour intrusion would occur under the current building construction and operating conditions. The indoor air concentrations of contaminants detected within the Sales Building during the investigations conducted by Golder were not considered to represent a chronic health risk to workers in a commercial setting or to visitors of the site. However, thorough exposure modelling has not been conducted and some variation of indoor air concentrations may occur over time. It is acknowledged that there is sufficient evidence to conclude that the majority of indoor air vapours are likely to be as a result of air exchange with outdoor air with only a small contribution from soil vapour. Furthermore the contribution of SCN to vapours beneath the building is also considered to be low, because of the thicker	• Additional vapour monitoring at the Sales Building for chemicals of potential concern and comparison to the Health Screening Levels. It is recommended that a minimum of an additional two monitoring events is conducted, to assess the variation in sub-ground vapour conditions due to changing weather and sub-surface conditions.

Environmental Segment and Beneficial Use	Source and Exposure Pathway	Risk Ranking	Auditor's Summary of Risk Ranking	Risk Treatment Summary
			basaltic clay layer present in this area of the site. It is therefore concluded that whilst there is potential for the pathway to be complete, the contribution of SCN to indoor air vapour at the 7-Eleven Service Station (under its current building configuration) is low and the consequences of this are **minor**.	
Air (vapour): Human Health – Commercial Workers and Visitors of the 7-Eleven Mechanics Workshop.	Steam Cracked Naphtha LNAPL Plume Migration of vapours from LNAPL plumes to indoor air (Mechanics Workshop)	Low	The conceptual site model indicated that there was a potentially complete pathway for the volatilisation and subsequent vapour intrusion into the indoor air of the mechanics workshop. No preferential vapour migration pathways were identified and no sumps pits or subsurface structures were identified in the workshop. However, it was identified that the thickness of the basaltic clays in the north west corner of the site was less than in other areas of the site. Based on the reduced thickness of clay in this area, and the increased likelihood of preferential pathways due to the older age of the building, it is considered to be ***Probable*** that some vapour intrusion could occur. The indoor air investigations conducted by Golder did not include sampling from within the mechanics workshop. Three large doors are present at the front of the workshop to allow cars inside which would provide a significantly higher air exchange through the workshop than in a typical commercial building. The door openings would also prevent a negative pressure developing within the building a result of air extraction. As with the Sales Building, there is sufficient evidence to conclude that the presence of indoor air vapours would likely be a result of workshop activities or air exchange	• Installation of an additional sub-slab monitoring bore within the mechanics workshop, and conducting monitoring to assess the risk to this receptor in more detail. • Additional monitoring of sub-slab bores in the Workshop for chemicals of potential concern and comparison to the Health Screening Levels. It is recommended that a minimum of an additional two monitoring events is conducted, to assess the variation in sub-ground vapour conditions due to changing weather and sub-surface conditions

Environmental Segment and Beneficial Use	Source and Exposure Pathway	Risk Ranking	Auditor's Summary of Risk Ranking	Risk Treatment Summary
			with outdoor air, with only a small contribution from soil vapour. It is therefore concluded that whilst there is potential for the pathway to be complete, the contribution of SCN to indoor air vapour at the 7-Eleven Workshop (under its current building configuration), is very low and the consequences of this are considered **negligible**.	
Air (vapour): Human Health – Residents and, sub-surface maintenance or construction workers	Steam Cracked Naphtha LNAPL Plume Air (vapour): Human Health – Residents and sub-surface maintenance or construction workers to the north of the Refinery	Low	Volatile contaminants, including TPH fractions, have been reported in groundwater off-site to the North of the Refinery. As such there is potential for occupants of buildings and sub-surface excavations to be exposed to contaminants in air. The current monitoring data indicates that the LNAPL plumes derived from the Refinery operations are currently sufficiently distant from the residential and commercial receptors to the north of the Refinery, to not represent a vapour risk (i.e. ***Rare***). Some uncertainty remains regarding the potential for further migration of SCN to areas north of the Refinery, therefore a ***Medium*** consequence has been adopted	• Installation of an additional delineation monitoring well in the general vicinity of (but not close to) GA071 to provide further detail regarding SCN LNAPL northerly plume extent. • Ongoing monitoring for contaminant trend analysis and SCN LNAPL migration assessment. The GQMP is required to be updated and reviewed by an Auditor as part of the Clean Up Plan verification, to include trigger conditions and contingencies in relation to the assessment of the SCN LNAPL mobility, including the necessary response measures, if the SCN LNAPL was found to be migrating further north in this area towards residences. The GQMP may also include a rationale for future changes in monitoring scope, depending on monitoring results and risk profile. • Mobil to maintain the 'Dial Before You Dig' notification which provides a hazard warning to subsurface maintenance and construction workers who use the Dial Before You Dig notification service.

Environmental Segment and Beneficial Use	Source and Exposure Pathway	Risk Ranking	Auditor's Summary of Risk Ranking	Risk Treatment Summary
				• The utility pit monitoring program to be extended to incorporate utility pits to the north of the Refinery, including utility pits along Ross Road. • Underground utility asset owners in the Ross Road area to be notified of the potential to encounter groundwater contamination in this area, and that appropriate exposure control measures should be implemented when workers enter underground pits.
Groundwater discharge to underground services (Human Health risk to workers)	Discharge of contaminated groundwater from the Processing Area into deeper sewers off-site to the north of the Refinery	Low	As the sewers along Ross Road and Kyle Road are below the water table, it is ***Probable*** that some seepage of groundwater into these sewers is occurring. However, the groundwater levels to the north of the Refinery do not indicate that groundwater drawdown is occurring in the vicinity of the sewer. Therefore seepage to sewer does not appear to be occurring at a significant rate. Potential health effects to maintenance workers are likely to be ***Min*or** due to the short exposure times and relatively low concentrations, and the fact that underground service workers routinely use safe work procedures for confined space entry, including the use of PPE and air monitoring.	• Notification of sewer owner of the potential to encounter groundwater contamination in this area, and that appropriate exposure control measures should be implemented when workers enter the sewer system. • Ongoing monitoring for contaminant trend analysis and groundwater elevations in accordance with the GQMP. In addition, where monitoring well construction details are not know (such as MB53 and MB54), then further investigation to determine the well construction details, or replacement of monitoring wells, is recommended.
Groundwater: Extractive Uses	All off-site areas where groundwater contamination is present above adopted criteria due to Refinery operations.	Low	In the ***Rare*** event that a groundwater extraction bore was installed in the area to the immediate west of Millers Road, then potential adverse health effects may occur as a result of the SCN LNAPL plume and associated dissolved phase	• SCN LNAPL and associated dissolved phase contamination to be remediated to restore beneficial uses based on adopted criteria (to the extent practicable). • Notification of groundwater extraction licensing

Environmental Segment and Beneficial Use	Source and Exposure Pathway	Risk Ranking	Auditor's Summary of Risk Ranking	Risk Treatment Summary
	Exposure to contaminants in extracted groundwater		plume at the immediate periphery of the SCN LNAPL zone. The potential consequences should exposure occur is considered to be ***Medium***, with potential for chronic health effects.	authority that groundwater should not be used for extractive uses in the areas where contaminated groundwater is present. • Ongoing monitoring in accordance with the Auditor reviewed *Mobil Altona Refinery Groundwater Quality Management Plan*.
Groundwater: Maintenance of Ecosystems, Primary Contact Recreation at point of discharge	Steam Cracked Naphtha LNAPL Discharge of groundwater in Kororoit Creek	Low	As the SCN LNAPL plume is greater than ~100m from Kororoit Creek and the groundwater chemistry indicates that the SCN LNAPL plume is delineated and stable, it is considered ***Rare*** that groundwater contaminants would discharge to Kororoit Creek under the current conditions. Should discharge of contaminated groundwater occur, the potential impacts/consequences to ecological and human receptors are considered to be ***Significant*** given the chemistry of the SCN having a significant toxicity profile.	• Continue remediation of SCN LNAPL and dissolved phase contamination to mitigate the potential for SCN contamination to discharge to Kororoit Creek. • Ongoing monitoring of SCN plume stability.
Groundwater discharge to sub-surface excavations – Human Health	Exposure to contaminants in groundwater intercepted during excavation south of Blending Area	Low	Based on the depth of groundwater in this area (1 to 2.5 mbgs), sub-surface excavation works in the Kororoit Creek Reserve may intercept contaminated groundwater, however it is noted that deeper excavations in this area are ***Not Likely*** occur due to the nature of the landuse and the Ecological Significance Overlay. Potential health effects to sub-surface excavation workers who come in direct contact with contaminated groundwater are likely to be ***Minor*** due to the short exposure times and relatively low concentrations based on current site conditions and groundwater flow.	• Notification of the land manager for Kororoit Creek Reserve of the potential to encounter groundwater contamination in this area (ie between the southern boundary of Blending and Kororoit Creek), and that appropriate exposure control measures should be implemented when workers are conducting sub-surface excavation works.
Air (vapour):	Migration of vapours from	Low	Based on current site conditions and groundwater flow, the	• Notification of the land manager for Kororoit

Environmental Segment and Beneficial Use	Source and Exposure Pathway	Risk Ranking	Auditor's Summary of Risk Ranking	Risk Treatment Summary
Human Health	groundwater plume (outdoor air and sub-surface excavations) – south of Blending Area		presence of volatile groundwater contaminants beneath the Kororoit Creek area indicates there is a potential sub-surface excavation workers and recreational users may be exposed to contaminants in air. However, a semi-quantitative risk assessment completed by Golder indicated that adverse health effects due to vapour inhalation were ***Not Likely*** to occur given the expected attenuation during migration through the vadose zone and mixing with fresh outdoor air. Should adverse health effects occur they are expected to be temporary (***Minor***).	Creek Reserve of the potential to encounter soil vapour in this area (ie between the southern boundary of Blending and Kororoit Creek), and that appropriate exposure control measures should be implemented when workers are conducting sub-surface excavation works.
Groundwater: Human health – adult maintenance workers	LNAPL (excluding SCN LNAPL which is addressed separately) Excavations intercepting groundwater	Low	Based on the depth to groundwater and the depth of services generally being above the groundwater standing water level, it is generally considered ***Not Likely*** that this event would occur, except where services are present below the groundwater table, such as to the north and east of the site, where deeper sewers exist. In these areas is it considered ***Probable*** that this would occur. In the event that discharge of groundwater occurred in these areas, the consequences are considered to be ***Minor***, due to the low contaminant concentrations to the north and east of the Refinery.	• Mobil to maintain the Dial-Before-You-Dig registration of potentially hazardous areas for third parties conducting sub-surface works; • Notify utility owners in the area of the potential for human health hazards to exist in the vicinity of the Refinery. The area covered by the notification needs to include all off-site areas where LNAPL is present, or dissolved phase contamination above the adopted criteria, including a suitable buffer distance. This should be documented in the Clean Up Plan. • Ongoing monitoring in accordance with the Auditor reviewed Mobil Altona Refinery Groundwater Quality Management Plan (Golder, 2013h).
Groundwater:	South Crude Tank Farm	Low	The shallow stormwater drain runs along the eastern	• Notify utility owners in the area of the potential for

Environmental Segment and Beneficial Use	Source and Exposure Pathway	Risk Ranking	Auditor's Summary of Risk Ranking	Risk Treatment Summary
underground services	petroleum hydrocarbons in groundwater Discharge of groundwater into shallow sewers/stormwater		boundary of the SCTF. It is inferred that the drain or sections of the backfill material may be intercepting the watertable only when the watertable is at its highest. Thus it is considered ***Not Likely*** that contaminated groundwater will be discharged to the stormwater drain and the potential consequences ***Minor***.	human health hazards to exist in the vicinity of the SCTF. The area covered by the notification needs to include all off-site areas where dissolved phase contamination is above the adopted criteria, including a suitable buffer distance. This should be documented in the Clean Up Plan.

Following the implementation of the Risk Treatment items, it is considered that the identified risks to beneficial uses will be reduced to acceptable levels. In some instances, notwithstanding the goal to restore beneficial uses, complete restoration of all beneficial uses may not be achievable, and therefore ongoing management of residual risk items may be required as a management measure to ensure those residual risks do not result in a deleterious effect to the identified receptors.

A summary of the Risk Treatment measures, and other recommendations regarding further delineation or risk assessment, as required under the Clean Up Notice, are presented in the following section.

9.2.1 Recommendations

Recommended measures to reduce risks to beneficial uses to acceptable levels, or, where risks cannot be determined, measures to determine risks, are presented as follows. In addition, recommended measures for further delineation and monitoring, where warranted to further assess risk, are included. The recommendations also include items related to communication of the measure to the identified stakeholders. These recommendations have been listed in prioritised order under each sub-heading, so that the milestones for the measures which are required to address these risks, as will be detailed in the Auditor verified Clean Up Plan, reflect the priority ranking; that is, higher priority recommendations are implemented sooner than the lower priority recommendations.

Delineation

1. Installation of an additional groundwater monitoring bore in the general vicinity of (but not close to) monitoring well GA071 which is the only well delineating the northern extent of the SCN LNAPL plume between wells MBB1and MB9, which are over 300 m distant. This is to be installed as a sentinel well to assess the stability of the SCN LNAPL plume in this area.
2. A potential delineation gap for the SCN LNAPL extent remains for groundwater near Kororoit Creek Road to the north-west of the Pegasus Centre and south-west of the 7-Eleven site, specifically north-west of monitoring bore MBB34 and south-west of GA031. Further delineation is required in this area to address this data gap.
3. Off-site groundwater bore(s) to be installed south of MB44, to delineate petroleum hydrocarbons in groundwater to the south of the South Crude Tank Farm.
4. Soil sampling to be conducted in the five ‘Legacy’ soil contamination areas, including the four areas to the south of the Blending Area (Assessment Areas 1 to 3 and the ‘Legacy Area) and the one area to the south of the South Crude Tank Farm (Assessment Area 4).
5. Off-site groundwater bore(s) to be installed east of the south-eastern part of the North Crude Tank Farm, to delineate groundwater contamination in this area (in GA076). In addition, the source of ammonia in groundwater in this area is not known, therefore it is recommended that further investigation into possible source(s) of ammonia (both on-site and off-site) in this area is undertaken.
6. Monitoring bores MB28 and MB44, located on the southern boundary of the SCTF, are screened below the static water level. The depth to groundwater below ground surface is approximately 1.2 m in these wells, therefore it is considered practical to replace these groundwater bores with wells screened across the water table.

Monitoring and further risk assessment

1. Additional vapour monitoring in the 7-Eleven Sales Building for chemicals of potential concern and comparison to the Health Screening Levels. It is recommended that a minimum of two additional monitoring events be conducted, to assess the variation in sub-ground vapour conditions due to changing weather and sub-surface conditions.
2. Further assessment of vapour risk within the 7-Eleven mechanics workshop.
3. The GQMP is required to be updated and reviewed by an Auditor as part of the Clean Up Plan verification, to include trigger conditions and contingencies in relation to the groundwater

mound near the southern boundary of the Blending Area, including consideration of the likelihood of LNAPL mobilisation in the event that the groundwater mound dissipated, and the necessary response measures, such as monitoring to confirm stability in changed conditions, or remediation of the LNAPL in this area.

4. The GQMP is required to be updated and reviewed by an Auditor as part of the Clean Up Plan verification, to include trigger conditions and contingencies in relation to the assessment of the SCN LNAPL mobility, including the necessary response measures, if the SCN LNAPL was found to be migrating further north in this area, towards residences.

5. Further assessment of the potential ecological risks to Kororoit Creek associated with discharges of contaminants in groundwater, surface run-off water and mobilisation of soil contaminants. This should include investigation of the accumulation of contaminants in Creek sediments from the Refinery (south of the Blending Area) and south of the southern boundary of the South Crude Tank Farm, including assessment of potential risks to benthic organisms.

6. Further data is required to understand interaction and potential for preferential flow pathways, along SCTF southern boundary (MB44, GA085 and GA086). Additional data required includes off-site groundwater bore(s) to the south of MB44, and an assessment of the flux of contaminant movement from groundwater to sediments and surface waters of Kororoit Creek. The following investigations could assist in understanding the interaction between groundwater (and contamination) and the creek:

    - Survey the morphology and surface water level in the creek.
    - Assess hydraulic gradients within the creek beds.
    - Assess the magnitude of short and longer term creek and groundwater level fluctuations.
    - Installation of a surface water gauging station.

7. Ongoing monitoring to be conducted in accordance with the Auditor verified *Mobil Altona Refinery Groundwater Quality Management Plan* (Golder, 2013h). This Plan is to be verified by the Auditor as part of the Clean Up Plan verification.

8. Periodic monitoring of utility pits to be continued, in areas previously monitored. Preparation of a program of continuous utility pit monitoring for a period of one month (in order to cover a range of atmospheric conditions) in utility pits in the vicinity of the Pegasus Building, where elevated vapours have been previously recorded.

9. The utility pit monitoring program to be extended to incorporate utility pits to the north of the Refinery, including all utility pits along Ross Road.

10. Investigation to establish whether the utility pits previously identified with elevated VOC concentrations have any vapour pathway connection to the Refinery sewer system, as indicated by the site assessor. This will provide further information on the source of the utility pit vapours reported in these pits, and whether these pits represent a higher risk of vapour intrusion.

11. Ongoing maintenance of monitoring points which are detailed in the GQMP, including wells and surface water monitoring locations, is required so that representative data is obtained. Where monitoring well construction details are not known (such as MB53 and MB54), then further investigation is required to determine the construction details, or the wells need to be replaced. Where sampling locations (such as surface water gauging locations or monitoring wells) are

inaccessible due to the presence of vegetation, clearance of vegetation must be undertaken and maintained.

Remediation:

1. In accordance with Clause 18 of the *State Environment Protection Policy (Groundwaters of Victoria)* (State Government of Victoria, 1997), where NAPL is present in an aquifer, it must be removed unless the Authority (EPA) is satisfied that there is no unacceptable risk posed to any beneficial use by the NAPL. Currently, the off-site Steam Cracked Naphtha NAPL is considered to represent a risk to the beneficial uses of groundwater, such as the extractive uses of Primary Contact Recreation and Stockwatering, and also represent a risk to the beneficial uses of land, such as workers who may occasionally conduct subsurface construction or maintenance works at the 7-Eleven Service Station. Notwithstanding that the beneficial uses of groundwater are unlikely to be realised, and the risks to subsurface workers can generally be controlled through appropriate health and safety procedures, remediation of groundwater to remove the SCN LNAPL (which extends off-site) to the extent practicable is considered necessary to comply with Clause 18 of the SEPP. It is noted that groundwater remediation to remove the SCN LNAPL has been underway from 2006 to date, in the Pegasus Paddock Area.
2. Management and/or remediation of soil contamination present in four former drainage areas in Kororoit Creek Reserve, including the LNAPL in the former drainage line of the 'Legacy Area' south of the Blending Area. As part of the plan for these areas, delineation of the soil contamination, where currently not delineated, is required to be completed.
3. Management and/or remediation of soil contamination present in the former drainage area in Kororoit Creek Reserve (Assessment Area 4), south of the South Crude Tank Farm. As part of the plan for this area, delineation of the soil contamination where currently not delineated is required to be completed.
4. SCN dissolved phase contamination to be remediated to the extent practicable to reduce risks of vapour migration to enclosed spaces.
5. LNAPL mobile skimming is undertaken in the on-site areas of the Blending Area and Processing Area on a quarterly basis. It is recommended that these remediation works continue, to reduce the volume of LNAPL present on-site.

Management controls:

1. Notification of utility owners in the area of the potential for human health hazards to exist in the vicinity of the Refinery. The area covered by the notification needs to include all off-site areas where LNAPL is present (including under Kororoit Creek Road, and the rail corridor between the Processing Area and the NCTF), or dissolved phase contamination above the adopted criteria, including a suitable buffer distance. This should be documented in the Clean Up Plan.
2. The occupant of the 7-Eleven Service Station site, and any other relevant underground utility asset owners at the 7-Eleven Service Station site, to be notified of the potential to encounter hydrocarbon vapours in this area, and that appropriate exposure control measures should be implemented when workers are conducting sub-surface maintenance or construction works, or when conducting any above ground 'hot works' that may generate an ignition source (for example, fence post grinding).

3. Continuation of continual air space monitoring in the Pegasus Building basement to assess vapour ingress, and maintenance of access control of persons into the basement area under the Mobil permitting system. This management may need to be reviewed in the event that the building is eventually demolished.
4. Mobil to maintain the 'Dial Before You Dig' notification which provides a hazard warning to subsurface maintenance and construction workers who use the Dial Before You Dig notification service. This will continue to provide a mechanism to notify parties conducting subsurface works in this area of the potential to encounter contaminated groundwater or associated vapours. The Dial Before You Dig notification letter and plan is included in **Appendix E1**.
5. Notification of groundwater extraction licensing authority (Southern Rural Water) that groundwater should not be used for extractive uses in the areas where beneficial use criteria are exceeded, including a suitable buffer distance. The defined areas are required to be documented in the Auditor verified Clean Up Plan.
6. Mobil implements a process which ensures that no extractive groundwater bores are installed on its land (other than monitoring or remediation bores), including Mobil land leased to 7-Eleven. It is recommended that this forms part of the *Mobil Altona Refinery Groundwater Quality Management Plan* (Golder, 2013h).
7. Notification of the land manager for Kororoit Creek Reserve of the potential to encounter groundwater and soil vapour contamination in this area (ie between the southern boundary of Blending and Kororoit Creek), and that appropriate exposure control measures should be implemented when workers are conducting sub-surface excavation works.

Communication with stakeholders:

1. Mobil to inform 7-Eleven of the potential 'High' risks associated with conducting below ground maintenance or construction works on the 7-Eleven Service Station Site, with respect to SCN vapour exposure, and that appropriate exposure control measures should be implemented when workers are conducting sub-surface excavation works on this site.
2. The EPA appointed Auditor to present the key findings of the Audit Report at a future Mobil Refinery Community Consultation meeting.

The recommendations of this 53V Audit are required to be addressed in the Auditor Verified Clean Up Plan, to be submitted to EPA by 1 February 2015.

10 REFERENCES

AGC Woodward-Clyde (1991a) Soil and groundwater investigation, Initial field programme report, Volume 1, PRA Altona Refinery (Document No JN 1567/11). Dated November 2011.

AGC Woodward-Clyde (1991a) Soil and groundwater investigation, Initial field programme report, Volume 2, PRA Altona Refinery (Document No JN 1567/11). Dated November 2011.

Agency for Toxic Substances and Disease Registry (2007), Toxicological Profile for Benzene

Alberta Government (2014), Alberta Soil and Groundwater Remediation Guidelines, May 2014

ANZECC & NHMRC (1992), Australian and New Zealand Environment & Conservation Council/National Health and Medical Research Council, *Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites.*

ANZECC (2000), National Water Quality Management Strategy Australian and New Zealand, *Guidelines for Fresh and Marine Water Quality.*

EPA Victoria (2014), *EPA Publication 759.2 Environmental Auditor (Contaminated Land) Guidelines for Issue of Certificates and Statements of Environmental Audit.*

EPA Victoria (June 2009) Industrial Waste Resource Guidelines (IWRGs) *Environmental Protection (Industrial Waste Resource) Regulations.*

EPA Victoria (2010) Licence Assessment Guidelines, Guidelines For Using a Risk Management Approach to Assess Compliance With Licence Conditions.

EPA Victoria (2009), *EPA Publication IWRG 621 Soil Hazard Categorisation and Management*

EPA Victoria (2009), *EPA Publication IWRG 701 Sampling and Analysis of Waters, Wastewaters, Soils and Wastes*

EPA Victoria (June 2009) Publication IWRG702, *Soil Sampling.*

EPA April 2000 Guideline 669 *Groundwater Sampling Guideline*

EPA Victoria (2013), Environmental Auditor Guidelines for the Preparation of Environmental Audit Reports on Risk to the Environment, Publication 952.4

Golder Associates (2011), Kororoit Creek Reserve Soil Validation and Surface Water Sampling, , Ref 097651007 302R Rev 2 dated 17 May 2011

Golder Associates (2012a) Newfields LNAPL Report and Interpretation of LNAPL Zones (3 August 2012).

Golder Associates (2012b), Kororoit Creek Soil Investigation, Mobil Altona Refinery, Reference 097651007-532-R-Rev0 dated 23 October 2012

Golder Associates (2012c), Volume 1: Summary and Findings, Historical Operations Review, Mobil Altona Refinery, 097651007-389R-Rev 0, December 2012

Golder Associates (2012c), Volume 2: Supporting Information, Historical Operations Review, Mobil Altona Refinery097651007-389R-Rev 0, December 2012

Golder Associates (2012d), Legacy Soils Impact Assessment - Kororoit Creek Reserve, 097651007-428L-Rev 0, 1 April 2012

Golder Associates (2013a), 53 V Audit Roadmap, 097651007-487-R-Rev2, 12 November 2013

Golder Associates (2013b), Soil Gas Monitoring: 7-Eleven Service Station, Quarter 3, 2012, 097651007-569R-Rev 1 (12 June 2013)

Golder Associates (2013c), Soil Gas Monitoring: 7-Eleven Service Station, Quarter 4, 2012 097651007-615R-Rev 1, (12 June 2013)

Golder Associates (2013d), Indoor Air Quality Monitoring 7-Eleven & Refinery Lab 097651007-609-R-Rev1, 21 October 2013

Golder Associates (2013e) - South Crude Tank Farm Groundwater Condition Report137613001-024-R-Rev1, 20 January 2013

Golder Associates, (2013f), J.T. Grey Reserve Soil Investigation, 097651007-591R-Rev0 , 9 January 2013

Golder Associates (2013g), Hydrogeological Assessment, 137613001-002-R-Rev0, 1 November 2013

Golder Associates (2013h), Groundwater Quality Management Plan, 097651007-447-R-Rev1, 21 August 2013

Golder Associates (2014a), Mobil Altona Refinery Updated Conceptual Site Model,137613001-012-R-Rev0, 17 April 2014

Golder Associates (2014b), 7-Eleven Service Station Indoor Air Quality and Soil Gas Monitoring,137613001-092-R-Rev0, 21 January 2014

Golder Associates (2014c), 7-Eleven Service Station Updated Conceptual Site Model, 201 147613001-010-R-Rev 0-Rev 1, 21 May 2014

Golder Associates (2014d), Updated Site Assessment Criteria Report, 137613001-017-R-Rev 2, 1 April 2014

Golder Associates (2014e), Review of Potential Offsite Risk Pathways and Receptors137613001-049-R-Rev1, 13 May 2014

Golder Associates (2014f), Altona Refinery -Groundwater Condition Report, 137613001-071-R-Rev1, 4 February 2014

Golder Associates (2014g), Groundwater Monitoring Event Second Half 2013, 137613001-084-R-Rev0, 14 January 2014

Golder Associates, (2014h), Utility Pit Monitoring Report 4Q13, 137613001-100-L-Rev 0, 3 February 2014

Golder Associates (2014i), Soil Gas Condition Report, 137613001-058-R-Rev1, 29 May 2014

Golder Associates (2014j) - Q4 2013 Status of Works: 7-Eleven Service Station Millers Road Altona 137613001-098-L-Rev0, 21 January 2014

International Standards Organisation (1996), Guidelines for environmental auditing – general principles

Netherlands Government (2009), Ministry of Housing, Spatial Planning and the Environment, Netherlands, *Soil Remediation Circular.*

National Environment Protection Council (1999), *National Environment Protection (Assessment of Site Contamination) Measure,* and Amendment (2013)

NHMRC (2004) National Health and Medical Research Council '*Australian Drinking Water Guidelines'*

NSW EPA (1994), *Guidelines for Assessing Service Station Sites*

SKM (1991), Environment Protection Authority, Lower Kororoit Creek Sediment Assessment Study (prepared for EPA), June 1991, Mobil Archive P161, 5.2.53

Standards Australia (2005), *Guide to the Investigation and Sampling of Sites with Potentially Contaminated Soil. Part 1: Non-volatile and Semi-volatile Compounds*. Australian Standard AS 4482.1-2005.

Standards Australia (1999), *Guide to the Sampling and Investigation of Potentially Contaminated Soil. Part 2: Volatile Substances*. Australian Standard AS 4482.2-1999.

Standards Australia (2009), *Piling – Design and Installation.* Australian Standard AS 2159-2009.

Standards Australia (2013) HB436:2013 *Risk Management Guidelines – Companion to AS/NZS ISO standard 31010:2009*

State Government of Victoria (1970), *Environment Protection Act,* Act No. 8056/1970 (and amendments)

State Government of Victoria (December 1997), *State Environment Protection Policy, Groundwaters of Victoria.*

State Government of Victoria (September 2013), *State Environment Protection Policy Prevention and Management of Contamination of Land.*

State Government of Victoria (June 2003), *State Environment Protection Policy Waters of Victoria*.

Statement of Uncertainties

This report represents a review of data and information (together, “Information”) relating to the property which is the subject of this report. The Information was not obtained by the Auditor and Coffey but from other sources and contacts, some of whom may be noted in the report. The Auditor has conducted reasonable checks as to the adequacy of the information provided, and is satisfied that it is suitable for that purpose of auditing. However, the Auditor notes that, inherent in any assessment approach (and audits that rely on such assessments), is the fact that information is based on a number of “spot” tests and that conditions may vary between those locations.

The analyses, evaluations, opinions and conclusions presented in this report are based on the information provided, and they could change if the information is, in fact, found to be unrepresentative of conditions between sampling and analysis locations.

The Environmental Auditor and Coffey will not update the report and has not taken into account events occurring after the time its review was conducted.

COFFEY ENVIRONMENTS AUSTRALIA PTY LTD

Figures

53V Environmental Audit Report
Mobil Altona Refinery

A3

LEGEND

- Site Boundary
- Road
- Railway
- Watercourse

N

0 75 150 225 300

Metres
Scale 1:7,500
Projection: GDA 1994 MGA Zone 55

Source:
Site boundaries from Golder Associates.
Roads, railways and watercourses from VICMAP.
Imagery from Fastlook (2010-11).

MXD Template Reference: 9627AB_01_GIS001_v0_1

Coffey Environments Pty Ltd

Rev	Date	Revision Details	Drn
A	04.06.14	ISSUE	HU

coffey
126 Trenerry Crescent
Abbotsford, VIC 3067
Ph: (03) 9473 1400
Fax: (03) 9473 1450

Client:
Mobil Refining Australia

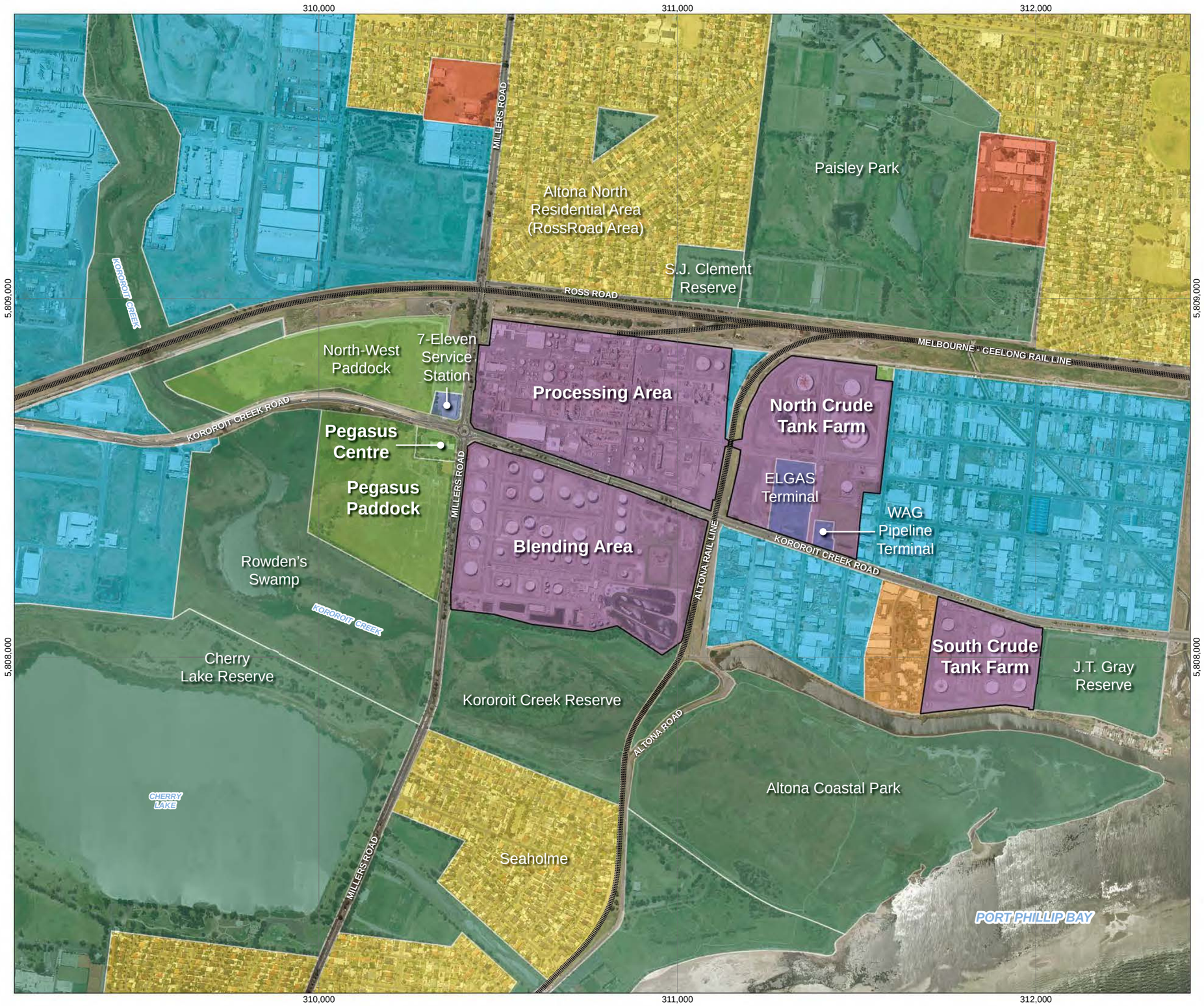
Project:
53V Audit

Location:
Mobil Altona Refinery

Drawing Title:
Site Location Plan and Boundary

Drawn	Date	
HU	05.06.2014	
Project - Drawing No.	Figure No.	Rev.
9627AB_01_F001_GIS	1	A

A3



LEGEND

- Mobil Altona Refinery Site Boundary
- Mobil owned Off-site Area
- Mobil owned and leased to third party
- Predominantly Industrial and Commercial
- Industrial, Commercial and Residential
- Predominantly Residential
- Schools and Education
- Public Open Space / Recreational

N

0 100 200 300 400

Metres

Projection: GDA 1994 MGA Zone 55

Source:
Image sourced from Golder Associates report
Updated Conceptual Site Model, 17 April 2014

Rev	Date	Revision Details	Drn
A	04.06.14	ISSUE	HU

coffey
126 Trennery Crescent
Abbotsford, VIC 3067
Ph: (03) 9473 1400
Fax: (03) 9473 1450

Client: **Mobil Refining Australia**

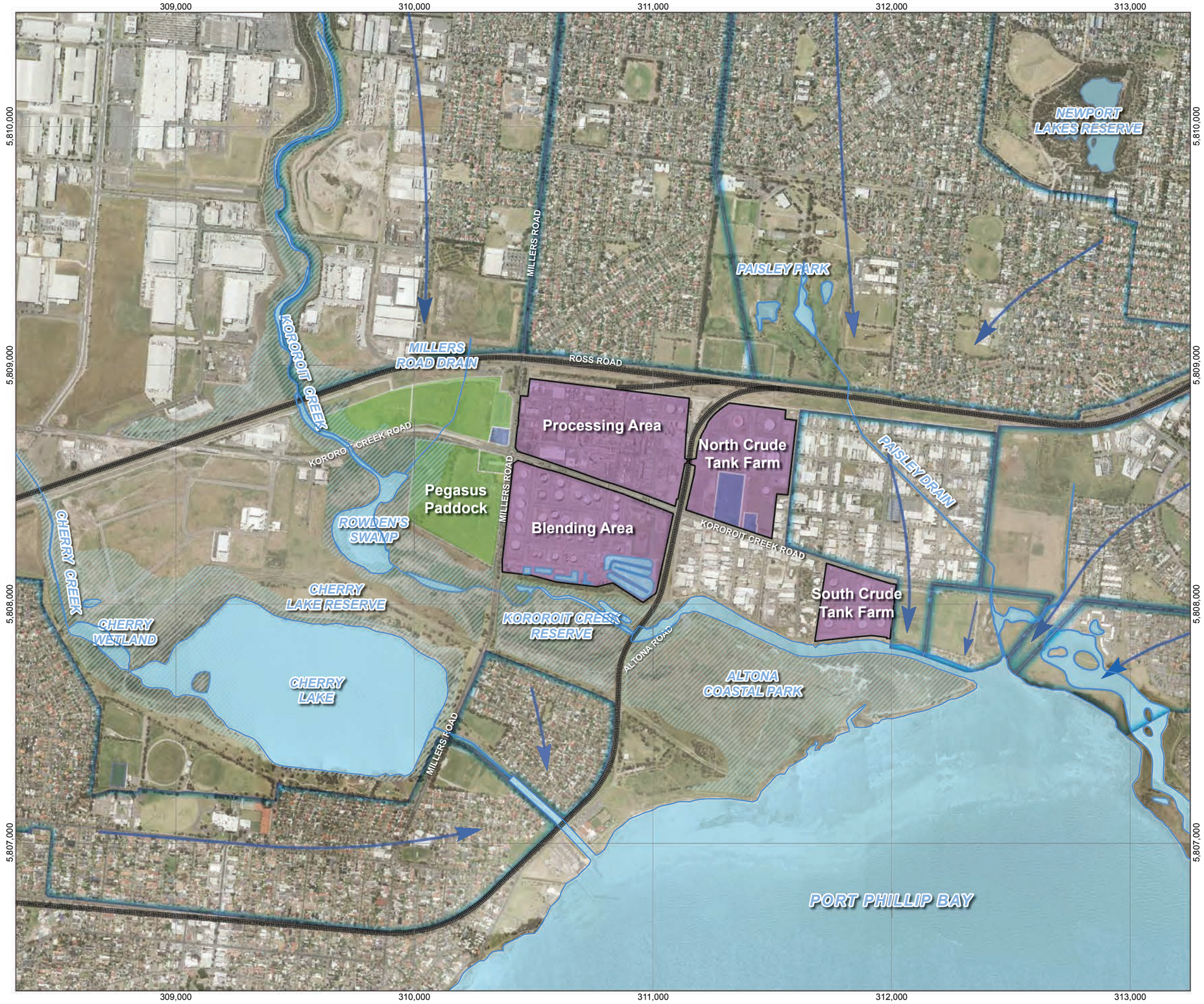
Project: **53V Audit**

Location: **Mobil Altona Refinery**

Drawing Title: **Surrounding Land Uses**

Drawn	Date		
HU	04.06.2014		
Project - Drawing No.		Figure No.	Rev.
9627AB_01_F002_AI		2	A

A3



LEGEND

- Surface water body, creek or drain
- Area subject to inundation
- Sub Catchment Boundary
- Drainage Direction
- Mobil Altona Refinery Site Boundary
- Mobil owned Off-site Area
- Mobil owned and leased to third party

N

0 150 300 450 600

Metres

Projection: GDA 1994 MGA Zone 55

Source:
Image sourced from Golder Associates report
Updated Conceptual Site Model, 17 April 2014

Coffey Environments Pty Ltd ©

Rev	Date	Revision Details	Dm
A	04.06.14	ISSUE	HU

coffey

126 Trennery Crescent
Abbotsford, VIC 3067
Ph: (03) 9473 1400
Fax: (03) 9473 1450

Client:
Mobil Refining Australia

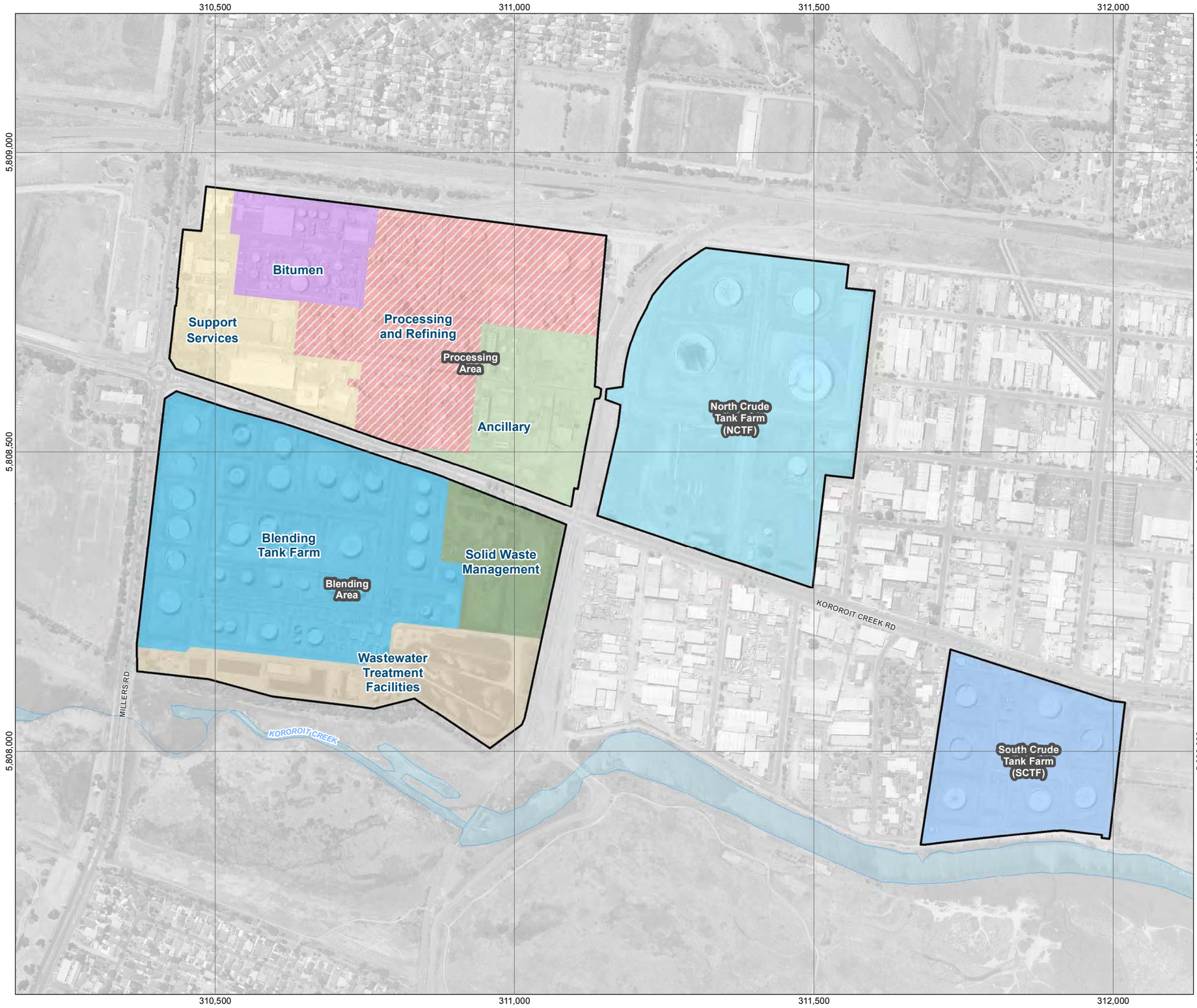
Project:
53V Audit

Location:
Mobil Altona Refinery

Drawing Title:
Surface Water and Drainage Features

Drawn	Date	
HU	04.06.2014	
Project - Drawing No.	Figure No.	Rev.
9627AB_01_F003_AI	3	A

A3



LEGEND

- Site Boundary

Site Sub Areas

- Processing and Refining
- Bitumen
- Support Services
- Ancillary
- Solid Waste Management
- Wastewater Treatment Facilities
- Blending Tank Farm
- North Crude Tank Farm
- South Crude Tank Farm

NOTES
1. Boundaries based on cleanup notice No.10753 (EPA Victoria), Issued 27 June 2012

N

0 75 150 225 300

Metres

Projection: GDA 1994 MGA Zone 55

Source:
Image sourced from Golder Associates report Updated Conceptual Site Model, 17 April 2014

Coffey Environments Pty Ltd ©

Rev	Date	Revision Details	Drn
A	04.06.14	ISSUE	HU

coffey

126 Trennery Crescent
Abbotsford, VIC 3067
Ph: (03) 9473 1400
Fax: (03) 9473 1450

Client:
Mobil Refining Australia

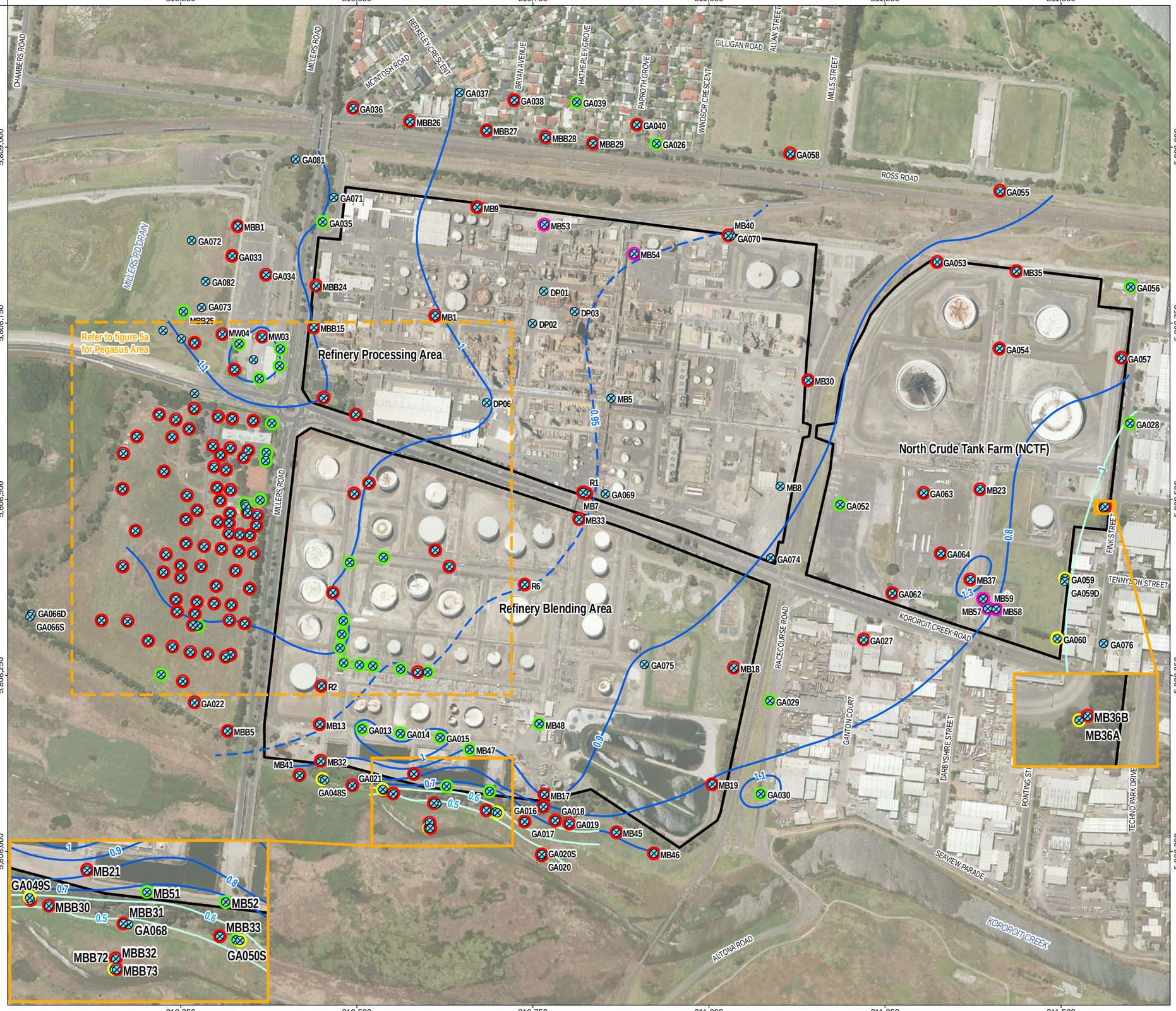
Project:
53V Audit

Location:
Mobil Altona Refinery

Drawing Title:
Site Boundary and Sub Site Areas

Drawn	Date	
HU	04.06.2014	
Project - Drawing No.	Figure No.	Rev.
9627AB_01_F004_AI	4	A

A3



LEGEND

- Site Boundary
- Groundwater Monitoring Well
- Air Hammer
- Auger
- Cored
- Push Tube/Auger
- Unknown
- Inferred Major Groundwater Contour of Newer Volcanics Aquifer (mAHD)
- Inferred Minor Groundwater Contour of Newer Volcanics Aquifer (mAHD)
- Inferred Groundwater Contour of Quaternary Sediments Aquifer (mAHD)

N

0 50 100 150 200

Metres
Scale 1:5,500
Projection: GDA 1994 MGA Zone 55

Source:
Site boundaries, monitoring wells and groundwater contours from Golder Associates.
Imagery from Fastlook (2010-11).

Coffey Environments Pty Ltd

Rev	Date	Revision Details	Drn
A	04.06.14	ISSUE	HU

coffey
126 Trenerry Crescent
Abbotsford, VIC 3067
Ph: (03) 9473 1400
Fax: (03) 9473 1450

Client:
Mobil Refining Australia

Project:
53V Audit

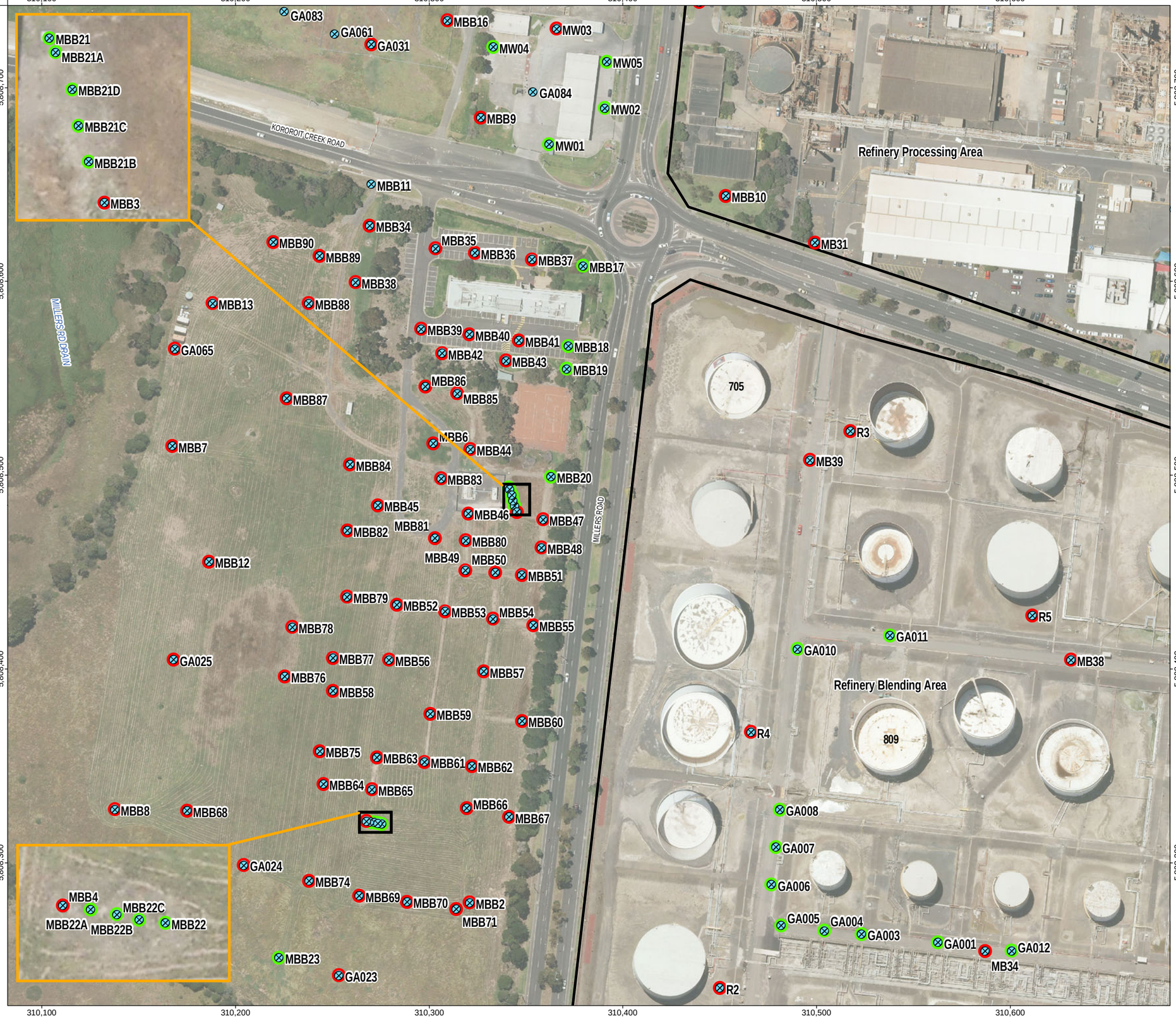
Location:
Mobil Altona Refinery

Drawing Title:
Monitoring Well Location Plan and Groundwater Contours (Refinery)

Drawn	Date	
HU	17.06.2014	
Project - Drawing No.	Figure No.	Rev.
9627AB_01_F005a_GIS	5a	A

MXD Template Reference: 9627AB_01_GIS003_v0_2

A3



LEGEND

- Site Boundary
- Groundwater Monitoring Well
- Air Hammer
- Cored

N

0 20 40 60 80

Metres
Scale 1:2,000
Projection: GDA 1994 MGA Zone 55

Source:
Site boundaries and monitoring wells from Golder Associates.
Imagery from Fastlook (2010-11).

MXD Template Reference: 9627AB_01_GIS002_v0_1

Coffey Environments Pty Ltd

Rev	Date	Revision Details	Drn
A	04.06.14	ISSUE	HU

coffey
126 Trenerry Crescent
Abbotsford, VIC 3067
Ph: (03) 9473 1400
Fax: (03) 9473 1450

Client:
Mobil Refining Australia

Project:
53V Audit

Location:
Mobil Altona Refinery

Drawing Title:
Monitoring Well Location Plan (Pegasus Paddock)

Drawn	Date
HU	05.06.2014

Project - Drawing No.	Figure No.	Rev.
9627AB_01_F005b_GIS	5b	A

A3

311,600 311,800 312,000

5,808,200 5,808,000 5,807,800

GA077 1.01
GA043 1.08
GA044 1.04
GA045 0.85
GA042 0.93
MB27 0.96
GA046 0.75
GA078 0.62
MB56 0.83
GA087
MB55 0.73
GA041 0.65
GA047 0.54
GA079 0.52
GA032 0.5
MB44 0.58
R9 0.54
MB28 0.54
R10 0.55
R8 0.47
MB43 0.43
MB50 0.13
R7 0.45
GA051 0.38
GA085
GA086
KCR3
KCR4
KCR5
KCR6

1.00 0.90 0.80 0.70 0.60 0.50 0.40

BYRON ST
CHURCHILL ST
SOUTHEY ST
KOROROIT CREEK RD
TECHNO PARK DR
KOROROIT CREEK
800 801 802 803 804 805 806 807

LEGEND

- No LNAPL Observed in Well
- No LNAPL Observed in Well (screened below water table)
- Not Gauged
- Surface Water Sampling Location
- Inferred Groundwater Contour of Quaternary Sediments Aquifer (mAHD)
- Project Boundary
- Refinery Infrastructure
- 0.51 Corrected Groundwater Level (m AHD)
- Quaternary Sediments Aquifer

NOTES

1. Groundwater levels presented from gauging results measured from 2 to 4 September 2013.
2. Refinery base layout drawing sourced from URS.

N

0 15 30 45 60

Metres

Projection: GDA 1994 MGA Zone 55

Source:
Image sourced from Golder Associates report Updated Conceptual Site Model, 17 April 2014

Coffey Environments Pty Ltd ©

Rev	Date	Revision Details	Dm
A	04.06.14	ISSUE	HU

coffey
126 Trennery Crescent
Abbotsford, VIC 3067
Ph: (03) 9473 1400
Fax: (03) 9473 1450

Client:
Mobil Refining Australia

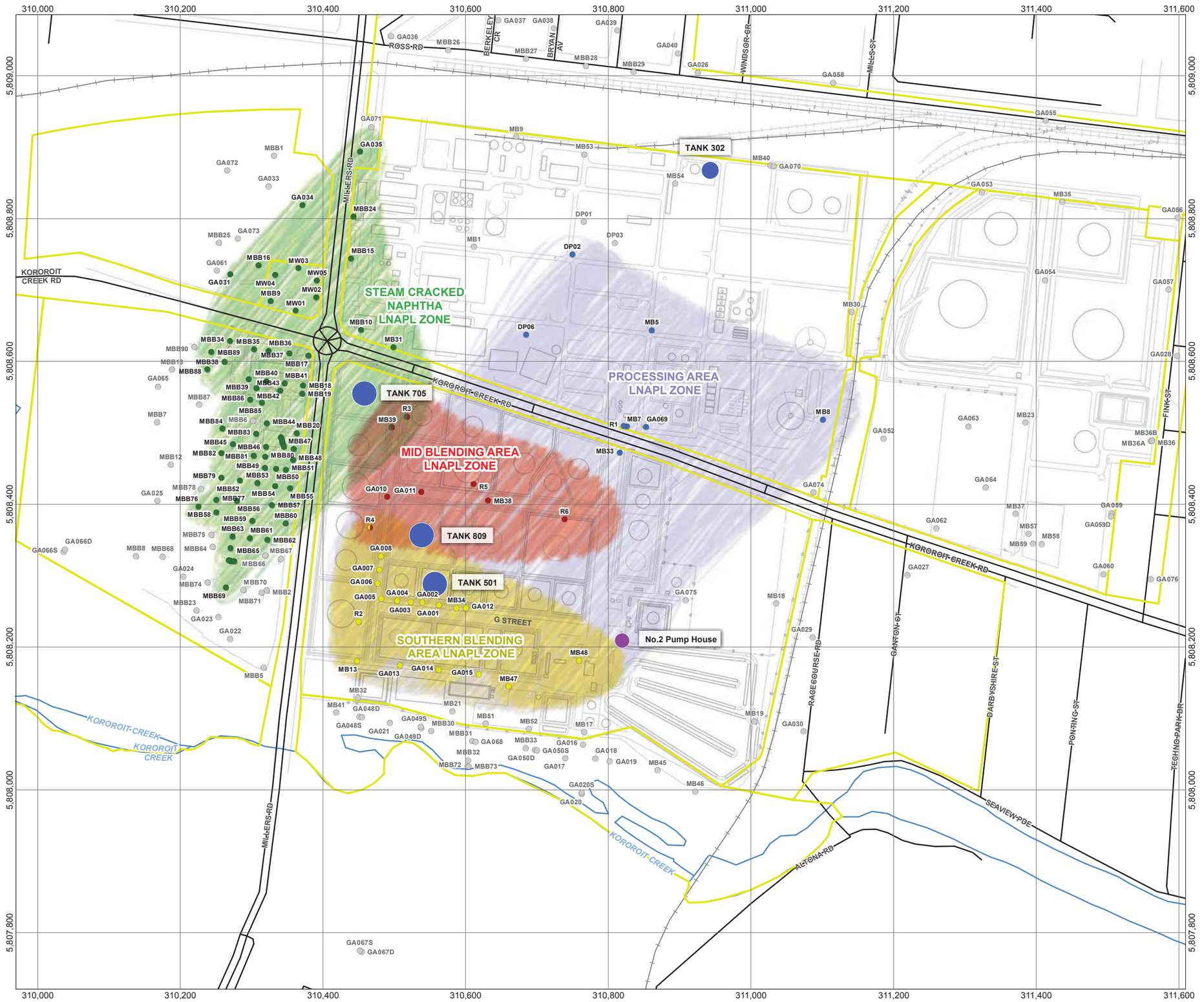
Project:
53V Audit

Location:
Mobil Altona Refinery

Drawing Title:
Monitoring Well Location Plan and Groundwater Contours (South Crude Tank Farm)

Drawn	Date	
HU	04.06.2014	
Project - Drawing No.	Figure No.	Rev.
9627AB_01_F006_AI	6	A

A3



LEGEND

- Processing area and North Blending area LNAPL
- Kerosene and Petrol Dominant LNAPL
- Steam Cracked Naphtha and Petrol Dominant LNAPL
- Kerosene Dominant LNAPL
- Petrol Dominant LNAPL
- Steam Cracked Naphtha
- Well Outside of LNAPL plumes
- Southern Blending Area LNAPL Zone
- Mid Blending Area LNAPL Zone
- Steam Cracked Naphtha LNAPL Zone
- Inferred total extent of LNAPL plume (East of Refinery)
- Project Boundary
- Refinery Infrastructure

NOTES

1. Wells with LNAPL in Pegasus Area are not labelled due to space constraint.
2. Refinery base layout drawing sourced from URS.
3. LNAPLplume areas drawn 4th September, 2013.

N

0 50 100 150 200

Metres

Projection: GDA 1994 MGA Zone 55

Source:
Image sourced from Golder Associates report
Updated Conceptual Site Model, 17 April 2014

Coffey Environments Pty Ltd ©

Rev	Date	Revision Details	Drn
A	04.06.14	ISSUE	HU

coffey

126 Trennery Crescent
Abbotsford, VIC 3067
Ph: (03) 9473 1400
Fax: (03) 9473 1450

Client:
Mobil Refining Australia

Project:
53V Audit

Location:
Mobil Altona Refinery

Drawing Title:
LNAPL Distribution and Chemical Fingerprints

Drawn	Date	
HU	24.06.2014	
Project - Drawing No.	Figure No.	Rev.
9627AB_01_F007_AI	7	A

A3

LEGEND

- Assessment Area
- Project Boundary

NOTES

1. Aerial Photography dated 1970
2. Assessment areas taken from 1970 aerial photo

N

0 60 120 180 240

Metres

Projection: GDA 1994 MGA Zone 55

Source:
Image sourced from Golder Associates report
Updated Conceptual Site Model, 17 April 2014

Projec

Coffey Environments Pty Ltd ©

Rev	Date	Revision Details	Drn
A	04.06.14	ISSUE	HU

coffey

126 Trennery Crescent
Abbotsford, VIC 3067
Ph: (03) 9473 1400
Fax: (03) 9473 1450

Client: **Mobil Refining Australia**

Project: **53V Audit**

Location: **Mobil Altona Refinery**

Drawing Title: **Kororoit Creek Soil Investigation Areas**

Drawn	Date	
HU	04.06.2014	
Project - Drawing No.	Figure No.	Rev.
9627AB_01_F008_AI	8	A

A3

310,250 310,500 310,750 311,000 311,250 311,500 311,750 312,000

5,809,250 5,809,000 5,808,750 5,808,500 5,808,250 5,808,000 5,807,750

CABOT DRIVE
SEVENTH AVENUE
MCINTOSH ROAD
PADROTH GROVE
HATHERLEY GROVE
ALLAN STREET
BERKELEY CRESCENT
BRYAN AVENUE
GILLIGAN ROAD
MILLS STREET
WINDSOR CRESCENT
ROSS ROAD
BLENHEIM ROAD
ROSSHIRE ROAD
MILLERS RD DRAIN
MACAULAY STREET
PAISLEY DRAIN
ALBEMARLE STREET
BENTLEY STREET
CHELMSFORD STREET
TENNYSON STREET
FINK STREET
CHURCHILL STREET
BYRON STREET
SOUTHEY STREET
MILLERS ROAD
RACECOURSE ROAD
GANTON COURT
DARBYSHIRE STREET
PONTING STREET
KOROROIT CREEK ROAD
TECHNO PARK DRIVE
SEAVIEW PARADE
KOROROIT CREEK
ALTONA ROAD
WATERS DRIVE

Refinery Processing Area
Refinery Blending Area
North Crude Tank Farm (NCTF)
South Crude Tank Farm (SCTF)

E E' F F' G1 G1' G2 G2' H H' A A' B B' C C' D D'

GA001 GA002 GA003 GA004 GA005 GA006 GA007 GA008 GA010 GA011 GA012 GA013 GA014 GA015 GA017 GA018 GA019 GA020 GA020S GA021 GA022 GA023 GA025 GA026 GA027 GA028 GA029 GA030 GA032 GA033 GA034 GA035 GA036 GA037 GA038 GA039 GA040 GA041 GA042 GA043 GA044 GA045 GA046 GA047 GA048S GA050S GA051 GA052 GA053 GA054 GA055 GA056 GA057 GA058 GA059 GA059D GA060 GA061 GA062 GA063 GA064 GA065 GA067D GA067S GA068 GA069 GA070 GA071 GA072 GA073 GA074 GA075 GA076 GA077 GA078 GA079 GA081 GA082 GA083 GA085 GA086 GA087

MB1 MB2 MB5 MB7 MB8 MB9 MB10 MB11 MB12 MB13 MB17 MB18 MB19 MB21 MB23 MB27 MB30 MB31 MB32 MB33 MB34 MB35 MB36A MB36B MB37 MB38 MB39 MB40 MB41 MB43 MB44 MB45 MB46 MB47 MB48 MB50 MB51 MB52 MB53 MB54 MB55 MB56 MB57 MB58 MB59

MBB1 MBB2 MBB6 MBB7 MBB8 MBB9 MBB10 MBB11 MBB12 MBB13 MBB15 MBB17 MBB18 MBB19 MBB20 MBB23 MBB24 MBB25 MBB26 MBB27 MBB28 MBB29 MBB30 MBB33 MBB34 MBB36 MBB40 MBB47 MBB60 MBB62 MBB67 MBB68 MBB69 MBB70 MBB71 MBB72 MBB73 MBB74 MBB75 MBB76 MBB78 MBB82 MBB84 MBB87 MBB88 MBB90

DP01 DP02 DP03 DP06

MW01 MW02 MW04 MW05

R1 R2 R3 R4 R5 R6 R7 R8 R9 R10

LEGEND

- Site Boundary
- Groundwater Monitoring Well
- Cross Section
- Railway
- Watercourse

N

0 50 100 150 200

Metres
Scale 1:6,500
Projection: GDA 1994 MGA Zone 55

Source:
Site boundaries and monitoring wells from Golder Associates.
Roads, railways and watercourses from VICMAP.
Cross sections from Coffey.
Imagery from Fastlook (2010-11).

MXD Template Reference: 9627AB_01_GIS004_v0_1

Coffey Environments Pty Ltd

Rev	Date	Revision Details	Drn
B	17.06.14	AMENDS	HU
A	04.06.14	ISSUE	HU

coffey
126 Trenerry Crescent
Abbotsford, VIC 3067
Ph: (03) 9473 1400
Fax: (03) 9473 1450

Client:
Mobil Refining Australia

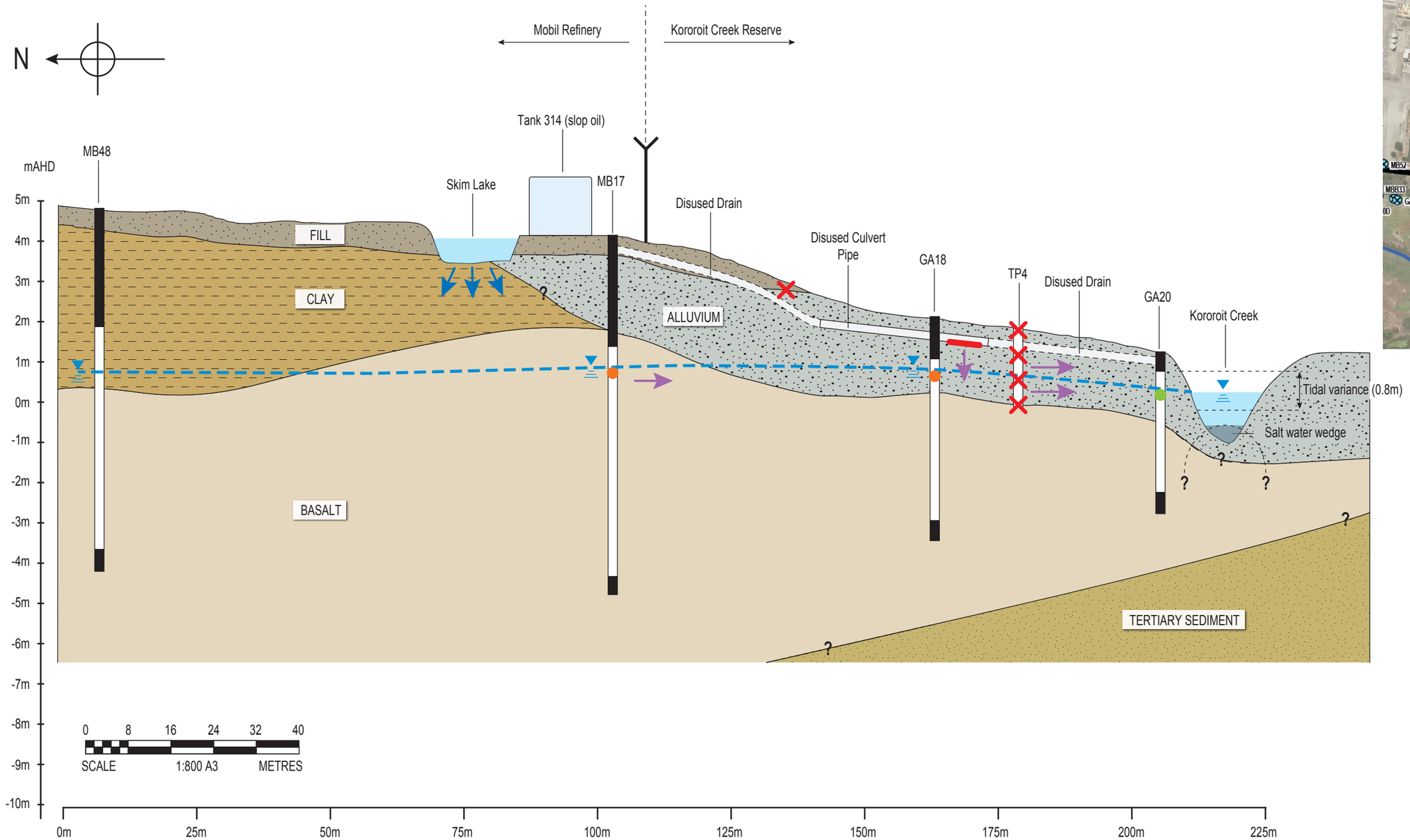
Project:
53V Audit

Location:
Mobil Altona Refinery

Drawing Title:
Cross Section Alignments

Drawn	Date	
HU	17.06.2014	
Project - Drawing No.	Figure No.	Rev.
9627AB_01_F009_GIS	9	B

A3



Light Non-Aqueous Phase Liquid

Groundwater level

Hydrocarbon contamination in soil greater than adopted criteria

Potential contaminant pathways

Potential water leakage

TPH (C10-C36) groundwater concentration below laboratory limit of reporting

TPH (C10-C36) groundwater concentration above laboratory limit of reporting, but less than adopted criteria

TPH (C10-C36) concentration greater then adopted criteria

Monitoring Well

— Seal

— Screen

— Backfill

Coffey Environments Pty Ltd ©

coffey
126 Trennery Crescent
Abbotsford, Victoria
Ph: (03) 9473 1400
Fax: (07) 9473 1450

Rev	Date	Revision Details	
A	DATE	ISSUE	XX
			Drn

Client: Mobil Refining Australia

Project: 53V Audit

Location: Mobil Altona Refinery

Drawing Title: **Cross Section A-A'**

Drawn: GL

Date: 17.07.2014

Project - Drawing No.: 9627AA_ENVIABTF-D01_F010_GL

Figure No.: **10**

Rev.: A

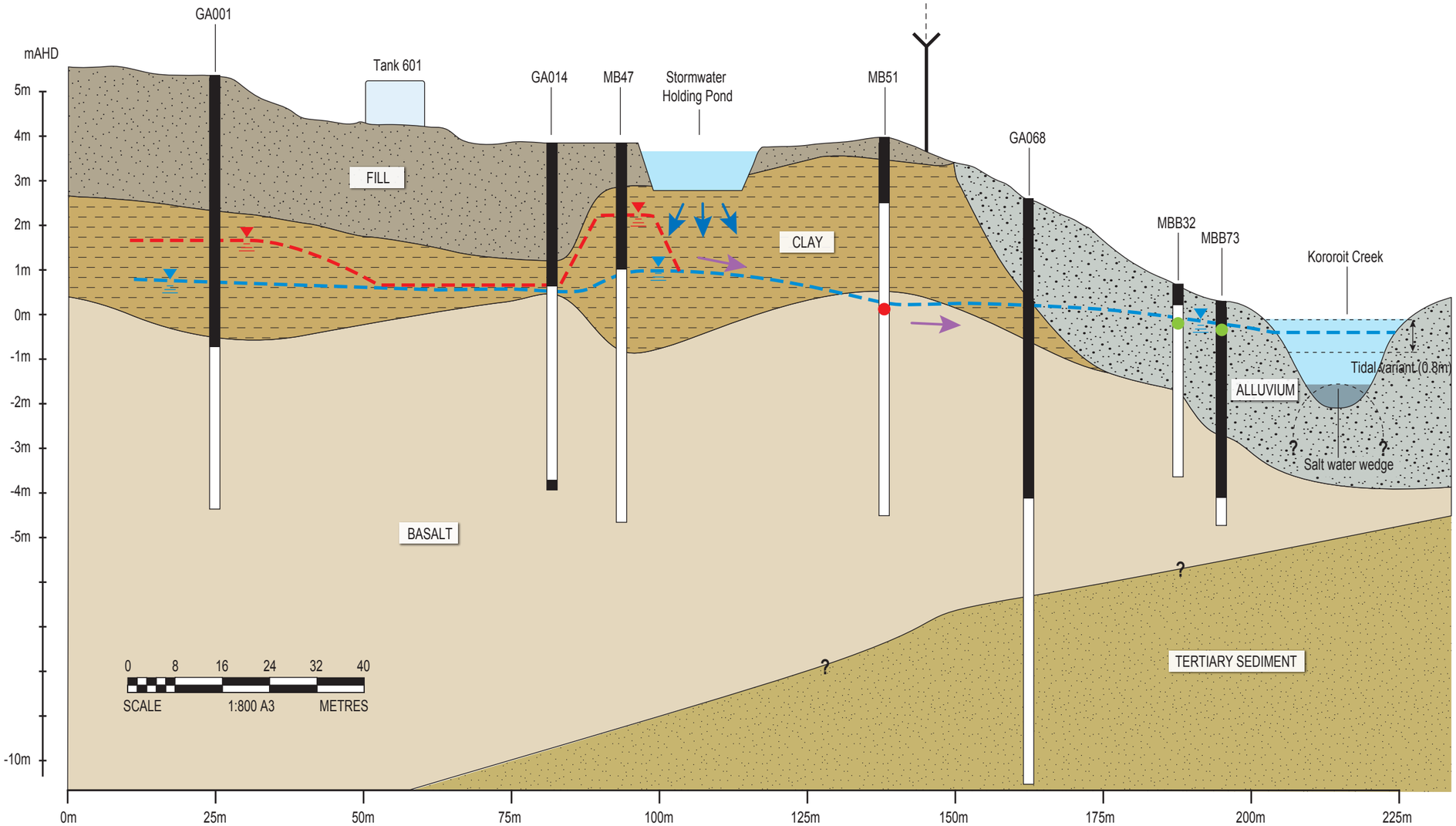
A3

N-NW

100m ← Tank 809

Mobil Refinery

Kororoit Creek Reserve



- Light Non-Aqueous Phase Liquid
- Groundwater level
- Hydrocarbon contamination in soil greater than adopted criteria
- Potential contaminant pathways
- Potential water leakage
- TPH (C10-C36) groundwater concentration below laboratory limit of reporting
- TPH (C10-C36) groundwater concentration above laboratory limit of reporting, but less than adopted criteria
- TPH (C10-C36) concentration greater then adopted criteria

Monitoring Well
- Seal
- Screen
- Backfill

Coffey Environments Pty Ltd ©

coffey
126 Trennery Crescent
Abbotsford, Victoria
Ph: (03) 9473 1400
Fax: (07) 9473 1450

Rev	Date	Revision Details	
A	DATE	ISSUE	XX
			Drn

Client: Mobil Refining Australia

Project: 53V Audit

Location: Mobil Altona Refinery

Drawing Title: **Cross Section B-B'**

Drawn: GL

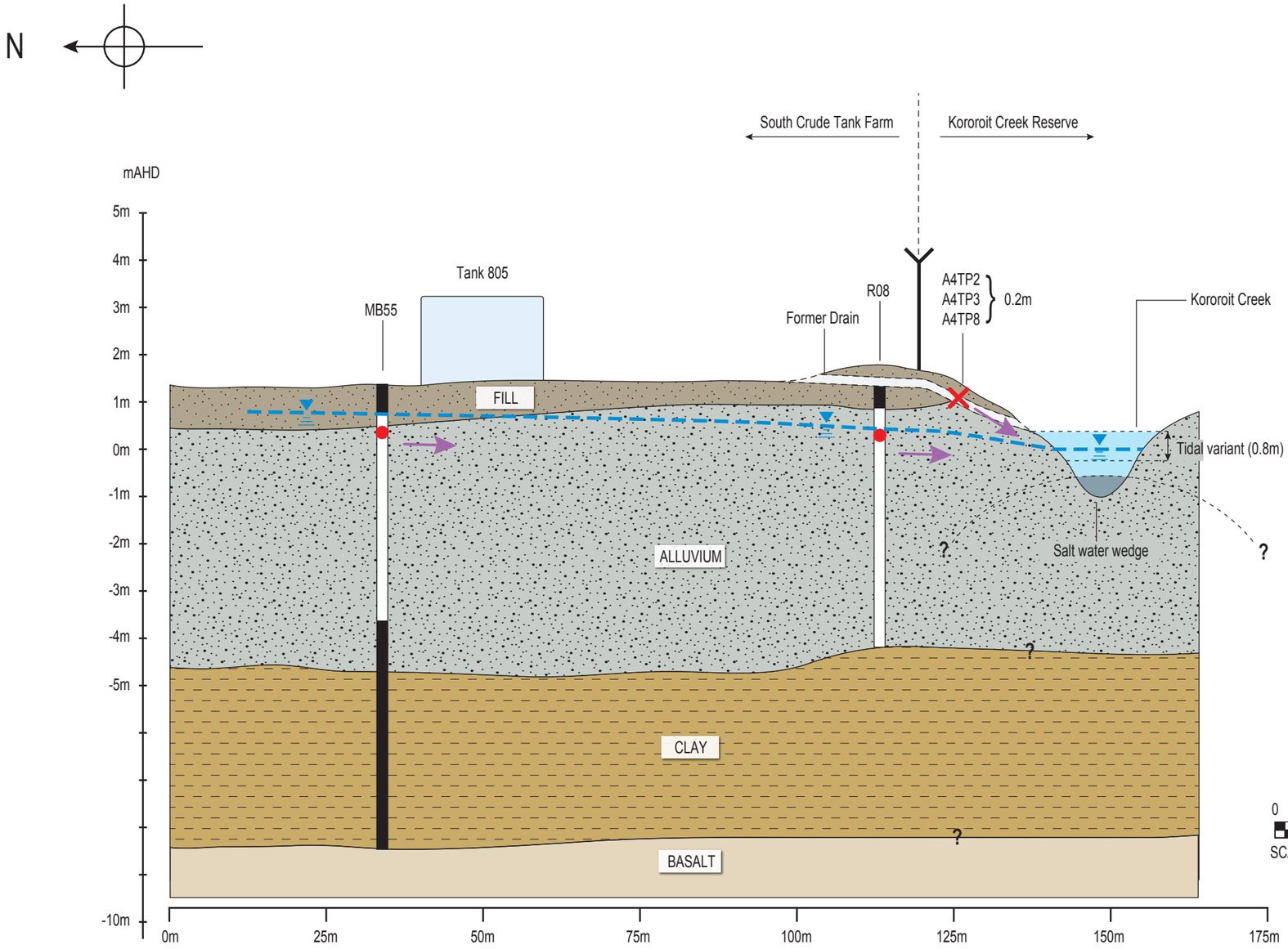
Date: 17.07.2014

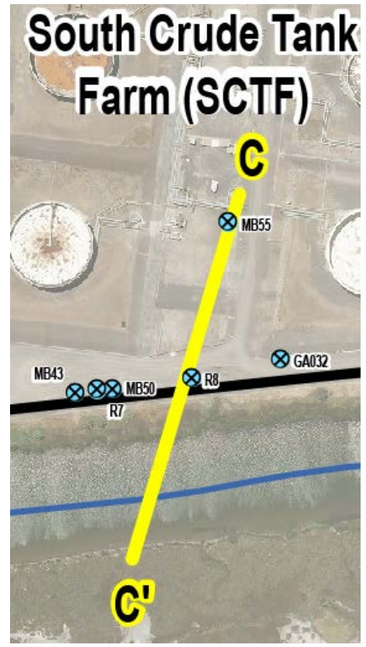
Project - Drawing No.: 9627AA_ENVIABTF-D01_F011_GL

Figure No.: **11**

Rev.: A

A3





0 8 16 24 32 40

SCALE 1:800 A3 METRES

- Light Non-Aqueous Phase Liquid
- Groundwater level
- Hydrocarbon contamination in soil greater than adopted criteria
- Potential contaminant pathways
- Potential water leakage
- TPH (C10-C36) groundwater concentration below laboratory limit of reporting
- TPH (C10-C36) groundwater concentration above laboratory limit of reporting, but less than adopted criteria
- TPH (C10-C36) concentration greater then adopted criteria

Monitoring Well
- Seal
- Screen
- Backfill

Coffey Environments Pty Ltd ©

coffey
126 Trennery Crescent
Abbotsford, Victoria
Ph: (03) 9473 1400
Fax: (07) 9473 1450

Rev	Date	Revision Details	
A	DATE	ISSUE	XX
			Drn

Client: Mobil Refining Australia

Project: 53V Audit

Location: Mobil Altona Refinery

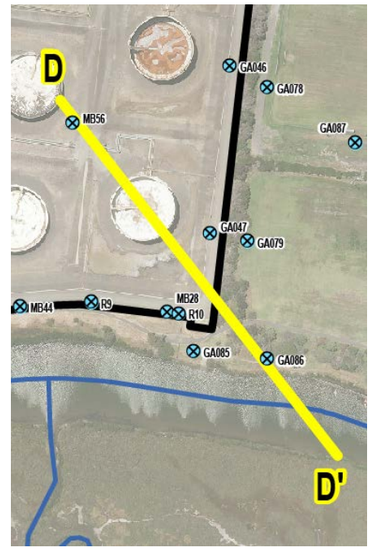
Drawing Title: **Cross Section C-C'**

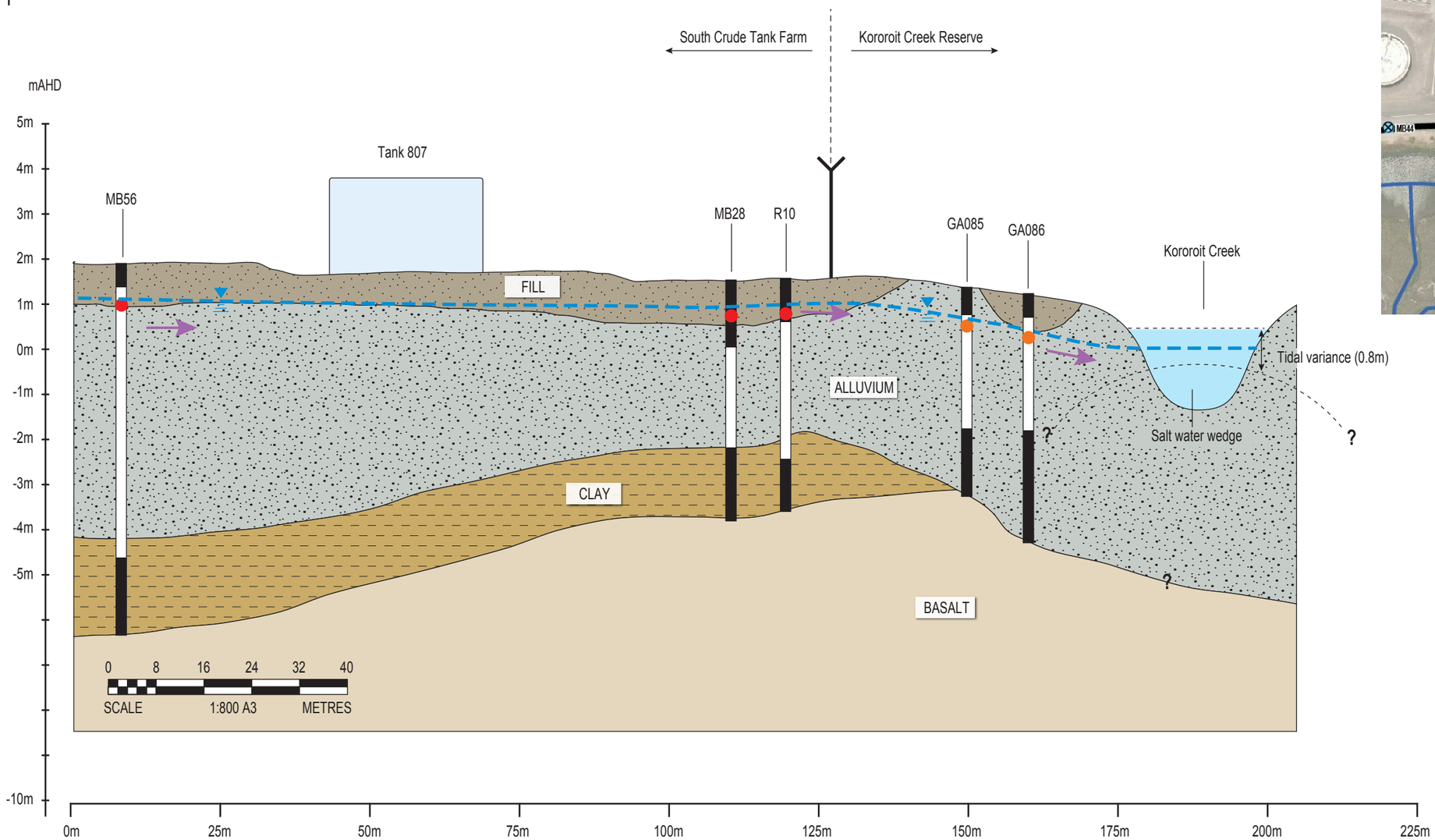
Drawn: GL | Date: 17.07.2014

Project - Drawing No.: 9627AA_ENVIABTF-D01_F012_GL | Figure No.: **12** | Rev.: A

A3

NW





Light Non-Aqueous Phase Liquid

Groundwater level

Hydrocarbon contamination in soil greater than adopted criteria

Potential contaminant pathways

Potential water leakage

TPH (C10-C36) groundwater concentration below laboratory limit of reporting

TPH (C10-C36) groundwater concentration above laboratory limit of reporting, but less than adopted criteria

TPH (C10-C36) concentration greater then adopted criteria

Monitoring Well

Seal

Screen

Backfill

coffey
126 Trennery Crescent
Abbotsford, Victoria
Ph: (03) 9473 1400
Fax: (07) 9473 1450

Rev	Date	Revision Details	
A	DATE	ISSUE	XX
			Drn

Client: Mobil Refining Australia

Project: 53V Audit

Location: Mobil Altona Refinery

Drawing Title: **Cross Section D-D'**

Drawn: GL

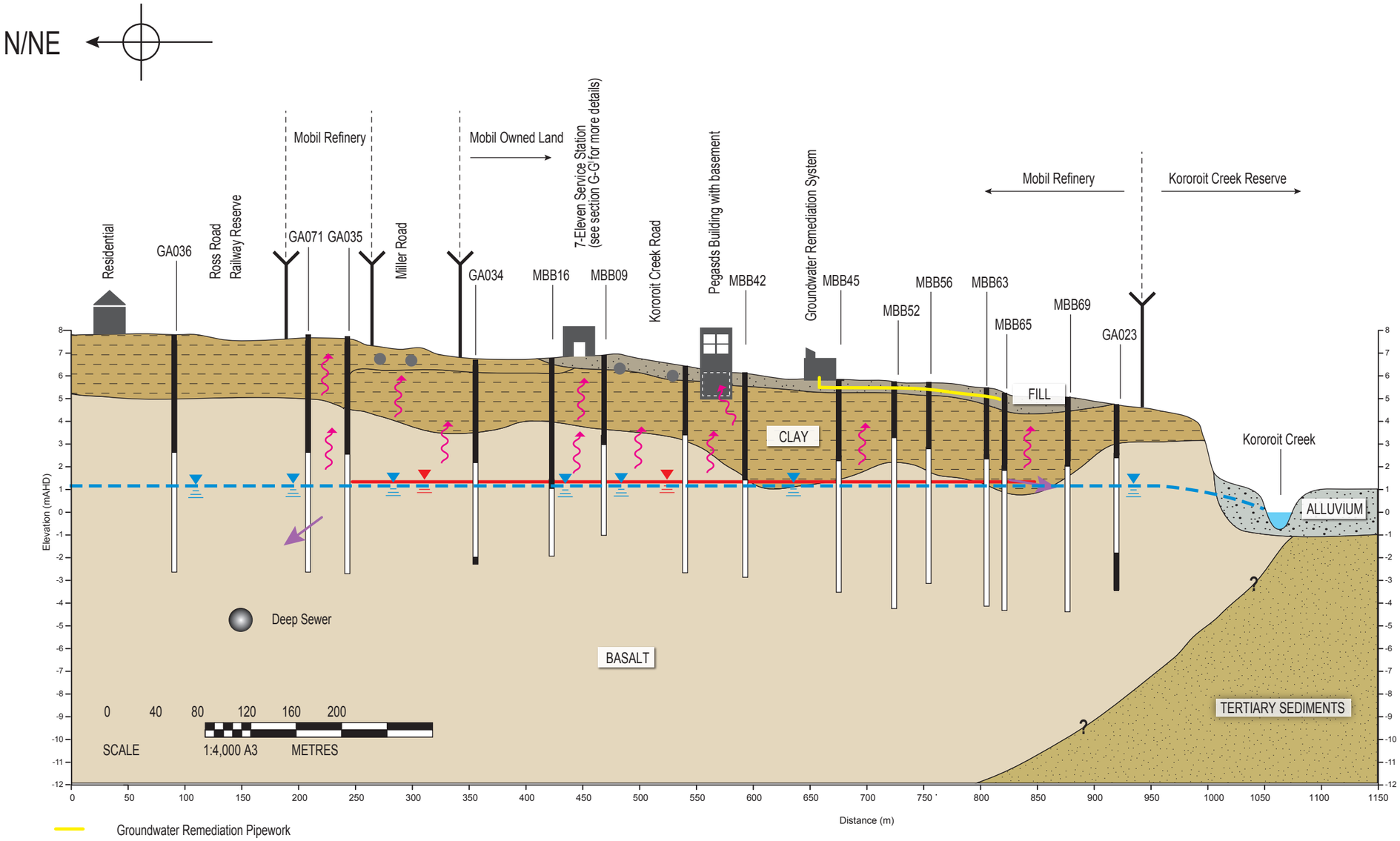
Date: 17.07.2014

Project - Drawing No.: 9627AA_ENVIABTF-D01_F013_GL

Figure No.: **13**

Rev.: A

A3



Groundwater Remediation Pipework

Light Non-Aqueous Phase Liquid

Groundwater level

Hydrocarbon contamination in soil greater than adopted criteria

Potential contaminant pathways

Potential water leakage

Vapour

TPH (C10-C36) groundwater concentration below laboratory limit of reporting

TPH (C10-C36) groundwater concentration above laboratory limit of reporting, but less than adopted criteria

TPH (C10-C36) concentration greater then adopted criteria

Underground Services

Monitoring Well

Seal

Screen

Backfill

Coffey Environments Pty Ltd ©

coffey
126 Trennery Crescent
Abbotsford, Victoria
Ph: (03) 9473 1400
Fax: (07) 9473 1450

Rev	Date	Revision Details	
A	DATE	ISSUE	XX
			Drn

Client: Mobil Refining Australia

Project: 53V Audit

Location: Mobil Altona Refinery

Drawing Title: **Cross Section E-E'**

Drawn: GL

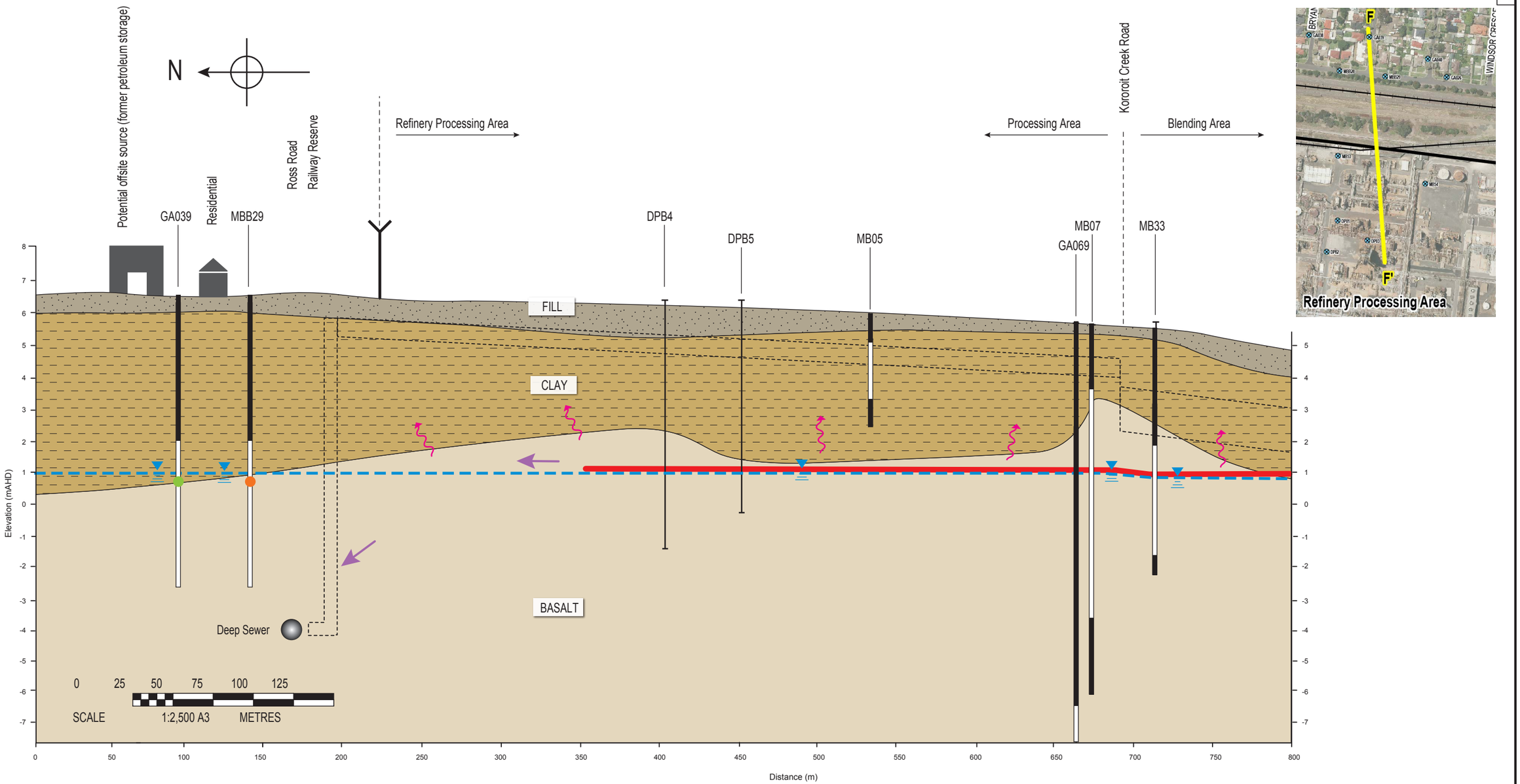
Date: 17.06.2014

Project - Drawing No.: 9627AA_ENVIABTF-D01_F014_GL

Figure No.: 14

Rev.: A

A3



- Light Non-Aqueous Phase Liquid
- Groundwater level
- Hydrocarbon contamination in soil greater than adopted criteria
- Vapour
- Potential contaminant pathways
- Potential water leakage
- TPH (C10-C36) groundwater concentration below laboratory limit of reporting
- TPH (C10-C36) groundwater concentration below laboratory limit of reporting
- TPH (C10-C36) groundwater concentration above laboratory limit of reporting, but less than adopted criteria
- TPH (C10-C36) concentration greater then adopted criteria

Monitoring Well
- Seal
- Screen
- Backfill

Coffey Environments Pty Ltd ©

coffey
126 Trennery Crescent
Abbotsford, Victoria
Ph: (03) 9473 1400
Fax: (07) 9473 1450

Rev	Date	Revision Details	
A	DATE	ISSUE	XX
			Drn

Client: Mobil Refining Australia

Project: 53V Audit

Location: Mobil Altona Refinery

Drawing Title: **Cross Section F-F'**

Drawn: GL | Date: 17.06.2014

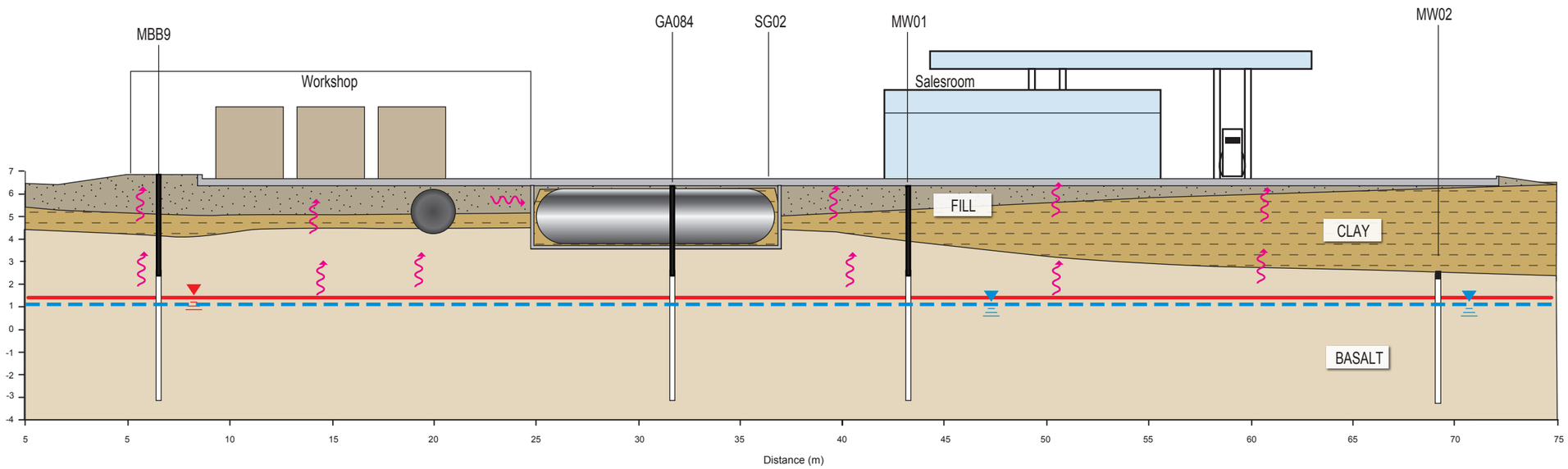
Project - Drawing No.: 9627AA_ENVIABTF-D01_F015_GL | Figure No.: 15 | Rev.: A

A3

WEST - SECTON

G2

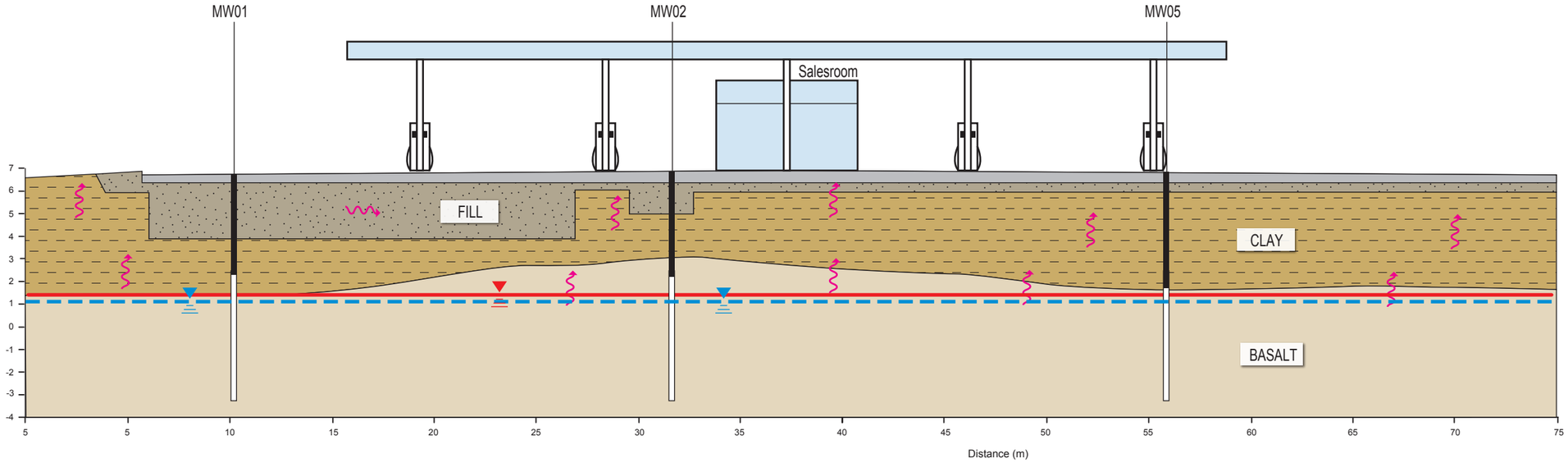
G2'



SOUTH - SECTON

G1

G1'



Light Non-Aqueous Phase Liquid

Light Non-Aqueous Phase Liquid

Vapour

0 2.5 5 7.5 10 12.5

SCALE 1:250 A3 METRES

Monitoring Well

Seal

Screen

Backfill

Coffey Environments Pty Ltd ©

coffey
126 Trennery Crescent
Abbotsford, Victoria
Ph: (03) 9473 1400
Fax: (07) 9473 1450

Rev	Date	Revision Details	
A	DATE	ISSUE	XX
			Drn

Client: Mobil Refining Australia

Project: 53V Audit

Location: Mobil Altona Refinery

Drawing Title: **Cross Section G-G'**

Drawn: GL

Date: 17.06.2014

Project - Drawing No.: 9627AA_ENVIABTF-D01_F016_GL

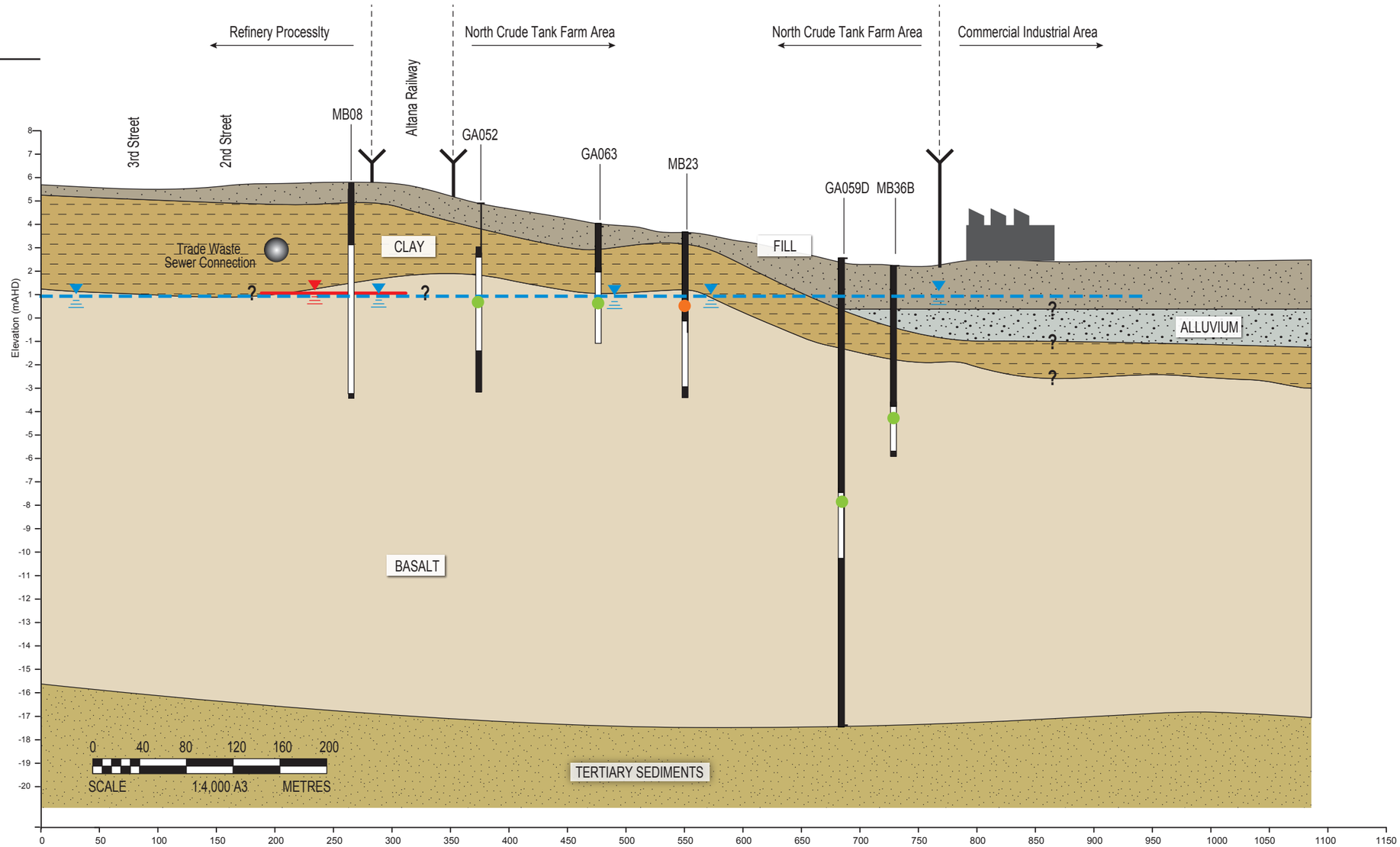
Figure No.: 16

Rev.: A

A3

W

E



Light Non-Aqueous Phase Liquid

Groundwater level

Hydrocarbon contamination in soil greater than adopted criteria

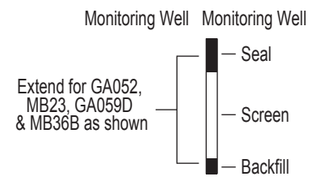
Potential contaminant pathways

Potential water leakage

TPH (C10-C36) groundwater concentration below laboratory limit of reporting

TPH (C10-C36) groundwater concentration above laboratory limit of reporting, but less than adopted criteria

TPH (C10-C36) concentration greater then adopted criteria



coffey
126 Trennery Crescent
Abbotsford, Victoria
Ph: (03) 9473 1400
Fax: (07) 9473 1450

Rev	Date	Revision Details	
A	DATE	ISSUE	XX
			Drn

Client: Mobil Refining Australia

Project: 53V Audit

Location: Mobil Altona Refinery

Drawing Title: **Cross Section H-H'**

Drawn: GL

Date: 03.06.2014

Project - Drawing No.: 9627AA_ENVIABTF-D01_F017_GL

Figure No.: 17

Rev.: A