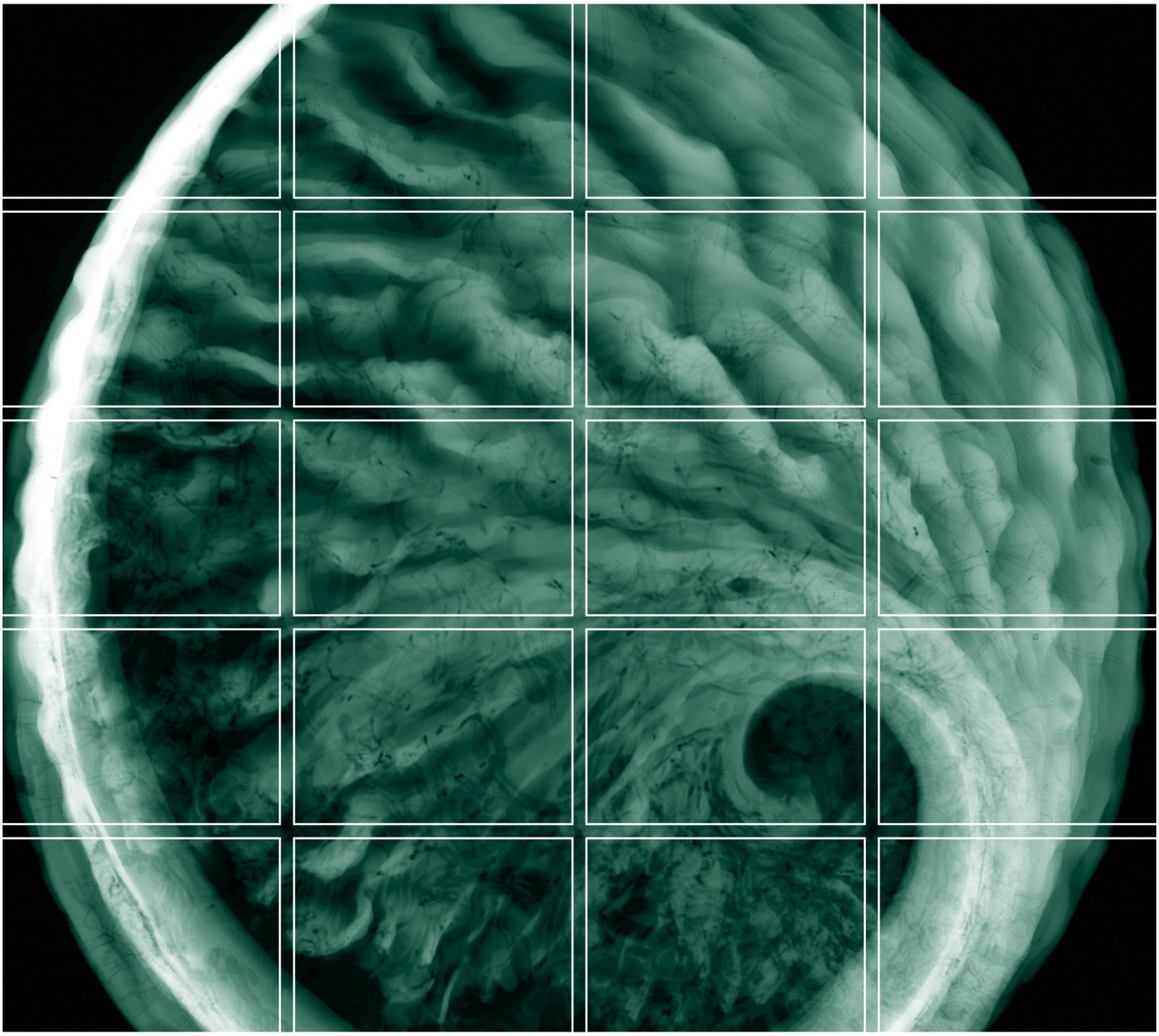

Wentworth Point Marinas - Block B, C, E, H

Environmental Site Assessment

Fairmead Business Pty Ltd

November 2014

0263003_RP02_ESA

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Wentworth Point Marinas – Block B, C, E, H

Environmental Site Assessment

Approved by:	*Anne Ashworth*
Position:	Project Manager
Signed:	*DRAFT*
Date:	*November 2014*
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Environmental Resources Management Australia Pty Ltd Quality System

Fairmead Business Pty Ltd

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1 INTRODUCTION

1.1 GENERAL

Environmental Resources Management (ERM) was engaged by Fairmead Business Pty Ltd (Fairmead) to undertake additional soil and groundwater investigations at the Wentworth Point Marinas site ('the WPM Site'). The WPM Site is located at 1 Burroway Road, Wentworth Point, as shown in *Figure 1 of Annex A*. This report addresses the area defined in *Figure 2 of Annex A,* including Block 'B', 'C', 'E', 'H' and excludes Block 'A', 'D' and 'G' which have been reported elsewhere. It is noted that the area previously referred to as Block 'F' and 'I' have been amalgamated into Block 'E' and 'H' respectively.

ERM prepared an Environmental Site Assessment (ESA) report "*Soil and Groundwater Contamination Status Summary Report - Block B, C, E, F, H, I - 47 Hill Road, Wentworth Point*" in November 2013 which provides a comprehensive review of previous soil and groundwater assessments within these blocks. The objective of this further soil and groundwater investigation is to address the data gaps identified in the *Soil and Groundwater Contamination Status Summary Report* (ERM, August 2013).

1.2 BACKGROUND

ERM understands that Fairmead propose to redevelop the Site in seven blocks. It is noted that the development previously comprised nine blocks of which Block 'F' and 'I' have been amalgamated into Block 'E' and 'H' respectively. A previous Development Consent for the development construction was granted by the NSW Land and Environment Court on 29 July 1998 (No. 10251 of 1998). In order to satisfy the Conditions of Consent, a program of environmental investigations and remediation works were conducted at the Site by Woodward-Clyde (WWC) (1993 to 1994), Australian Defence Industries (ADI) (1997) and ERM (2002 to 2006). There have been three Site Audit Statements (SAS) issued for portions of the WPM Site, including Block 'A' in 2005 (by Site Auditor Mr. Bill Ryall), and Block 'D' and Block 'G' in 2014 (by Site Auditor, Ms. Kylie Lloyd). Construction of both Block 'A' and Block 'D' has been completed and these sites are now occupied. Block 'G' construction commenced in October 2014.

1.3 *OBJECTIVES*

ERM understands that a Site Audit Statement will be required as a condition of development approval and that a NSW EPA accredited Site Auditor will be engaged to review the works. The objective of these works is to provide additional soil and groundwater data to supplement the existing data set.

The overall project objective is to provide a conclusion on whether the Site is suitable for the intended land-use as residential with minimal access to soils. However, it is noted that the development design for the Site has not yet been finalised and the current proposed layout, including four blocks and associated roadways, and the building design for the individual Blocks is subject to change. This report is based on the development designs for Block 'B' and 'C' as submitted for the relevant DA, and the assumption that the design for Block 'E' and 'H' will be generally consistent with that proposed for Block 'B' and 'C', as described in *Section 7.2*.

2 CONCEPTUAL SITE MODEL

2.1 SITE IDENTIFICATION

The area under investigation comprises Block 'B', 'C', 'E', 'H' of the Wentworth Point Marina site, located at 1 Burroway Road, Wentworth Point, New South Wales, described as Lot 4 of Deposited Plan (DP) 207708. It is noted that the area previously referred to as Block 'F' and 'I' have been amalgamated into Block 'E' and 'H' respectively.

The site is situated in a predominantly commercial/industrial area which is being redeveloped for high density residential/commercial usage.

2.2 SITE HISTORY

The history of the WPM site is detailed in previous reports prepared by Woodward-Clyde (1993), ADI (1997), ERM (2003), and ERM (2013). The WPM site was originally mangrove swampland and was progressively reclaimed from the river with dredged sediments from as early as the 1880's, with final reclamation in the 1930's by the Maritime Services Board. Reclamation is known to have been completed in late 1953-early 1954, with construction of a large warehouse building on the site by Ralph Symonds Plywood being completed in 1959 (TBIA, 2013).

Ralph Symonds operated a plywood manufacturing operation on the whole of the WPM Site from its opening in 1959 until downsizing in the 1970s when the building structure was subdivided for sub-tenants and the closure in the 1990's. A number of different operations were subsequently conducted at the site including timber treatment, plywood manufacture, a paper treatment plant and a phenol formaldehyde resin plant.

The original Ralph Symonds building was separated into three main buildings which have been subdivided into warehouse units. There are also two additional buildings which were constructed in the mid-1980s (Unit 20, 15 and 16). The Site is currently used for warehousing and storage in areas which are not currently scheduled for re-development.

2.3 POTENTIAL AND KNOWN SOURCES OF CONTAMINATION

2.3.1 Areas of Potential Environmental Concern

A summary of the historical operations at the WPM Site is provided in ERM (2013) based on available documentation.

A Conceptual Site Model (CSM) was developed in ERM (2013) and is summarised in *Annex C* of this report, including the following identified areas of potential environmental concern:

- Imported fill material – potentially impacted sediments dredged from Homebush Bay;
- Imported fill material – potentially impacted shallow fill material including clay and building rubble;
- ACM in buildings - potentially impacted surface soils within Block 'B' and 'C' where buildings with potential ACM were demolished;
- Plywood manufacturing – former operations of Ralph Symonds across the Site, as well as specifically in Unit 4 and 5 including:
    - logs were delivered by water and off loaded near Unit 14 and log slicing was conducted in the area (potentially Unit 14, 12, 11);
    - a timber treatment plant using copper, chrome and arsenate (CCA) began in the late 1960s or early 1970s in the area outside Unit 12 on the sea wall. A boiler fired by fuel oil was located in the vicinity near the sea wall and one or more fuel oil tanks were reportedly located in this area;
    - the CCA treatment plant was relocated to the area to the south of Unit 21 (within Block 'B') and to Units 15 and 16 in the late 1970s;
    - a paper treatment plant and phenol formaldehyde resins plant was operated by Ralph Symonds in a separate building, north west of the site adjacent to the fire water reservoir (in former Unit 21). No commencement date was available, however operations ceased in 1995;
    - underground pipework and stormwater drainage including pits identified on service plans which may have transported waste water containing phenols, glue residues, chlorinated solvents, metals and other contaminants; and
    - Ralph Symonds plywood manufacturing equipment was reportedly located between Units 17/18/19 and Units 4 and 5 by WWC (1994).
- Bulk Chemical Storage including - underground storage tanks (USTs) and above-ground storage tanks (ASTs) including petroleum, mineral spirits, and phenols within Block 'B' and Block 'H';
- Operational unsealed ground - including foreshore areas formerly used for unloading/loading and storage of timber and the southern part of the Site (Units 15, 16, 20 and 21) which were unsealed prior to construction circa 1986; and

- Warehousing & storage – miscellaneous products including paper, timber, electrical products and parts, steel fabrication, storage of explosives.

2.3.2 *Fill Materials*

The Wentworth Point Marina site was originally mangrove swampland and was progressively reclaimed from as early as the 1880's, with final reclamation in the 1930's by the Maritime Services Board. The reclamation of land involved the dredging of sediments from Homebush Bay and the Parramatta River. Wentworth Point is shown in an early government plan from the late 19th century (Clarke and Benson, 1988) with Haslem's (now Haslam's) Creek re-aligned by the construction of a seawall ("Fascine Dyke") along the Parramatta River. The land of Wentworth Point is shown at this time as being "reclaimed land about 201 acres" and "mud flat dries about two feet". Reclamation activities were recorded as early as 1827, and the seawall was constructed in 1891 (PB, 2002).

The fill materials used to reclaim the site were dredged from Homebush Bay in the period 1930-1953. During this period, the Timbrol chemical plant (later Union Carbide) was operational on the Rhodes Peninsula, across Homebush Bay (PB, 2002). Reclamation of 200 acres at Wentworth Point behind the seawall is known to have been completed in late 1953-early 1954, being "hard and dry and almost ready for industrial use" (SMH, 1954). The project objective was to raise the land behind the seawall by up to 2.7 m (8-9 feet) above the low water mark. The project also included the filling of Wentworth Bay, and dredging of Homebush Bay to a minimum depth of 3 m (10 feet).

Union Carbide Construction of the Timbrol site began in the 1930s, prior to extensive land reclamation in the 1950's when production increased. The Timbrol factory produced chemicals from coal-tar sourced from the AGL Mortlake Gasworks site from 1928, including timber preservatives (PB, 2002). Chemicals produced on the Rhodes Peninsula until the completion of land reclamation at Wentworth Point in 1953 included timber preservatives (1928), xanthates (1932), aniline (1940), nitrobenzene (1940), phenol (1942), chlorophenol and chlorobenzenes (1947), 2,4,5-T and 2,4-D herbicides (1949) and chlorine (1952) (PB, 2002). Sediment contamination of Homebush Bay from the chemical manufacture on the Rhodes Peninsula was largely the result of overflow during reclamation of the peninsula and flow of stormwater and other wastewater from the chemicals factory, including dioxins, chlorinated organic substances and metals (PB, 2002). Dioxins were largely associated with the loading and unloading operations on the jetty at Rhodes (PB, 2002). Sediment contamination is highest along the eastern side of Homebush Bay, directly adjacent to the Rhodes Peninsula (PB, 2002). The contamination of sediments in Homebush Bay adjacent to the Rhodes Peninsula by the discharge of contaminated wastewater streams occurred over a 20 years period of operations until the improvements to waste management in the 1970's.

Dredging of Homebush Bay for land reclamation at Wentworth Point was likely from the western side and the main channel of Homebush Bay, away from Rhodes Peninsula. It is unlikely that dredged sediments from Homebush Bay used for reclamation of Wentworth Point prior to 1954 were contaminated by the activities at Rhodes (including dioxins, chlorinated organic substances and metals), as there was at most three years of production of dioxins prior to the completion of dredging.

Construction of the large warehouse building on the site by Ralph Symonds Plywood was completed in 1959 (TBIA, 2013). Final preparation of the site and pouring of the concrete slab was undertaken in 1958 however there is no evidence to suggest further land reclamation at this time (TBIA, 2013). The building was constructed of timber arches with steel supports over the concrete floor (TBIA, 2013). Ralph Symonds operated a plywood manufacturing operation on the whole of the site from its opening in 1959 until downsizing in the 1970s. The building structure was subdivided at this time for sub-tenants, and was reinforced with steel in 1972 (TBIA, 2013).

Fill material used to reclaim the Site may be potentially impacted with metals and hydrocarbons (TRH, BTEX, PAHs). Fill material was sourced from dredging of sediments from Homebush Bay prior to 1954 (typically highly organic silty clays with shell fragments), with other unidentified sources of fill materials, including clays. It is noted that no evidence of domestic or industrial wastes was noted in the borehole logs.

The distribution of PAH concentrations on Block 'A', 'D' and 'G' appear dominantly in the fill materials suggesting that it is a characteristic of the dredged fill. Dioxins are a known contaminant of concern at the Union Carbide site on the Rhodes Peninsula which is across Homebush Bay from the Wentworth Point Marinas site.

ERM considers that dioxins are unlikely to be a contaminant of potential concern at the site, given the timing of historical events in the area. It is unlikely that dredged sediments from Homebush Bay used for reclamation of Wentworth Point prior to 1954 were contaminated by the activities at Rhodes (including dioxins, chlorinated organic substances and metals), as there was at most three years of production of dioxins prior to the completion of dredging.

2.3.3 *Manufacturing Operations - Timber Treatment, Plywood, Glue and Paper*

Industrial operations known to have been conducted at the Site include the plywood and glue manufacturing as well as paper and timber treatment. Limited information is available on the historical operations, however, based on the available information from WWC (1994) and from the Dangerous Goods Search it is known that:

- various chemicals were stored in bulk quantities at the Site as discussed in *Section 2.3.4*;

- the original Ralph Symonds building extended from the foreshore to Hill Road and was used for plywood manufacture from 1958 until downsizing in the 1970s, when operations were consolidated to Units 4 and 5;

- timber treatment was initially undertaken in the areas along the foreshore, and subsequently moved to the area to the south of Unit 21 (within Block 'B') and later to Unit 15 and 16; and

- the building known as Unit 21 (demolished circa 2005) was formerly used for glue manufacture and later for paper treatment and storage.

2.3.4 *USTs and Chemical Storage*

Based on the information provided by WWC (1993), several Underground Storage Tanks (USTs) and Aboveground Storage Tanks (ASTs) were removed from the WPM site, and the surrounding areas validated including:

- phenol impact resulting from two phenol ASTs located to the west of Unit 21 which were subsequently removed (Block 'B'). It is noted that the removal of these tanks was not documented;

- two 15, 000 L petroleum USTs located between Unit 3 and the main car park (Block 'A' and 'D');

- petroleum and methylated spirits USTs in a tank compound to the south of the open water storage tank (Block 'B').

Based on the available information there are two historical USTs which have not been abandoned or removed from the Site:

- a petroleum UST (unknown volume) in an unconfirmed location in the eastern portion of Unit 4 (Block 'H') (see *Figure 2* for approximate location); and

- a petroleum UST (unknown volume) in an unconfirmed location in the northern portion of Unit 7 (Block 'H') (see *Figure 2* for approximate location).

WWC (1993) provided limited details on the tank compound between the open water storage tank and Unit 20 (Block 'B'), and no further reference to these tanks was found in reports by ADI or ERM. Dangerous goods were also held in other areas of the WPM Site which included:

- Amcor trading within Unit 12 (within Block 'H') including various liquid chemicals (poisons, phenols, arsenic compounds, acids) between 1993 and 1997;

- applied Explosives Technology within Unit 22 (within Block 'B') including storage of ammonium nitrate, fireworks, igniters, detonators and explosives for use on a film set from 2011 (no end date declared); and

- a detailed drawing was provided for "Proposed treatment Plant – Sydney – Ralph Symonds Ltd – Homebush Bay" dated June 1980 prepared by Koppers which shows the location of tanks including "immunise" and "LOSP" work and mix tanks, pyrolith work and mix tanks, treatment cylinders, drum unloading facility, bulk store (white spirits), storage shed, drying area, chemical storage and rail tracks. The exact location of this work area could not be correlated to the current site layout, however the CCA treatment vessel appears on Dangerous Goods Plan dated 1994 in the area to the south-east of the water tank in Block 'B'.

In addition to the tanks, an inventory of chemicals and wastes for part of the WPM site was documented by WWC (1993) and included the following:

- Sodium hydroxide solution (50%);
- Phenol;
- Methylated spirits;
- Methanol;
- Hexamine;
- Formaldehyde;
- Contact Adhesive;
- Phenol/Formaldehyde resins;
- Paints and paint solvents;
- CCA treatment concentrations and solutions;
- Fire retardant (diammonium phosphate);
- Heating oil;
- Lubricating/ hydraulic oils; and
- Greases.

Drums may have been stored in the areas around the paper treatment factory (Block 'B'), glue factory (within Block 'C') and CCA treatment areas (Block 'B', 'C', 'E' and 'H').

2.3.5 Asbestos

As seen in the 1986 and 2000 aerial photos, the asbestos roof on the original Ralph Symonds warehouse was removed and replaced with corrugated iron sheeting. The site owner indicated that these works were undertaken between 1988 and 1990 (ERM, 2002). There were no clearance monitoring certificates for the asbestos removal works (ERM, 2002). The long, rectangular building located in the south-east corner of the original Ralph Symonds warehouse (as seen in the 1961 to 1978 aerial photos) was demolished between 1978 and 1986 and Units 15 and 16 (Block C) were constructed in this area.

The site was filled with dredged sediments from the river from as early as the 1890's until the late 1950s, with the original Ralph Symonds building (and its foundation concrete slab) occupying the entire northern portion of the WPM Site. Therefore there is unlikely to be a potential pathway for asbestos fibres or fragments to migrate to soils within the footprint of the original Ralph Symonds building. There is potential for asbestos containing materials (ACM) building debris to have been buried and/or for fibres to have migrated to surface soils in the southern portion of the Site which was not concreted until the late 1970s-early 1980s. The roof of the original Ralph Symonds building is known to have been constructed of ACM and was replaced following a storm in the late 1980s early 1990s. Therefore, analysis for asbestos fibres in soil will be included in the proposed additional ESA and targeted to current and formerly unsealed areas of the Site.

2.3.6 *Pesticides*

It is likely that pesticides were sprayed around the foundations of the warehouse building across the Site, and these may have included OCP and OPPs. Analysis for pesticides will be targeted to the shallow soils (<1 m below ground level) which are most likely to have been impacted from surface spraying and/or from imported fill used for reclamation of the Site. Some pesticides are also considered to be a marker for dioxins, and detections of pesticides above the laboratory limit of detection will be further considered.

2.3.7 *Contaminants of Potential Concern*

The contaminants of potential concern (COPC) associated with the historical and/or current activities within the Areas of Potential Concern discussed in *Section 2.3.1 to 2.3.6* is provided below in *Table 2.1*.

Table 2.1 Summary of Contaminants of Potential Concern

APEC	COPC
Imported fill material	Metals & PAHs[1]
CCA Treatment Areas	Metals, VOCs (BTEX & Chlorinated Hydrocarbons), SVOCs
Bulk Chemical Storage (including former tanks), glue & plywood manufacturing	TRH, VOCs (BTEX & Chlorinated Hydrocarbons), SVOCs including phenols and PAHs
Operational unsealed ground	Asbestos, metals, VOCs (TRH, BTEX & Chlorinated Hydrocarbons)
Warehousing & storage	Explosives (limited to the storage areas within Block 'B' and currently used in Unit 14)

Notes: 1. Considered to be a COPC at all locations across the Site.

In summary, the following are considered to be COPCs for the Site:

- Metals and metalloids (arsenic, cadmium, chromium (hexavalent), copper, nickel, lead, mercury, and zinc);
- Total Recoverable Hydrocarbons (TRH);
- Polycyclic Aromatic Hydrocarbons (PAHs);
- Phenols;
- Volatile Organic Compounds (VOCs) (benzene, toluene, ethylbenzene and xylenes –BTEX, and);
- VOCs including Chlorinated Hydrocarbons;
- Semi-volatile Organic Compounds (SVOCs) including Chlorinated Hydrocarbons, Organochlorine Pesticides and Organophosphorus Pesticides;
- Explosives; and
- Asbestos.

2.4 *GEOLOGY*

2.4.1 *Regional Geology*

The 1:100 000 geology map of the Sydney area (Herbert, 1983) indicates that the site is underlain by man-made fill generally consisting of dredged estuarine sand and mud. Holocene sediments composed of silty to peaty quartz sand, silt and clay underlie the man-made fill. Shell layers are common and there is ferruginous and humic cementation in places.

The peninsula known as Wentworth Point was originally mangrove swampland and was progressively reclaimed from the 1880's to 1954 (Clarke and Benson, 1988). Reclamation activities were recorded as early as 1827, and the seawall was constructed in 1891 (PB, 2002). The reclamation of land involved the dredging of sediments from Homebush Bay and the Parramatta River.

2.4.2 *Site Geology*

A generalised description of the lithology encountered at the Site is presented in *Table 2.2*. Detailed descriptions of the Site geology as observed during the investigation are presented on the borehole logs in *Annex E*.

Table 2.2 Generalised Field Lithology Descriptions

Lithological Unit	Description	Depth[1] (m bgl)
Hardstanding	Concrete generally in good condition	0 - 0.25 m
Fill – Clay	Reworked sandy clay orange to brown, moist highly-plastic, no odours or staining. Contains gravels and cobbles (varying amounts).	0.25 - 0.9 m
Fill - Dredged Sediment - Sandy silt/ sandy clay	Black, soft, moist becoming wet, contains up to 50% shell fragments, no odours or staining.	0.9 – 2.0 m
Natural Material – Silty clay	Dark grey, moist – wet, soft, moderately plastic, contains 1-5% shell fragments, no staining, organic/decay odour.	2.0 – 5.7 m

1. Given the variation in topography across the Site, depths and lithologies may vary.

The encountered lithology during the current investigation was consistent with previous investigations, and is indicative of two phases of filling. As discussed in *Section 2.3.2*, the Site was reclaimed using dredged sediments between the late 1800s and 1954 when the Ralph Symonds Plywood facility was constructed, typically described as highly organic silty clays with shell fragments.

The majority of the site was capped with concrete, with a layer of orange clay fill beneath the concrete. The fill materials were typically confined to the upper 1.0 m of the subsurface. Following the reclamation of the Site with the dredged sediment, clays were placed at the surface for stabilisation of ground level prior to placement of the concrete slab foundation for the Ralph Symonds buildings across Block 'D', 'G, 'E' and 'H'. Coarser fill material comprising bricks and cobbles was encountered within Block 'B' at depths up to 0.9 m bgl.

Dark grey to black highly organic silty clays and sandy silt with shell fragments were encountered at depths from 0.9 m bgl which appears to be the dredged sediment from Homebush Bay. The dredged sediment contained up to 50% shell fragments and was saturated from approximately 1.2m. The distribution of PAH concentrations across the WPM Site dominantly in the silty clay dredged fill materials suggesting that it is a characteristic of the dredged sediments sourced from Homebush Bay.

The natural formation was encountered across the entire site at varying depths and was comprised of black soft, clayey silt and silty clay which was remnant of the mangroves present in this area prior to industrialisation. Natural sediments were inferred to be present at depths from 1.2 m bgl. However it is noted that the encountered natural wetland sediments are similar in composition to the dredged sediments sourced from Homebush Bay and the interface was difficult to differentiate.

The maximum depth drilled in this investigation was 5.7m with no significant change in lithology between 2.3m and 5.7m. Borelogs from geotechnical investigations by JK Geotechnics (*Annex E*) indicate that sandstone bedrock was encountered at a depth of 19 m bgl.

2.5 *POTENTIAL ACID SULPHATE SOILS*

Soils in the upper 1 metre of the subsurface at the WPM Site have a moderate to high potential for acid sulphate soils (ERM, 2003). This does not include the upper fill material which has been found to consist of a firm, brown clay and is present across much of the Site. The previous investigations have included 4 sampling points within the WPM Site. Based on the findings of the investigations to date, site works to be undertaken as part of any redevelopment will need to consider the potential for generation of acid generating soils.

2.6 *POTENTIAL FOR HAZARDOUS GROUND GASES*

As a preliminary gas investigation, six ground gas wells were installed within Block 'G' in June 2014, with two rounds of monitoring, as reported in ERM (2014) *Wentworth Point Marinas Block 'G' - Consolidated Stage 2 Environmental Site Assessment, 28 July 2014, Reference: 0250707_RP01_Final.* The assessment followed the NSW EPA (2012) *Guidelines for the Assessment and Management of Sites Impacted by Hazardous Ground Gases.*

Potential sources of hazardous ground gas at the WPM Site include natural silty and sandy clay soils at depths of greater than 1.3 m bgl with a high level of organic matter and the potential for acid sulphate soils. Potential off-site sources of hazardous ground gas include the Woo-la-ra landfill located approximately 250 m to the south-west on Hill Road. It is understood that this landfill contains gasworks wastes. Based on publically available information, there are no known hazardous ground gases associated with the land adjacent to the Woo-la-ra landfill.

The characteristic gas situation for Block 'G' was determined to be "CS-1" which represents a very low risk. Typical sources of "CS-1" include natural soils with low organic content and typical fill, and this is consistent with the conceptual site model. The findings of the assessment for Block 'G' can be inferred for the WPM Site as the encountered lithology across the WPM Site is relatively consistent. Therefore no further action is considered warranted.

2.7 *HYDROGEOLOGY AND HYDROLOGY*

Groundwater was encountered at the WPM Site at depths between 0.4 m bgl (MW317) and 1.3 m bgl (MW309 and MW318) in October 2014. The depth to groundwater was consistent with data from 2005. Site observations indicate that groundwater generally occurs both in the dredged fill material (encountered between 0.9 and 2m bgl) and in the underlying natural sediments.

Groundwater gauging results indicate that in general, the groundwater flow direction is towards the east in the direction of Homebush Bay (ERM, 2005b). As Homebush Bay is a tidally influenced estuarine environment groundwater levels in close proximity to the bay may be tidally influenced. It is further noted that localised variations in groundwater flow direction may occur in the vicinity of the water tank in Block B of the site as well as along the stormwater drains located on the southern boundary of the site (where localised groundwater recharge may be occurring).

Groundwater beneath the site is moderately to highly saline, with conductivity measurements recorded ranging from 2,699 mS/cm (MW14) to 64,360 mS/cm (MW306) in October 2014. Higher salinity conditions were noted in the vicinity of Block B where localised groundwater recharge may be occurring.

A reducing environment was observed across the site with negative oxidation reduction potentials (ORP) values noted at all wells sampled across the site in October 2014. This is consistent with groundwater within a mangrove environment and marine muds. pH across the site was generally noted to be circum-neutral.

Homebush Bay and the Parramatta River are the closest surface water bodies to the site, with Homebush bay located to the east and directly adjacent to the site and the Parramatta River between 120m and 400m to the north of the site. The local topography is relatively flat, with surface water captured in storm water drains which discharge to Homebush Bay.

2.8 *TOPOGRAPHY*

The Site is relatively flat, with the exception of some areas which have been graded for drainage purposes. The site levels vary from RL 1.5 to RL 2.2 m AHD. The Lower Parramatta River Floodplain Risk Management Study (SKM, 2005) estimates that the 100 year ARI level in Parramatta River is RL 1.42m AHD. The flood level in Homebush Bay was estimated to be RL 0.99m AHD.

2.9 *SURROUNDING ENVIRONMENT*

The area surrounding the WPM site is characterised by progressive redevelopment of existing commercial and industrial sites for high density residential use, including shops and restaurants. The construction of the WPM site is on-going, with construction of multi-storey residential and commercial developments within Block 'A' and 'D' completed, and Block 'G' currently in progress. Construction of a bridge across Homebush Bay is due to commence in December 2014 which will connect to Footbridge Boulevard.

The landuses in the surrounding area include:

- North: commercial/industrial factory units, ferry wharf, parklands and the Parramatta River;
- East: Parramatta River and Homebush Bay;
- South: construction site which includes redevelopment of commercial/industrial site for residential apartments; and
- West: Hill Road, further west commercial/industrial factory units, parklands and the Parramatta River.

3 DATA QUALITY OBJECTIVES

Data Quality Objectives (DQOs) have been developed to define the type and quality of data required to achieve the project objectives outlined in *Section 1.2.* The DQOs were selected with reference to relevant guidelines published by the NSW Environmental Protection Authority (EPA), Australian and New Zealand Environment and Conservation Council (ANZECC) and National Environment Protection Council (NEPC), which define minimum data requirements and quality control procedures.

The DQOs have been prepared in line with the DQO process outlined in NSW Department of Environment and Conservation (DEC) (2006) *Guidelines for the NSW Site Auditor Scheme 2nd Edition*. The seven-step DQO approach identified in NSW DEC (2006) is described in the following sections.

3.1 STEP 1: STATE THE PROBLEM

Objectives

The project objectives are as stated previously in *Section 1.3*. The objective of these works is to provide additional soil and groundwater data to supplement the existing data set. The overall project objective is to provide a conclusion on whether the Site is suitable for the intended land-use as residential with minimal access to soils.

3.2 STEP 2: IDENTIFY THE DECISIONS

3.2.1 Decision Statements

The principal decision to be made is whether the Site is suitable for the intended land-use as residential with minimal access to soils.

The decisions to be made as part of this ESA (which may lead to further investigation, remediation and/or management) include:

- Is there soil impact beneath the Site which may represent a risk to human health and/or the environment, based on the proposed use of the Site?
- Are there concentrations of hexavalent chromium in former timber treatment areas where soil with elevated total chromium concentrations has been identified?
- Does the data support the hypothesis that identified PAH concentrations in soil are characteristic of the fill material imported from other sites; and that PAH concentrations in soil are unlikely to represent a risk to human health based on the proposed use of the Site?

- Does the data support the hypothesis that identified metals concentrations in groundwater may be representative of background groundwater quality?

- Is there groundwater impact beneath the Site which may represent a risk to human health and/or the environment (in relation to neighbouring sensitive receptors)?

- Is remediation or management likely to be required?

  Additional decisions to be made subsequent to this ESA, following finalisation of the development design include:

- Is there sufficient data to characterise the soil and groundwater conditions at the Site in order to make the principal decision?

- Based on the proposed development and intended land-use, is remediation or management required to make the Site suitable?

3.2.2 *Screening Values*

The proposed sources of adopted screening values are presented in *Section 3.5.2*.

3.2.3 *Waste Classification for Off-Site Disposal*

Any excess soil or groundwater generated during the fieldworks will be classified in accordance with the NSW Department of Environment, Climate Change and Water (2009) *Waste Classification Guidelines, Part 1: Classifying Waste* and relevant associated Chemical Control Orders.

3.3 *STEP 3: IDENTIFY INPUTS TO DECISION*

The inputs required to make the above decisions are as follows:

- Existing relevant environmental data, taking into consideration the number and location of existing sampling locations, the construction and condition of existing groundwater monitoring wells and the date of the most recent surface and groundwater monitoring event;

- direct measurement of environmental variables including soil type, soil gas concentrations, odours, staining, water strike, groundwater level and water quality parameters;

- laboratory measurement of soil and water samples for one or more of the identified contaminants of potential concern;

- field and laboratory quality assurance/quality control data;
- the relevant soil and water quality criteria outlined in *Section 3.5.2*; and
- assessment of whether the concentrations of the contaminants of concern are greater than or equal to or less than the adopted criteria.

3.4 STEP 4: DEFINE THE STUDY BOUNDARIES

The spatial boundaries of the study are as per the description of the Site provided previously in *Section 2* and figures presented in *Annex A*. Temporally, the environmental investigations conducted to date as well as the proposed scope of work herein are intended to provide an assessment of the suitability of the Site for the proposed development and land-use change.

3.4.1 Constraints within the Study Boundaries

Constraints on the delivery of the program within the study boundaries may include:

- location of underground or overhead services or infrastructure;
- constraints associated with other safety issues or causing unacceptable disruption to site operations; and
- the condition of existing monitoring wells.

3.5 STEP 5: DEVELOP A DECISION RULE

The DQOs have been designed to facilitate the collection of adequate soil and groundwater data to address the decisions in Step 2 of the DQO process.

3.5.1 Field and Laboratory QA/QC

The suitability of soil and groundwater data will be assessed based on acceptable limits for field and laboratory QA/QC samples outlined in relevant guidelines made or endorsed under the *Contaminated Land Management Act (1997)* which includes the National Environmental Protection Council (NEPC) (2013) *National Environment Protection (Assessment of Site Contamination)*.

In the event that acceptable limits are not met by laboratory analyses, the field observations relating to the nature of the samples will be reviewed and if no obvious source for the non-conformance is identified, such as an error in sampling, preservation of sample/s or heterogeneity of sample/s, liaison with the laboratories will be undertaken in an effort to identify the issue that had given rise to the non-conformance.

If the soil and groundwater data is deemed to be unsuitable, additional analyses may be undertaken on the original sample/s, on duplicate samples or on other samples, if required to meet the objectives of the assessment. If no explanation for the non-conformance is identified, the concentrations for the affected samples will be considered as an estimate.

3.5.2 *Adopted Screening Value*

Individual soil and groundwater data, along with the maximum, minimum, mean, standard deviation and 95% Upper Confidence Limit (UCL) of the mean concentration (if required) will be compared to the adopted screening value. Exceedence of the adopted screening value will not necessarily indicate the requirement for remediation or a risk to human health and / or the environment. If individual or 95% UCL concentrations exceed the adopted screening value, consideration of the extent of the impact, the potential for receptors to be exposed and regulatory compliance will be considered.

The adopted screening value have generally been sourced from guidelines made or approved under the *Contaminated Land Management (CLM) Act* (*1997*) which includes the National Environmental Protection Council (NEPC) (2013) *National Environment Protection (Assessment of Site Contamination* and where alternative sources have been utilised appropriate justification has been provided.

Soil

Soil data will be assessed against investigation criteria published in the following documents:

- National Environmental Protection Council (NEPC) (2013) *National Environment Protection (Assessment of Site Contamination) 1999* Schedule B1 Guideline on the Investigation Levels for Soil and Groundwater (NEPM).
    - Health Investigation Level (HIL) 'B' – Residential with minimal access to soils; and
    - Health Screening Levels (HSLs) for Vapour Intrusion and Direct Soil Contact (HSL) 'B' – Residential with minimal access to soils.
- Where no Australian endorsed screening values are available and concentrations are reported above the laboratory LOR, reference will be made to the US Environmental Protection Agency Regional Screening Levels. It is noted that these guideline values have no regulatory standing in NSW.

Groundwater

Groundwater data will be assessed against investigation criteria published in the National Environmental Protection Council (NEPC) (2013) *National Environment Protection (Assessment of Site Contamination) 1999* Schedule B1 Guideline on the Investigation Levels for Soil and Groundwater (NEPM) which references the following guidance:

- Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Trigger values for marine water, level of protection 95% species;

- National Health and Medical Research Council (NHMRC) and National Resource Management Ministerial Council (NRMMC) (2013) *Australian Drinking Water Guidelines Paper 6 National Water Quality Management Strategy*, Commonwealth of Australia, Canberra; and

- NHMRC(2008) *Guidelines for Managing Risks in Recreational Waters,* Commonwealth of Australia, Canberra (note that these will be applied with reference to NHMRC and NRMMC 2011 – referenced above).

The Health Screening Levels (HSLs) for hydrocarbons in groundwater presented in the NEPM (2013) and the Cooperative Research Centre for Contamination Assessment and Remediation of the Environment (CRC CARE) (2011) *Technical Report No. 10, Health Screening Levels for Petroleum Hydrocarbons in Soil and Groundwater* have not been applied to groundwater results at the Wentworth Point Marinas site as the groundwater standing water level has historically been measured at less than 2 m bgl. The NEPM (2013) recommends assessment of groundwater quality against background conditions which have been considered in this assessment.

It should be noted that the ANZECC (2000) trigger values are designed predominantly for the assessment of surface waters. The values are intended to be adopted for groundwater as a starting point to trigger further investigation. In the context of this investigation, the area has a long industrial history with many potential sources. Exceedance of an ANZECC (2000) trigger value does not therefore necessarily indicate that a risk to water quality is present.

Trigger values are preferably derived from multiple-species toxicity tests to provide high and moderate reliability trigger values. However, where insufficient data is available from the study of marine or freshwater species, a low reliability value is derived and is based on the limited amount of available data and the confidence level to which they are applied.

Due to insufficient data, the use of a low reliability value is required for the assessment of arsenic groundwater concentrations.

Where no Australian endorsed screening value is available and concentrations are reported above the laboratory LOR, reference will be made to the US Environmental Protection Agency Regional Screening Levels. It is noted that these guideline values have no regulatory standing in NSW.

3.5.3 Appropriateness of LOR

Comparison of the laboratory Limit of Reporting (LOR) to the screening values has been undertaken confirming that the screening values are less than the laboratory LOR with the exception of the following compounds:

- 1,1 – dichloroethene and vinyl chloride in soil – LOR of 5 mg/kg compared to direct contact criteria of 0.1 mg/kg. It is noted that vinyl chloride is not generally found in isolation but rather associated with other breakdown products of trichloroethene (TCE) such as cis-1,2-dichloroethene. These other breakdown products have LORs below the criteria and are considered suitable for identifying the potential presence of vinyl chloride and determining any further action; and

- some volatile organic compounds in water (including chloromethane, bromomethane, carbon tetrachloride, 1,2-Dichloroethane, hexachlorobutadiene, 1,2,3-trichlorobenzene) and pentachlorophenol have LORs marginally above the adopted ecological protection criteria and/or above the drinking water guidelines. It is noted that these contaminants are not regarded as key contaminants of concern and no drinking water receptors have been identified within the vicinity of the Site. In the event that a detection of these compounds is noted, further investigation and/or explanation may be required.

3.6 STEP 6: SPECIFY LIMITS ON DECISION ERRORS

The acceptable limits on decision errors applied during the review of the results will be based on the Data Quality Indicators (DQIs) of precision, accuracy, representativeness, comparability and completeness (PARCC) in accordance with the NEPC (2013) *National Environment Protection (Assessment of Site Contamination) Measure 1999, Schedule B (3) - Guidelines on Laboratory Analysis.*

The potential for significant decision errors will be minimised by:

- completing a robust Quality Assurance/Quality Control (QA/QC) assessment of the assessment data and application of the probability that 95% of data will satisfy the DQIs, therefore a limit on the decision error would be 5% that a conclusive statement may be incorrect;
- assessing whether appropriate sampling and analytical density has been achieved to meet the project objectives; and
- ensuring that the criteria set was appropriate for the proposed use.

3.7 STEP 7: DEVELOP (OPTIMISE) THE PLAN FOR COMPLETING THE WORKS

The DQOs have been developed based on a review of existing data. If data gathered during the assessment indicates that the objectives of the assessment programme are not being met, the sampling design (including sampling pattern, type of samples and analytes) will be adjusted accordingly using feedback (where necessary) from project stakeholders. In the event that the findings of the additional ESA identify issues which require delineation or further investigation these will be delineated to the extent practicable, the scope of which is subject to approval from Fairmead.

4 SAMPLING METHODOLOGY

4.1 RATIONALE

The location of new and existing soil bores and monitoring wells are shown in *Figures 2, Annex A*, including the location of monitoring wells which have been damaged or lost. The sampling design for these additional works allows for consideration of the broader site context and the distribution of sampling locations reflects the objectives and findings of the previous works.

4.1.1 Soil

The Wentworth Point Marinas site was reclaimed using fill materials largely dredged from Homebush Bay and the Parramatta River prior to 1954 (refer to *Section 2.4*). The nature of the shallow soils at the Wentworth Point Marinas site is therefore relatively consistent and homogenous, and this was observed during drilling works as noted on borelogs. The sampling design adopted for the previous investigations was largely based on a judgemental sampling pattern, with distribution of sampling points across the broader site with targeted sampling of known potential point sources such as USTs and treatment areas. This approach remains valid as the fill materials are relatively homogenous.

A number of specific gaps in the previous site investigations were identified in ERM (2013), which were targeted in the SAQP (ERM, 2014) and were addressed by the investigations reported herein.

Data Gap #1 – Distribution of Sampling Locations

The NSW EPA (1995) Sampling Design Guideline does not provide recommendations for sites with an area greater than 5 hectares. There are 263 discrete sampling locations across the Site (including data from the current and previous investigations), which is generally considered to be acceptable for the total Site area (7.8 ha). The total number of sampling locations for each block is considered to be acceptable to meet the NSW EPA (1995) guidelines, and provides sufficient coverage of potential sources. The area for each remaining block and the corresponding minimum number of sampling locations recommended by NSW EPA (1995) is provided in *Table 4.1* below.

Table 4.1 Summary of Sampling Density Requirements

Development Block	Block B	Block C	Block E	Block H
Area (hectares)	1.0 ha	2.1 ha	2.16 ha	2.55 ha
Recommended minimum no. locations	21	31	32	36
No. existing sampling locations	70*	45	35	50
No. new sampling locations	10	10	8	17
Total sampling locations	80*	55	43	67

Notes: * Not including 18 tank validation samples

Data Gap #2 – Analytical Suite

The analytical suite from previous investigations was variable, and was considered to be insufficient to target the known potential sources. For example in investigations completed in 1997 (ADI, 1997) most locations were analysed for metals only. The sampling rationale for this investigation aimed to address this identified data gap through analysis of soil samples for key analytes targeted to the known potential sources, as identified in *Table 2.1* of *Section 2.3.7*.

This data gap has been addressed in the 2014 investigation with additional analysis targeted to key areas. A summary of the number of analyses for each contaminant of concern is presented in *Table 1 of Annex B* and summarised below in *Table 4.2*.

Table 4.2 ***Summary of Analytical Density –Soil***

Analyte	Block B	Block C	Block E	Block H	Total
Arsenic	109	97	69	93	368
Cadmium	66	75	56	71	268
Chromium (hexavalent)	26	4	24	4	58
Chromium (total)	109	96	69	93	367
Copper	105	88	68	90	351
Lead	93	86	68	86	333
Mercury	45	75	35	71	226
Nickel	66	75	56	71	268
Zinc	84	92	69	94	339
PAH	79	37	47	46	209
Phenols	47	25	19	42	133
OPP	38	21	37	26	122
TRH	99	32	44	55	230
BTEX	101	33	45	58	237
PCB	24	9	28	9	70
VOCs	14	13	10	17	54
SVOCs	14	13	9	17	53
Asbestos	3	5	9	16	33
Explosives	3	0	0	1	4
Phenoxy acid herbicides	2	1	2	5	10

Source: *Table 1 of Annex B* of this report.

4.1.2 *Groundwater*

Previous investigations have reported concentrations of arsenic, chromium, copper, lead and zinc concentrations in groundwater which exceed the adopted screening value in several locations in multiple monitoring rounds. The elevated concentrations of metals in groundwater in previous investigations are unlikely to be attributed to leaching of metals from soil, and are more likely to be representative of background groundwater quality.

However, groundwater at the Site does not comply with the ASC NEPM (2013) adopted screening value and further groundwater investigation is required to establish if the Site is suitable for on-going use, or if remediation is required.

The existing monitoring well locations were inspected by ERM in March 2014 and it was noted that most wells had been damaged or destroyed during construction activities around the WPM Site. The following 4 monitoring wells were identified as viable for groundwater sampling; MW2, MW4, MW4S, MW14. A further 3 monitoring wells (MW301, MW302 and MW303) were installed in Block G in June 2014. The previous sampling rounds (up to 2005) included 23 monitoring wells, and ERM considered that in order to produce an acceptable outcome, a comparable number are required.

Groundwater sampling was undertaken in this investigation at 4 existing viable groundwater monitoring wells, and 18 new monitoring wells. During the site investigation works in September 2014 it was observed that monitoring wells MW4, MW301 and MW302 had been destroyed or were inaccessible due to construction.

4.2 *SITE INSPECTION*

The work areas of the Site were inspected and the soil and groundwater sampling locations were marked out to target identified Site features and potential contamination sources. At the same time as clarifying the investigation locations, sub-surface utilities were marked out using an appropriately qualified service locator. Ground penetrating radar (GPR) and cable avoidance tool (CAT), along with DBYD plans were utilised to identify underground services and utilities.

The following additional observations were noted during the site inspection which are relevant to the Site CSM:

- monitoring wells MW4, MW301 and MW302 had been destroyed or were inaccessible due to construction;
- wash-down facilities including a wash bay and an oil-water separator in the truck maintenance facility in Unit 5A;
- steel fabrication in Unit 18;
- Unit 14 (in Block 'H') was occupied by Applied Explosives Technology formerly located in Unit 22 (within Block 'B'). Applied Explosives Technology store and manufacture explosives for film use. Information on the Workcover Dangerous Goods search includes storage of ammonium nitrate, fireworks, igniters and detonators. Due to security restrictions a more detailed list of chemicals and processes was not able to be obtained; and

- irregularities were detected with the GPR in the vicinity of rectangular concrete scars on the floors in Unit 5 and Unit 4 which indicate that underground tanks may have been removed in these areas.

4.3 SOIL INVESTIGATION

4.3.1 Soil Sampling Procedure

Soil investigation and sampling works were undertaken in general accordance with ERM's standard operating procedures (SOPs). The location and number of sampling locations are presented within *Figure 3a to 3d of Annex A* and listed in *Table 1 of Annex B*. Where practicable, all boreholes were advanced to an initial depth of 1.5 m bgl using hand augering or vacuum excavation techniques in accordance with ERM's sub-surface clearance procedures. Drilling and soil sampling of subsurface material beyond 1.5 m bgl, were undertaken using a Geoprobe® drilling rig with solid stem augers. The ground conditions did not allow for the use of a continuous push tube sampler, as soils could not be recovered by this method due to the ground saturation and the fine particle size at depths greater than 1.5 m.

Regardless of the drilling methodology adopted, soil sampling techniques which minimised the potential for loss of volatiles were utilised. Where the collection of undisturbed samples was not possible (eg during hand augering) the potential for loss of volatiles was minimised by sampling from larger clods and minimising the duration between sample excavation and placement into the sample container.

Field screening was conducted in accordance with ERM's SOPs using a photo-ionisation detector (PID) fitted with a 10.6 eV lamp, calibrated at the beginning of each working day. Calibration certificates are presented in *Annex D*. Where practicable, soil was collected at 0.5 m depth intervals (or where significant changes in lithology were identified) to 2 m bgl and at 1 m depth intervals thereafter. Soil samples were placed in a zip lock bag, sealed and screened for the presence of ionisable volatile compounds. Where the presence of volatiles or other impact was suspected, additional samples were collected.

Soil properties were logged by an appropriately trained and experienced field scientist in general accordance with Australian Standard AS 1726-1993, Geotechnical Site Investigations (Australian Standards Committee, 1993). Representative soil samples were collected for laboratory analysis at selected locations, based on visual and/or olfactory evidence of the following:

- multiple layers of fill material;
- changes in the soil profile; and
- potential impact.

Soil samples were collected, to the extent practicable, in accordance with techniques described in Australian Standard AS4482-2005 (Parts 1 and 2) to maintain the representativeness and integrity of the samples. Soil samples for laboratory analysis were collected from either the hand auger or directly from the push tube core. No samples were collected for laboratory analysis from solid flight augers, unless otherwise stated within borehole logs presented in *Annex E*. The frequency and nature of field QA/QC samples collected during the assessment works are summarised in *Annex F*.

Soil samples were generally labelled using the nomenclature presented *in Table 4.3* (below).

Table 4.3 Sample Naming Protocol

Sample	Identification
Sample taken from shallow hand auger soil bore or deeper soil bore, SB01 at depth of 0.5 m bgl	SB01_0.5
Sample taken from depth of 5 m bgl from a soil bore to be installed as Monitoring Well MW07	MW07_5.0
Groundwater samples taken from MW07	MW07

Sample jars were sealed and immediately placed in an insulated cooler, on ice, and stored to minimise potential loss or degradation of volatile compounds. Samples were shipped under chain of custody documentation to the analytical laboratory. Trip blanks and field blanks were used to assess if cross contamination occurred during the sample collection process.

Soil samples were collected for asbestos analysis in general accordance with the requirements of the *ASC NEPM (2013)* incorporating the WA DOH guidelines *(WA DOH, 2009)* and the *ERM Assessment of Asbestos Impacted Areas SOP (2012)*. No potential asbestos containing material (ACM) was identified at the surface or during the investigation works, and there were no ACM fragments submitted for analysis.

Discrete 500 ml samples of soil were collected in snap lock bags during NDD for laboratory analysis for asbestos fibres.

4.3.2 Decontamination Procedure

Down-hole drilling and sampling equipment were decontaminated by initially removing any residual soil with a stiff brush and then washing the equipment in a 2% Decon 90 solution and rinsing with potable water.

4.3.3 *Soil Bore Reinstatement*

Upon completion, soil bores were backfilled and the surface covering reinstated to match existing.

4.4 *GROUNDWATER INVESTIGATION*

4.4.1 *Groundwater Well Installation*

Selected boreholes were converted to groundwater monitoring wells in accordance with ERMs SOPs. The following methodology was implemented to install the new monitoring wells:

- wells were constructed of heavy duty 50 mm diameter class 18 uPVC with factory slotted screen (0.4 mm slots) and plain well casing. Where practicable, the wells were screened within groundwater bearing strata in accordance with ERMs SOPs with consideration of potential regional and seasonal fluctuations of the water table and constructed to allow the potential ingress of non-aqueous phase liquids (NAPLs);

- following drilling, the well casing and screen were inserted into the drill casing. Washed and graded filter sand was poured into the annulus between the well screen and casing wall, ensuring that the sand covered the entire screened level and generally extended approximately 0.5 m above the top of the well screen;

- bentonite granules were then poured on top of the sand to an approximate thickness of 1 m and hydrated to effectively seal off the well from surface water or perched/shallow groundwater inflows; and

- the remaining annulus from the top of the seal to the base of the concrete was grouted with cement/bentonite grout to within 0.25 m of the surface and the final 0.25 m reinstated with concrete and a heavy duty well cover (flush gatic cover or raised monument as appropriate). The well casings were sealed with air-tight caps.

Following monitoring well installation, each well was developed using a submersible 12 V electric 'Typhoon' pump to remove any fine or granular materials or contaminants potentially introduced during drilling and to optimise hydraulic connectivity with the surrounding aquifer. Wells were considered developed when either a minimum of 10 well volumes had been removed, when water quality parameters had stabilised or if the well was developed dry prior to this. Where sufficient well volumes could not be obtained, attempts were made to remove fines and construction material by purging the well over several days to allow for recharge.

Monitoring well construction details are presented within the borehole logs in *Annex E*.

4.4.2 *Groundwater Purging and Sampling Protocol*

Both the new and existing monitoring wells were be purged and sampled as outlined below. The presence of odours was noted, where applicable, following removal of the well cap and prior to purging. Any odours were described by reference to their intensity and character.

Following a period of no pumping (as a minimum 24 hours), wells were dipped to gauge the depth to groundwater, and the potential presence and depths of NAPLs.

Monitoring wells were purged using either a thoroughly decontaminated peristaltic or micro purge pump under low flow conditions, where hydrogeological conditions allowed, until sufficient water had been removed to obtain stabilised readings of pH, conductivity, redox potential, temperature and dissolved oxygen which was calibrated prior to use. The stabilisation criteria are as described below.

Table 4.4 Water quality parameter stabilisation criteria

Parameter	Stabilisation criteria
pH	± 0.1 pH units
Electric Conductivity (EC)	± 3% (μS/cm or mS/cm)
Temperature	± 0.5ºC
Oxidation Reduction Potential (ORP)	± 10 mV
Dissolved Oxygen (DO)	± 0.3 mg/L

It is noted that both ORP and DO are typically slower to stabilise than the other parameters. Where ORP and DO did not stabilise, therefore, greater weight was given to pH and EC as the stabilising parameters.

Low-flow sampling techniques were used to obtain samples that were representative of the local groundwater environment at the Site. The inlet of the micro purge pump was placed approximately 50 cm from the base of the well in order to obtain a representative sample. Water samples were collected using equipment dedicated to each monitoring well to reduce the potential for cross-contamination between sampling locations.

The following order of sampling was adopted:

- samples to be analysed for volatile compounds placed into 40 mL amber vials;
- samples to be analysed for semi-volatile compounds placed into one 250 mL solvent washed amber bottles and two 1 litre solvent washed amber bottles; and
- samples to be analysed for metals filtered through disposable 0.45 μm filters and placed in 125 mL plastic bottles preserved with nitric acid.

No Non-Aqueous Phase Liquids (NAPLs) were observed during the groundwater monitoring and sampling event.

The containers were filled, where practical, to minimise headspace, before being sealed and appropriately labelled. Labels included the following information:

- sample identification number;
- sampler;
- job number; and
- date of collection.

Samples were sealed and immediately placed in a cooler on ice to minimise potential for degradation of the sample. All samples were shipped under chain of custody documentation to the analytical laboratories.

4.5 SURVEYING

All new groundwater monitoring wells were surveyed by a registered surveyor (Monteath Powys) to AHD for elevation and MGA coordinates for location. Survey data is presented in *Annex G*. The elevation of the highest point of the top of the uPVC well casing was surveyed to facilitate appropriate groundwater elevation calculations and groundwater flow direction interpretations.

4.6 LABORATORY ANALYSIS

The laboratories used for the investigations were accredited by the National Association of Testing Authorities (NATA), Australia. The primary laboratory used for soil and groundwater analysis was ALS Environmental Pty Ltd (ALS). Inter-laboratory duplicate samples were analysed by a secondary laboratory, Envirolab Services Pty Ltd (Envirolab). The analytical methods used by each laboratory are provided in the laboratory certificates in *Annex J*.

Soil and groundwater samples were analysed for one of more of the following COPCs:

- metals and metalloids (arsenic, cadmium, chromium, copper, nickel, lead, mercury, selenium and zinc);
- total recoverable hydrocarbons (TRH);
- polycyclic aromatic hydrocarbons (PAHs); and

- benzene, toluene, ethylbenzene and xylenes (BTEX).
- asbestos (presence / absence – soil only);
- semi-volatile organic compounds; and
- volatile organic compounds (VOCs in addition to BTEX).

4.7 *QUALITY ASSURANCE / QUALITY CONTROL*

A detailed QA/QC report including field procedures, laboratory methods and an analysis of QA/QC results from the investigation is provided in *Annex F*. QA/QC information incorporating inter-laboratory and intra-laboratory duplicates, rinsate samples and trip spike/blank samples is also presented in *Tables F6 to F13 of Annex F*.

In summary, the QA/QC data reported by ALS for soil and groundwater samples and field duplicate results were generally free of systematic and method biases and were assessed to be of sufficient quality for the purposes of this investigation.

There were some instances where the adopted screening values were less than the laboratory LOR. These potential non-conformances are discussed in *Section 3.6* of this report.

5 SOIL RESULTS

5.1 BLOCK B

5.1.1 *Methodology and Field Observations*

In total, including all previous and current investigations, there are 67 boreholes, 7 monitoring wells and 6 test-pit samples located in Block B. An additional 18 validation samples were collected following the removal of 5 USTs in a tank compound to the south of the fire water tank (ERM, 2003). A schedule of soil analysis (showing the number of samples analysed for each analyte) is presented in *Table 1 of Annex A* and relevant borehole logs are presented within *Annex E.* A total of 10 new soil investigation bores, 6 of which were completed as groundwater monitoring wells, were installed within Block B in the current investigation. All the locations are presented in *Figure 3a of Annex A*.

No field indicators of contamination, such as staining, odours or visibly stressed vegetation were noted within Block B. At most locations no staining or unusual odours were detected at any depth through the sampled soil profile. Measured concentrations of ionisable volatile compounds via headspace analysis generally were noted not to exceed 5 ppm (isobutylene equivalent) in samples collected from Block B. Exceptions included samples at TPA-2 (10 ppm) and TPA-3 (9.4 ppm), however no odours were reported at these locations. Odours were reported at SB65 and SB68, with headspace readings of less than 5 ppm (isobutylene equivalent).

5.1.2 *Soil Analytical Results*

The soil analytical results (complete data sets from all investigations) are compared to the adopted human health and ecological screening values as presented in *Table 4a to 4e of Annex B*. Exceedences of the adopted screening values are also graphically presented in *Figure* 4 of *Annex A.*

Measured concentrations of all COPCs in soil were below the adopted screening value in all soil samples analysed within Block 'B', with the exception of:

- arsenic in two soil samples (surface (0-0.1 m bgl) at SS014 and SS016); and
- chromium (total) (screened conservatively using the HIL-B for CrVI) in four soil samples (surface (0-0.1 m bgl) at SS004, SS014, SS016 and SS022); and

- carcinogenic PAHs (as B(a)P TEQ) in 7 soil samples:
  - SB07 at a depth of 0.5 m bgl;
  - SB08 at a depth of 0.5 m bgl and 1 m bgl;
  - SB09 at a depth of 0.4 m bgl;
  - SB14 at a depth of 0.4 m bgl;
  - SB17 at a depth of 0.7 m bgl;
  - SB19 at a depth of 0.9 m bgl; and
  - SB74 at a depth of 0.8 m bgl.
- total PAHs in one sample at SB08 at a depth of 0.5 m bgl.

The arsenic concentrations in soils from within Block 'C' were all <250% of the HIL-B and the 95% UCL of the mean concentration was less than the HIL-B. It is also noted that the standard deviation of these samples was less than 50% of the HIL-B (refer to *Annex H* for details of all relevant calculations). Therefore the exceedance in a single sample does not comprise exceedance of the HIL for Block 'B'.

There were no exceedances of HIL-B for CrVI (hexavalent chromium) in any sample that was analysed for CrVI. There is no health screening value for CrIII, which has low human toxicity. Because not all samples had CrVI data, total Cr results were screened against the HIL-B for CrVI. The concentration of total chromium from the surface sample at SS016 was >250% of the HIL-B for hexavalent chromium. There were no available hexavalent chromium results corresponding to this sample. The maximum reported concentration of hexavalent chromium within Block B was 5 mg/kg at SB09 at a depth of 0.4 m bgl corresponding to a total chromium concentration of 270 mg/kg. Given the low results for hexavalent chromium in all samples that have been analysed for that analyte, it is considered highly unlikely that the sample from SS016 (or any other sample) contained in excess of 500mg/kg CrVI (HIL-B).

Excluding the data from SS016, the total chromium concentrations in soils from within Block 'C' were all <250% of the HIL-B for CrVI and the 95% UCL of the mean concentration was less than the HIL-B. It is also noted that the standard deviation of these samples was less than 50% of the HIL-B (refer to *Annex H* for details of all relevant calculations). Therefore, even if the total Cr results were entirely comprised of CrVI, they would not result in exceedance of the HIL for the site. Therefore, lack of CrVI data for all exceedances is not considered to prevent drawing the conclusion that the site complies with HIL-B for CrVI.

The reported concentration of carcinogenic PAHs (as B(a)P TEQ) exceeded the adopted screening value at 7 locations. However, all concentrations in Block 'B' were below the Site Specific Trigger Levels (SSTLs), as discussed in *Section 5.5.2*.

Asbestos analytical results are presented in *Table 4.e of Annex B*. Since asbestos was not detected in the three soil samples analysed from fill material in the top 0.5m within Block B there was no evidence for the significant presence of asbestos within Site soils.

5.2 BLOCK C

5.2.1 Methodology and Field Observations

In total, including all previous and current investigations, there are 51 boreholes, and 4 monitoring wells located in Block C. A schedule of soil analysis (showing the number of samples analysed for each analyte) is presented in *Table 1 of Annex A* and relevant borehole logs are presented within *Annex E*. A total of 10 soil investigation bores, 4 of which were completed as groundwater monitoring wells, were installed within Block C in the current investigation. All the locations are presented in *Figure 3b of Annex A*.

No field indicators of contamination, such as staining, odours or visibly stressed vegetation were noted within Block C. No staining or unusual odours were detected at any depth through the sampled soil profile. Measured concentrations of ionisable volatile compounds via headspace analysis generally were noted not to exceed 5 ppm (isobutylene equivalent) in any sample collected from Block C. Exceptions included samples at SB60 (11.8 ppm) and SB61 (11.7 ppm), however no odours were reported at these locations. A slight hydrocarbon odour was reported at SB63, with headspace readings of 1.8 ppm (isobutylene equivalent).

5.2.2 Soil Analytical Results

The soil analytical results (complete data sets from all investigations) are compared to the adopted human health and ecological screening values as presented in *Table 5a to 5e of Annex B*. Exceedences of the adopted screening values are also graphically presented in *Figure 4* of *Annex A.*

Measured concentrations of all COPCs in soil were below the adopted screening value in all soil samples analysed within Block 'C', with the exception of:

- asbestos fibres in one soil sample (SB353 at a depth of 0.4 m bgl);
- arsenic in one soil sample (surface (0-0.1 m bgl) at SS016b); and

- chromium (total) (screened conservatively using the HIL-B for CrVI) in two soil samples (surface (0-0.1) at SS016b and composite C34 from AH097 and AH104 at surface (0-0.1 m bgl)); and
- carcinogenic PAHs (as B(a)P TEQ) in two soil samples (SB343 at a depth of 0.6 m bgl and SB60 at a depth of 2 m bgl).

The arsenic concentrations in soils from within Block 'C' were all <250% of the HIL-B and the 95% UCL of the mean concentration was less than the HIL-B. It is also noted that the standard deviation of these samples was less than 50% of the HIL-B (refer to *Annex H* for details of all relevant calculations). Therefore the exceedance in a single sample does not comprise exceedance of the HIL for the site.

There were no exceedances of HIL-B for CrVI (hexavalent chromium) in any sample that was analysed for CrVI. There is no health screening value for CrIII, which has low human toxicity. Because not all samples had CrVI data, total Cr results were screened against the HIL-B for CrVI. The total chromium concentrations in soils from within Block 'C' were all <250% of the HIL-B and the 95% UCL of the mean concentration was less than the HIL-B for CrVI. It is also noted that the standard deviation of these samples was less than 50% of the HIL-B CrVI (refer to *Annex H* for details of all relevant calculations). Therefore, even if the total Cr results were entirely comprised of CrVI, they would not result in exceedance of the HIL for the site. Therefore, lack of CrVI data for all exceedances is not considered to prevent drawing the conclusion that the site complies with HIL-B for CrVI.

Further it is noted that discrete samples from AH097 and AH104 corresponding to the composite sample C34 were subsequently analysed for total chromium and hexavalent chromium. The concentration of total chromium and hexavalent chromium from discrete samples at these respective locations were below the adopted screening values.

The reported concentration of carcinogenic PAHs (as B(a)P TEQ) exceeded the adopted screening value at two locations, with one individual sample exceeding 250% of the adopted screening value (SB343). However, all concentrations in Block 'C' were below the SSTLs, as discussed in *Section 5.6.3*.

Asbestos analytical results are presented in *Table 4e of Annex B*. Asbestos was detected in one sample SB353 at a depth of 0.4 m bgl which is likely associated with the demolition of the former administration building. .

Dioxin analytical results are presented in *Table 8 of Annex B*. Measured concentrations of dioxins were reported above the laboratory LOR, and are discussed further in *Section 5.6*. There are no currently available Australian guidelines for dioxins in soil.

5.3 *BLOCK E*

5.3.1 *Methodology and Field Observations*

In total, including all previous and current investigations, there are 38 boreholes, and 5 monitoring wells located in Block E. A schedule of soil analysis is presented in *Table 1 of Annex A* and relevant borehole logs are presented within *Annex E*. A total of 8 soil investigation bores, 3 of which were completed as groundwater monitoring wells, have been installed within Block E in the current investigation. All the locations are presented in *Figure 3c of Annex A*.

No field indicators of contamination, such as staining, odours or visibly stressed vegetation were noted within Block E. No staining or unusual odours were detected at any depth through the sampled soil profile. Measured concentrations of ionisable volatile compounds via headspace analysis were noted not to exceed 5 ppm (isobutylene equivalent) in any sample collected from Block E.

5.3.2 *Soil Analytical Results*

The soil analytical results (complete data sets from all investigations) are compared to the adopted human health and ecological screening values as presented in *Table 6a to 6e of Annex B*. Exceedences of the adopted screening values are also graphically presented in *Figure 4* of *Annex A.*

Measured concentrations of all COPCs in soil were below the adopted screening value in all soil samples analysed within Block 'E', with the exception of carcinogenic PAHs (as B(a)P TEQ).

The reported concentration of carcinogenic PAHs (as B(a)P TEQ) exceeded the adopted screening value in three soil samples (SB345 at a depth of 0.9 m bgl, SB347 and MW303 at a depth of 1.0 m bgl and SB338 at a depth of 1.5 m bgl). However, all concentrations in Block 'B' were below the Site Specific Screening Levels (SSL), as discussed in *Section 7.1*.

Asbestos analytical results are presented in *Table 4.e of Annex B*. Asbestos was not detected in the 9 soil samples analysed from fill material in the top 0.5m within Block E.

5.4 *BLOCK H*

5.4.1 *Methodology and Field Observations*

In total, including all previous and current investigations, there are 53 boreholes, 7 test-pit samples and 7 monitoring wells located in Block H.

A schedule of soil analysis is presented in *Table 1 of Annex A* and relevant borehole logs are presented within *Annex E*. A total of 17 soil investigation bores, 7 of which were completed as groundwater monitoring wells, were installed within Block 'H' in the current investigation. All the locations are presented in *Figure 3d of Annex A*.

No field indicators of contamination, such as staining, odours or visibly stressed vegetation were noted within Block H. No staining or unusual odours were detected at any depth through the sampled soil profile. Measured concentrations of ionisable volatile compounds via headspace analysis were noted not to exceed 5 ppm (isobutylene equivalent) in any sample collected from Block H.

5.4.2 Soil Analytical Results

The soil analytical results (complete data sets from all investigations) are compared to the adopted human health and ecological screening values as presented in *Table 7a to 7e of Annex B*. Exceedences of the adopted screening values are also graphically presented in *Figure 4* of *Annex A.*

Measured concentrations of all COPCs in soil were below the adopted screening value in all soil samples analysed within Block 'H', with the exception of:

- asbestos fibres in one soil sample (MW316 at a depth of 0.2 m bgl);
- arsenic in one soil sample (surface (0-0.1 m bgl) at SS012b); and
- carcinogenic PAHs (as B(a)P TEQ) in four soil samples (SB326 at a depth of 0.5 m bgl, SB330 at a depth of 0.6 m bgl and MW312 at a depth of 1.5 m bgl).

The arsenic concentrations in soils from within Block 'H' were all <250% of the HIL-B and the 95% UCL of the mean concentration was less than the HIL-B. It is also noted that the standard deviation of these samples was less than 50% of the HIL-B (refer to *Annex H* for details of all relevant calculations). Therefore the exceedance in a single sample does not comprise exceedance of the HIL for the site.

The reported concentration of carcinogenic PAHs (as B(a)P TEQ) exceeded the adopted screening value at 4 locations. However, all concentrations in Block 'H' were below the SSTLs, as discussed in *Section 5.6.3*.

Asbestos analytical results are presented in *Table 4.e of Annex B*. There were no visible ACM identified during the current or previous investigations. Asbestos fibres were detected in soils at one location MW316 at a depth of 0.2 m bgl likely associated with shallow clay fill imported for stabilisation of the concrete slab in Unit 12. Since asbestos fibres were not detected in 15 of the 16 soil samples analysed from fill materials within Block H, there was no evidence for the significant presence of asbestos within Site soils.

5.5 SOIL EXCEEDING ADOPTED SCREENING VALUES

5.5.1 *Asbestos*

There were no visible ACM identified during the current or previous investigations. Asbestos fibres were detected in soils at two locations:

- SB353 at a depth of 0.4 m bgl in Block 'C' likely associated with the demolition of the former administration building; and
- MW316 at a depth of 0.2 m bgl likely associated with shallow clay fill imported for stabilisation of the concrete slab in Unit 12.

Since asbestos was not detected in 30 of the 32 samples analysed for asbestos fibres, there was no evidence for significant presence of asbestos within Site soils.

It is noted that the vertical boring of soils is not an ideal method via which to identify asbestos impacts in soils. The absence of asbestos within fill materials or upon surface soils in other areas across the Site therefore cannot be guaranteed on the basis of the results of this assessment. Similarly, as with any investigation of this nature, the potential exists for unidentified contamination to exist.

5.5.2 *PAHs*

The reported total PAH concentration in one sample at SB08 at a depth of 0.5 m bgl exceeded the HIL-B. The reported concentration of carcinogenic PAHs (as B(a)P TEQ) exceeded the adopted screening value at 7 locations in Block B, 2 locations in Block C, 4 locations in Block E, 3 locations in Block H. Individual samples exceeded 250% of the adopted screening value at SB07, SB09, SB08, SB74 in Block B, SB343 in Block C and MW303 in Block E.

In accordance with the NEPM (2013) Schedule B1, exceedance of the adopted screening value indicates a need for further assessment, and does not automatically indicate a requirement for remediation. HILs are not designed as remediation levels. It is therefore appropriate to consider the environmental and human health risks in determining whether further action is necessary.

Based on exceedences of Tier 1 screening values (HIL-B) for carcinogenic PAHs (as B(a)P TEQ) site-specific target levels (SSTLs) were calculated. The calculation of the SSTLs is outlined in the document in *Annex I* of this report. The SSTLs were developed based on assumptions including that the placement of a foundation concrete slab covering the entirety of the WPM Site. Services will be constructed within the ground level, with construction of concrete lined lift pits, stormwater pits and water storage tanks.

The SSTL calculation considered a development scenario for a mixed high-rise residential and commercial complex, whereby shallow soil impacts may be exposed during limited intrusive maintenance works. The assumptions adopted in the calculation of the SSTLs are outlined in *Annex I* and included two receptors scenarios for intrusive maintenance workers and high density residential occupants.

The lowest carcinogenic PAHs (as B(a)P TEQ) SSTL developed for soils below concrete is 500 mg/kg. This SSTL is considered to be protective of future residential and worker exposure if sub-slab soils were exposed during intrusive works within the planned development. The concentrations of carcinogenic PAHs (as B(a)P TEQ) in soils within Block 'B', 'C', 'E' and 'H; were below the SSTL (as calculated in *Annex I*). It is noted that the development design for Block 'E' and 'H' has not yet been finalised it is noted that the evaluation of the data in the development of the SSTLs is based on the current understanding of the development design.

5.6 POTENTIAL COPCS - DIOXINS

Dioxins are a known contaminant of concern at the Union Carbide site on the Rhodes Peninsula which is across Homebush Bay from the Wentworth Point Marinas site. As discussed in *Section 2.3.2*, ERM considers that dioxins are unlikely to be a contaminant of potential concern at the site, given the timing of historical events in the area. It is unlikely that dredged sediments from Homebush Bay used for reclamation of Wentworth Point prior to 1954 were contaminated by the activities at Rhodes (including dioxins, chlorinated organic substances and metals), as there was at most three years of production of dioxins prior to the completion of dredging.

Two soil samples from the fill likely to be derived from dredged sediment, SB331 at a depth of 1.5 m bgl, and MW308 at a depth of 1.0 m bgl, were analysed for dioxins. Measured concentrations of dioxins were reported above the corresponding laboratory LOR in both samples.

The guidance on dioxins in soil provided by the World Health Organisation (Van den Berg et al., 2006) considers the total concentrations of dibenzo-p-dioxin (PCDD) and ten polychlorinated dibenzofuran (PCDF) as well as the toxic equivalency (TEQ) calculated by applying Toxic Equivalency Factors (TEF) to each dioxin or dioxin-like compound.

The toxicity equivalence (TEQ) is relative to a reference compound, 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD). The results discussed below are presented in the WHO TEQ system.

As discussed by Müller et al (2004), background levels of dioxins are present in most urban and industrial areas in Australia and may be related to a range of natural and anthropogenic sources. Müller et al (2004) reported total PCDD/PCDF concentrations at 3 urban sites in Sydney, ranging from 9,800 pg g^{-1} to 42,000 pg g^{-1}. Measured concentrations of total PCDD/PCDF at the WPM Site were comparable to the data reported by Müller et al (2004) for urban sites in Sydney, with a range from 6,682.8 pg g^{-1} to 23,101.7 pg g^{-1}.

There are no current Australian guidelines specifying a screening value for dioxin-like chemicals in soils. Reference values and action levels are provided in German guidelines (Umweltbundesamt, 1992), including a remediation action level for residential areas of 1,000 pg TEQ g^{-1}. Soil acceptance criteria for residential land use of 1500 pg TEQ g^{-1} has also been published in the *New Zealand Health and Environmental Guidelines for Selected Timber Treatment Chemicals* (Ministry for the Environment and Ministry of Health, 1997).

Measured concentrations of dioxins at the WPM Site ranged from 6.65 pg TEQ g^{-1} (at SB331 at a depth of 1.5 m bgl) to 38.51 pg TEQ g^{-1} (MW308 at a depth of 1.0 m bgl). The reported concentrations of dioxins at the WPM Site were below the German and New Zealand thresholds for residential land use.

6 GROUNDWATER RESULTS

6.1 FIELD OBSERVATIONS

Newly installed monitoring wells were generally gauged and sampled at least 72 hours after well installation and development to allow subsurface conditions to stabilise. Groundwater gauging and sampling was completed between 1 and 10 October 2014. During this time, a total of 2.8 mm of rain was recorded.

Groundwater gauging data is presented in *Table 3 of Annex B* and indicative groundwater flow directions are presented in *Figure 5, Annex A*. Groundwater was encountered at depths ranging from 0.55 m AHD to 1.34 m AHD.

Groundwater parameter readings collected during the groundwater sampling works are presented in *Table 3 of Annex B*. Field parameters were generally within the expected range. Electrical conductivity readings indicated that groundwater conditions were indicative of slightly brackish to highly saline conditions across the Site (10,470 to 64,358 µS/cm).

Measured pH readings ranged between pH 6.55 to 7.73 indicative of generally circum-neutral groundwater conditions across the Site.

No indications of contamination, such as sheens or odours, were observed during groundwater sampling. A summary of field observations from the groundwater sampling works are presented within *Annex E*.

6.2 CURRENT ANALYTICAL RESULTS

Groundwater analytical results compared to the adopted screening values are presented in *Table 9 of Annex B* and exceedances of the adopted screening values are also graphically presented in *Figure 5 Annex A*.

Measured concentrations of the majority of the COPCs were below the laboratory LOR and the adopted screening values in all groundwater samples analysed. Phenol was detected above laboratory LOR at MW317 and MW323; however all concentrations were below the adopted screening value.

Concentrations of TRH in the C10-C16 fraction were detected equal to the laboratory LOR of 100 µg /L in the groundwater sample from monitoring well MW321. As discussed in *Section 3.5.2*, the HSLs (NEPM and CRC Care) have not been applied to groundwater results as the groundwater standing water level is shallower than 2 m bgl. The detection is not considered significant enough to warrant further consideration. .

Arsenic was detected at concentrations in excess of the adopted human health (drinking water) screening values in three locations MW310, MW317 and MW322. The concentration of arsenic at MW317 also exceeded the human health (recreational) screening value. Arsenic, copper and zinc were detected at concentrations in excess of the adopted ecological screening values in groundwater samples analysed from wells across the Site.

6.3 *HISTORICAL ANALYTICAL RESULTS*

Ten groundwater monitoring events have been conducted within the WPM Site between 2003 and 2014. The results of the groundwater testing between May 2003 and June 2012 are presented in *Tables 10a* to *10d* of *Annex B*. The reported concentrations of VOCs, SVOCs, PAHs and phenols were below the laboratory limit of detection and/or the adopted screening value.

Metals and Metalloids

The reported concentrations of cadmium, nickel and mercury complied with the adopted screening values in all monitoring rounds. The reported concentrations of arsenic, chromium, copper, lead and zinc concentrations in groundwater have exceeded the adopted ecological screening values in several locations in different monitoring rounds. The adopted human health (drinking water) screening values were also exceeded for arsenic and nickel.

TRH and BTEX

Concentrations of BTEX compounds were not detected above the laboratory limit of reporting in any of the groundwater samples analysed at the WPM Site with the exception of 4 μg/L toluene in MW8 in May 2003 which did not exceed the adopted screening values. Concentrations of BTEX were not detected above the laboratory LOR in any monitoring wells in subsequent monitoring rounds in 2004, 2005, 2006 and 2014, and this has not been considered further.

Concentrations of TRH in the C6-C9 fractions were reported above the laboratory LOR, but below the adopted screening values at MW4 and MW9 in May 2003. Concentrations of TRH in the C6-C9 fractions were not detected above the laboratory LOR in any monitoring wells in subsequent monitoring rounds in 2004, 2005, 2006 and 2014, and this has not been considered further.

Concentrations of TRH in the C10-C40 fractions were detected above the laboratory LOR in groundwater samples from monitoring wells MW8 in May, MW5; MW8 and MW11 in October 2003; MW303, MW316 and MW321 in October 2014. There are no HSLs for TRH in the >C_{16}-C_{34} and >C_{34}-C_{40} fractions as these are non-volatile and therefore not of concern for vapour intrusion (NEPM, 2013). Therefore this has not been considered further.

7 DISCUSSION

7.1 UPDATED CONCEPTUAL SITE MODEL

7.1.1 *Development of a Conceptual Site Model*

The approach to the screening of the data gathered in this assessment was to initially adopt the most conservative potential assessment values to consider all potential receptors identified in the CSM (*Annex C*). The exceedances of the screening values outlined in *Section 5* were subsequently assessed on a case by case basis, in light of the specific characteristics of the individual samples and the potential sources which those samples targeted. The conclusions of these further assessments were incorporated into the CSM as presented in the following sections and summarised in *Annex C*. Potential source-pathway-receptor (SPR) linkages were subsequently revised on the basis of the available data and the refinement of receptors.

Potential exposure pathways are evaluated for completeness based on the existence of:

- a source of chemical contamination;
- a mechanism for release of contaminants from identified sources;
- a contaminant retention or transport medium (eg soil, air, groundwater, etc);
- potential receptors of contamination; and
- a mechanism for chemical intake by the receptors at the point of exposure (ingestion, dermal contact or inhalation or a combination of).

Whenever one or more of the above elements is missing, the exposure pathway is incomplete and there is therefore no risk to the identified receptor (human health for example). An exposure pathway can be either "direct", where the receptor comes into direct contact with the affected environmental media (eg soil ingestion) and "indirect", where exposure occurs at a different location or in a different medium than the source (eg soil vapours volatilising to ambient air).

7.1.2 *Potential Sources of Impact*

Soil above Screening Values

The soils beneath Block B, C, E and H comply with the adopted HIL-B with the exception of PAH.

PAH concentrations exceeded the adopted screening values in a number of soil samples. Further assessment was carried out and a Site Specific Target Level based on the proposed development was generated. There were no exceedances of the SSTL for carcinogenic PAH, and therefore a significant source of carcinogenic PAH is not considered to be present.

Asbestos fibres were detected in two locations in fill material (below Unit 12 in Block E and below Unit 15 in Block C). No visible asbestos was noted in soil samples. Since asbestos was not detected in 30 of the 32 samples analysed for asbestos fibres, there was no evidence for significant presence of asbestos within Site soils.

Metals in Groundwater above Screening Values

Concentrations of arsenic, copper and zinc in groundwater across the Site exceeded the adopted ecological screening values. Arsenic exceeded the drinking water screening value in three locations and the recreational screening value in one location.

Concentrations of arsenic in one location, MW317, screened in shallow fill material exceeded the adopted human health screening values (drinking water and recreational), and had a concentration two orders of magnitude above any other result for arsenic. Groundwater from adjacent monitoring wells MW314 and MW2, screened in the deeper dredged silty clay, were below the adopted human health screening values. Therefore it is considered that the arsenic impacted groundwater is likely to be limited to the shallow coarse fill material at depths to 1.1 m bgl. The monitoring well MW317 is located within the tank compound of the former CCA treatment area, adjacent to the removed petroleum USTs, and the former underground CCA treatment vessel (the abandonment of which has not been confirmed). It is considered likely that the arsenic impact in shallow groundwater is associated with the former underground infrastructure. Groundwater was not encountered in the shallow fill layer in Block 'E', 'H' or 'C'. The shallow groundwater encountered in Block 'B' was associated with coarse cobble and demolition rubble (bricks). The absence of wider occurrence of higher range arsenic concentrations indicates that the impacted water is not migrating significantly to the main water table.

The two other exceedances of the drinking water screening value for arsenic (MW310 and MW322) were marginally above the guideline (10µg/L) with a concentration of 17µg/L in both cases. These results are likely to be related to the soil quality locally, but are not likely to be indicative of a significant soil source of arsenic.

More widespread occurrences of exceedance of the ecological screening value for arsenic are likely to be also related to fill quality on site.

The elevated concentrations of copper and zinc in groundwater are considered likely to be representative of background groundwater quality. Zinc concentrations are considered likely to be driven by run-off from zinc roofing materials. Similar zinc concentrations are often observed in urban groundwater for this reason. Copper concentrations are sufficiently low that they are likely to be representative of close to natural background level.

No evidence of a significant source of organic compounds (eg, TRH, PAH, phenols) to groundwater was detected.

Remaining Underground Tanks

The five known USTs from Block 'B' were removed and validated as reported in ERM (2003). Based on historical reports, USTs are present in Unit 4, Unit 7 and between Unit 11 and the seawall, including:

- a petroleum UST (unknown volume) in the eastern portion of Unit 4 (Block 'E');
- a petroleum UST (unknown volume) in the northern portion of Unit 7 (Block 'H'); and
- a boiler fired by fuel oil was formerly located on or near the sea wall on the north-east boundary of the Site, and fuel oil tanks were reportedly located in this area (Block H).

Based on the GPR survey in Unit 4 and Unit 7, these tanks may have been removed, however there was no documentation available to corroborate the tank removal. There was no evidence of soil and/or groundwater impact identified at soil bores and groundwater monitoring wells in the vicinity of the identified tanks.

7.1.3 Potential Receptors

Potential ecological receptors include aquatic ecosystems in Homebush Bay and the Parramatta River. Terrestrial ecological receptors have not been considered as the proposed development includes 100% concrete cover and there will be no pathways for terrestrial ecological receptors for exposure to soils.

Potential on-site human receptors include construction workers, future residents and intrusive maintenance workers. Potential off-site human receptors include recreational users of Homebush Bay and the Parramatta River.

7.1.4 *Potential Pathways for Exposure (human & ecological)*

Exposure to Impacted Groundwater

The potential pathway for ecological exposure is the migration of groundwater to the off-site adjacent surface water bodies Homebush Bay and the Parramatta River.

Only arsenic exceeded human health screening values in Site groundwater, and this groundwater does not appear to have a viable pathway to migrate offsite in the site's current state. Even in the event that a migration pathway existed, the viability of pathways for exposure to contaminants from site is considered to be limited, on the basis that neither waterway is used for activities where people are likely to be swimming, and groundwater is not extracted for use in nearby industrial, commercial or residential premises. It is not considered likely that groundwater exiting the site into the adjacent waterways exceeds the drinking water screening value for arsenic.

It is noted that creation of a pathway for this groundwater to migrate into deeper groundwater or surface water could be created during construction if pumping to dewater an excavation in this area resulted in discharge to surface water drainage, or reinjection of the water into the formation.

Direct exposure to groundwater is highly unlikely for on-site or off-site residents since no groundwater extraction is planned. It is noted that there are no registered domestic groundwater extraction bores in the vicinity of the Site. Therefore it is considered that there is no current viable pathway for exposure to groundwater by residents.

Construction workers on Site may have opportunities for direct exposure to arsenic impacted groundwater if they are undertaking works that involve excavation in the impacted location in Block B. The identified significant arsenic impact appears to be localised in the vicinity of the former CCA treatment area in Block 'B' at MW317.

Exposure to Impacted Soil

Potential on-site pathways for human exposure to soils are direct contact with soil (ingestion and dermal contact) and dust inhalation.

Vapour inhalation is not a pathway requiring consideration because there were no exceedances of screening values for vapour intrusion.

Construction and maintenance workers may have opportunities for direct exposure to soils if they are undertaking works that involve excavation. However, since no exceedances of screening values for intrusive maintenance workers and/or commercial/industrial workers are present a complete SPR linkage is not considered likely to exist. The exception to this is for potential asbestos fibre in soils.

Given the proposed development scenario, direct exposure to soils for residents is considered unlikely to occur under normal circumstances, as exposure to soils will require breaching of the concrete slab (which is an essential element of the building structure) with machinery and excavation below the layer of sub-grade fill beneath the concrete. The SSTLs for PAHs were developed to consider the potential exposure to soils for residents and construction workers in the future if maintenance work was conducted that required the temporary removal of the concrete hardstand. Since there were no exceedances of the SSTLs, this potential exposure pathway is considered insignificant.

7.1.5 *Summary of potentially complete SPR linkages*

The potentially complete linkages resulting from the investigation are:

Potential for groundwater exceeding ecological criteria for arsenic, copper and zinc to exit the site into Homebush Bay. This linkage is considered present, but insignificant due to the exceedances being of limited magnitude, and likely very similar to the receiving water quality. Water quality is not likely to worsen in future, and the completed development may reduce discharge rate by increasing surface cover. No mitigation of this linkage is considered necessary.

Potential migration or discharge of arsenic impacted perched water from the CCA treatment area in Block 'B' during redevelopment. Prevention of the creation of a pathway (eg, by reinjection or direct pumping to surface water drainage) will be needed in the construction stage. No long term mitigation is considered necessary.

Potential exposure of construction workers to arsenic impacted groundwater during redevelopment of Block B. Mitigation of this linkage should be considered as part of the health and safety planning for construction of Block B.

Potential for release of contents from the remaining USTs, or encountering unknown impact in their vicinity during redevelopment.

Potential for inhalation of asbestos fibres should be considered as part of a procedure for management of unexpected contamination in planning for redevelopment of all Blocks on site.

7.2 *SITE SUITABILITY*

The conclusions of this report, including the CSM presented in *Section 7.1* above, were developed based on assumptions including that the development designs are consistent with that proposed for Block 'B' and 'C', including:

- removal of the existing concrete slab to facilitate piling;
- the removal of up to 0.5 m of soil across Block 'B' and 'C' and up to 3 m across Block 'E' and 'H';
- use of displacement (vibration) piling technique minimising the volume of soil excavated below the water table; and
- placement of a foundation concrete slab covering 100% of the final ground surface.

The development on Block 'B', 'C', 'E', and 'H' is proposed for mixed land uses including high density residential apartment buildings, with some commercial and/or retail spaces, community facilities (including a library) and landscaped areas (including the foreshore promenade.

The completed development will comprise 100% concrete hardstand, including the publically accessible foreshore areas. Lawn, garden and landscaped areas will be constructed over the concrete slab with all exposed soil surfaces at the completed development being imported for that purpose. Direct exposure to soils for residents is therefore unlikely to occur under normal circumstances, as exposure to soils will require breaching of the concrete slab with machinery and excavation below the layer of sub-grade fill beneath the concrete. Services will be constructed within the ground level, with construction of concrete lined lift pits, stormwater pits and water storage tanks, therefore limiting the potential for exposure to future maintenance workers.

Based on the available data it is considered that the Site known as Block 'B', Block 'C', Block 'E' and Block 'H' at the WPM Site is suitable for the proposed landuse, being residential with minimal access to soils as described above.

In order to be protective of workers, the general public and the environment during construction, health, safety and environmental management plans for the construction phase must consider the potentially complete SPR Linkages as described in *Section 7.1.5* above.

7.3 *REMEDIATION AND MANAGEMENT RECOMMENDATIONS*

A *Remediation Action Plan* (ERM, 2002) was prepared for the WPM Site, which requires the removal of USTs from Unit 4 and Unit 7 if they are found to be still in place. The USTs and associated pipes in Unit 4 and 7 should be decommissioned and removed and the tank pits validated if they are encountered during development. An additional RAP to cover this activity is not considered necessary. No other remediation is considered to be required to make the site suitable for use.

In order to be protective of workers, the general public and the environment during construction, ERM recommends that a Construction Environmental Management Plan (CEMP) is prepared for each Block. The CEMP would apply for the construction phases involving excavations, piling and construction of the foundation concrete slab. The CEMP should identify the potential locations of the USTs, outline the roles and responsibilities for implementation of the CEMP and describe management practices to be implemented during construction including:

- health and safety planning and induction processes to ensure site management and workers are appropriately aware and informed of anticipated site conditions;
- procedures to be followed if unexpected finds of contamination are identified (including asbestos, USTs and pipework);
- engaging an appropriately qualified and experienced environmental consultant to assist the developer and provide technical support to manage potential contamination during redevelopment; and
- any soil material imported to site during redevelopment must meet the requirements of "clean fill" detailed in the CEMP.
- establishing appropriate environmental controls to manage surface water run-off, erosion and dust;
- off-site disposal of excavated material in accordance with regulatory requirements to an appropriately licensed waste facility;
- a procedure for managing potential acid sulphate soils; and
- management of potentially impacted groundwater during dewatering of excavations, including appropriate disposal.

A *Validation Report* should be prepared for Council documenting the removal and validation of any USTs and associated pipework encountered during the construction. Following completion of the development in each Block, documentation of the final as-built development should be provided to Council and the Site Auditor in the form of a letter including the relevant as-built plans.

8 *CONCLUSION*

ERM undertook additional soil and groundwater investigations within Block 'B', 'C', 'E', 'H' at the Wentworth Point Marinas site at 1 Burroway Road, Wentworth Point to address the data gaps identified in the *Soil and Groundwater Contamination Status Summary Report* (ERM, August 2013). This report has been prepared for submission with the DA to allow Council to make an assessment relative to the requirements of *Clause 7 of SEPP55*.

Soil and groundwater data were compared against published environmental quality levels to provide a screening level assessment of potential risks to identified human and environmental receptors. The following conclusions were made for Block 'B', 'C', 'E' and 'H' based on the data collected during from current and previous investigations by ERM and others:

- There were exceedences of human health (drinking water and recreational) based screening values for arsenic in one location in shallow groundwater; however groundwater on the down-gradient boundary does not exceed human health screening values. There were marginal exceedences of the adopted ecological screening values for arsenic, copper and zinc in groundwater. No remedial action to address groundwater quality is considered necessary.

- The soils comply with the NEPM (2013) Health Investigation Level B and/or Site Specific Trigger Levels and therefore are considered suitable for the proposed use;

- in order to be protective of workers and the environment during construction a Construction Environmental Management Plan (CEMP) should be implemented; and

- based on the information presented in this report, ERM considers that Block 'B', 'C', 'E' and 'H' of the WPM site is suitable for the proposed mixed-use development which includes high density residential landuse.

9 *LIMITATIONS*

1. This report is based solely on the scope of work described in P0106206 "Proposal for Phase 2 Environmental Site Assessment at Wentworth Point Marinas" dated 20 August 2014 (**Scope of Work**) and performed by Environmental Resources Management (**ERM**) for Fairmead Business (the **Client**). The Scope of Work was governed by a contract between ERM and the Client (**Contract**).

2. No limitation, qualification or caveat set out below is intended to derogate from the rights and obligations of ERM and the Client under the Contract.

3. The findings of this report are solely based on, and the information provided in this report is strictly limited to that required by, the Scope of Work. Except to the extent stated otherwise, in preparing this report ERM has not considered any question, nor provides any information, beyond that required by the Scope of Work.

4. This report was prepared between 1 October 2014 and 27 November 2014 and is based on conditions encountered and information reviewed at the time of preparation. The report does not, and cannot, take into account changes in law, factual circumstances, applicable regulatory instruments or any other future matter. ERM does not, and will not, provide any on-going advice on the impact of any future matters unless it has agreed with the Client to amend the Scope of Work or has entered into a new engagement to provide a further report.

5. Unless this report expressly states to the contrary, ERM's Scope of Work was limited strictly to identifying typical environmental conditions associated with the subject site(s) and does not evaluate the condition of any structure on the subject site nor any other issues. Although normal standards of professional practice have been applied, the absence of any identified hazardous or toxic materials or any identified impacted soil or groundwater on the site(s) should not be interpreted as a guarantee that such materials or impacts do not exist.

6. This report is based on one or more site inspections conducted by ERM personnel, the sampling and analyses described in the report, and information provided by the Client or third parties (including regulatory agencies). All conclusions and recommendations made in the report are the professional opinions of the ERM personnel involved. Whilst normal checking of data accuracy was undertaken, except to the extent expressly set out in this report ERM:

   a) did not, nor was able to, make further enquiries to assess the reliability of the information or independently verify information provided by;

b) assumes no responsibility or liability for errors in data obtained from,

the Client, any third parties or external sources (including regulatory agencies).

7. Although the data that has been used in compiling this report is generally based on actual circumstances, if the report refers to hypothetical examples those examples may, or may not, represent actual existing circumstances.

8. Only the environmental conditions and or potential contaminants specifically referred to in this report have been considered. To the extent permitted by law and except as is specifically stated in this report, ERM makes no warranty or representation about:

   a) the suitability of the site(s) for any purpose or the permissibility of any use;

   b) the presence, absence or otherwise of any environmental conditions or contaminants at the site(s) or elsewhere; or

   c) the presence, absence or otherwise of asbestos, asbestos containing materials or any hazardous materials on the site(s).

9. Use of the site for any purpose may require planning and other approvals and, in some cases, environmental regulator and accredited site auditor approvals. ERM offers no opinion as to the likelihood of obtaining any such approvals, or the conditions and obligations which such approvals may impose, which may include the requirement for additional environment works.

10. The ongoing use of the site or use of the site for a different purpose may require the management of or remediation of site conditions, such as contamination and other conditions, including but not limited to conditions referred to in this report.

11. This report should be read in full and no excerpts are to be taken as representative of the whole report. To ensure its contextual integrity, the report is not to be copied, distributed or referred to in part only. No responsibility or liability is accepted by ERM for use of any part of this report in any other context.

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