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Eraring Power Station

Preliminary Environmental Site Assessment – Part 1

Environmental Resources Management

27 June 2013

NSW GOVERNMENT | The Treasury

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NSW Treasury

Eraring Power Station

Preliminary Environmental Site Assessment

Ref: 0194708RP02 Final

27 June 2013

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ERM

Eraring Power Station

Preliminary Environmental Site Assessment

NSW Treasury - Project Symphony

27 June 2013

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EXECUTIVE SUMMARY

ERM was engaged by NSW Treasury to provide advice in relation to potential soil and groundwater contamination issues which may be relevant to the sale of certain electricity generation assets owned and operated by Eraring Energy. The subject of this report is the Eraring Power Station.

The specific objectives for ERM's scope of works were to:

- *assess the nature and extent of potential soil, sediment and groundwater contamination issues which may be present at the site and relevant receiving environments;*
- *assess the potential financial liabilities associated with those issues (assuming ongoing commercial / industrial use as a power generating facility);*
- *identify what additional works may be required to establish a baseline of soil, sediment and groundwater conditions present at the site to support the potential sale of the asset.*

ERM met these objectives via the completion of a Preliminary Environmental Site Assessment (ESA) which included background research from a variety of sources as well as management and staff interviews and site visits undertaken on 18 and 19 March 2013.

The Preliminary ESA identified that limited previous intrusive ESAs appear to have been completed on the Site and a number of potential contamination sources were identified as follows:

- *CCP management facility (ash dam);*
- *transformer area;*
- *coal storage area;*
- *fuel oil installation;*
- *operational and decommissioned USTs;*
- *attemperation reservoir;*
- *truck wash out pits;*
- *workshops;*
- *former northern gas turbine area;*
- *sewage treatment area; and*
- *Lake Macquarie, Whiteheads Lagoon, the Return Water Pond and Crooked Creek sediments and sediments associated with drainage channels to Lake Eraring.*

Decommissioned and operational USTs, as well as the truck washout pits and immediate surrounds, were also considered secondary areas of potential concern.

Based on the results of the Preliminary ESA undertaken by ERM, and consideration of Government's intended approach to establishing a baseline of soil and groundwater contamination, a programme of intrusive (Stage 2) assessment of potential soil and groundwater contamination issues is provided. The most appropriate sampling design is considered to be a combination of systematic (grid based) and judgemental (targeted) sampling of soil and groundwater at locations across the Site and sediments and surface water in several areas of potential on and off-site impact; namely, Lake Macquarie, Whiteheads Lagoon, the Return Water Pond, Crooked Creek and drainage channels to Lake Eraring.

Based on the information available at the time of preparation of this report, ERM has not identified any actual or known material contamination issues which are currently undergoing or likely to require remediation. Preliminary remediation costs have not therefore been prepared at this point in time. There is however the potential for contamination arising from identified areas of concern to give rise to material cost, which can be confirmed following the proposed Stage 2 investigations. It is proposed that remedial costs be revisited following completion of the proposed Stage 2 investigations.

1 INTRODUCTION

1.1 BACKGROUND

On 24 November 2011, the New South Wales (NSW) State Government (Government) announced that it would divest the State-owned electricity generation assets and the Cobbora Coal Mine development. More specifically, the Government intends to:

- sell the electricity generation assets of Macquarie Generation, Eraring Energy and Delta Electricity, including the assets related to the generation trading ('GenTrader') agreements of Eraring Energy and Delta Electricity;
- sell the electricity generation development sites at Bayswater B, Munmorah and Tomago; and
- sell or lease the Cobbora Coal Mine development.

In order to support the sale of certain electricity generation assets owned and operated by Eraring Energy (a State Owned Corporation - SOC), NSW Treasury (Treasury) on behalf of the State of New South Wales, engaged ERM as the Site Contamination Environmental Adviser (the 'Adviser') to provide advice in relation to potential soil and groundwater contamination issues which may be relevant to the transaction at certain specified sites. The subject of this report is Eraring Power Station (the 'Site').

1.2 OBJECTIVE

The specific objectives for ERM's scope of works were to:

- assess the nature and extent of potential soil, sediment and groundwater contamination issues which may be present at the Site and relevant receiving environments;
- assess the potential financial liabilities associated with those issues (assuming ongoing existing landuse for the areas concerned, in accordance with the zoning presented in the City of Lake Macquarie council Local Environmental Plan 2004);
- identify what additional works may be required to establish a baseline of soil, sediment and groundwater conditions present at the Site to support the potential sale of the asset.

1.3 SCOPE OF WORK

The scope of this Preliminary ESA was outlined in the Request for Proposal (RFP) issued by Treasury on 14 February 2013 and following discussions with Treasury and a potential bidder and their advisors during the course of the works, the scope was amended. A copy of the revised scope of work is included as *Annex E*.

1.4 MATERIAL THRESHOLD

ERM adopts a technically rigorous approach to assessing potential risks and liabilities during Environmental Due Diligence (EDD), and typically focuses on what is *material* to the transaction. In this situation, a material threshold was applied to items contained within the EDD reports.

Based on ERM's experience of similar projects and discussions with the Client, ERM adopted a material threshold of $0.5M (+ GST if applicable) per contamination source.

Material costs are those costs for that item to meet relevant requirements of NSW EPA under its current land use to remediate or manage the contamination issue. Remediation or management includes additional assessment, environmental monitoring, management, containment or other remediation measures.

In addition, any issue that ERM considers could have the potential to lead to prosecution by the regulatory authorities that could lead to significant business disruption or reputational impact will be considered material.

1.5 APPROACH AND METHODOLOGY

ERM's approach to the assessment was to break the work down into individual tasks as follows.

1.5.1 *Project Initiation Meeting*

In order to ensure that ERM and Treasury were fully aligned in terms of the scope and anticipated deliverables, the ERM Partner in Charge and Project Manager attended a project initiation meeting with Treasury.

1.5.2 *Introductory meetings with the individual SOCs*

In order to facilitate cooperation with the SOC and to seek assistance from the asset maintenance and environmental team throughout the project, ERM completed introductory meetings with key contacts within Eraring Energy.

1.5.3 *Review of Existing Data*

Relevant environmental information on the specific SOC asset was made available to ERM via an electronic dataroom. ERM reviewed relevant information on all sites and a list of all documents reviewed is included in *Section 11*.

In addition, ERM conducted background research using publicly available information on each of the sites. Background research included those items identified in *Section 3* below, and *Annex E*.

A site setting review was also undertaken to understand both the sensitivity of the surrounding area to environmental impact and the potential impact on the site resulting from neighbouring activities, past and present. Key areas addressed included site description and activities, site history, geology, hydrogeology and hydrology (refer to *Section 2*).

ERM did not review capping, closure and other day to day operational costs for the Coal Combustion Products (CCP) Management Facility (Ash Dam) as this was considered to be an operational cost associated with the management of a primary waste stream associated with normal operations, as required under relevant planning approvals (refer to *Section 3.5*), rather than with the management of a site contamination issue.

1.5.4 *Site Visits and Management Interviews*

ERM mobilised to site and completed site management interviews and a site visit to Eraring Power Station on 18 and 19 March 2013.

The assessment focussed on potentially material contamination issues that were considered likely to require further assessment relevant to Bidders and to identify where a baseline assessment may be required. Topics that were evaluated as non-material were not assessed in detail.

1.5.5 *Preparation of Stage 1 ESA Reports*

The Stage 1 ESA Reports were prepared in general accordance with NSW OEH (2011) on the basis of information collected during the previous tasks. In preparing these reports, (and in particular the proposed scope of work for Stage 2 assessments and remedial cost estimation) ERM utilised a combination of experience gained in the planning and delivery of similar vendor due diligence projects for government, professional judgement of suitably qualified contaminated land professionals and reference to relevant guidelines made or approved under the *Contaminated Land Management Act* (1997), the *National Environment Protection (Assessment of Site Contamination) Measure* (1999 and the *National Environment Protection (Assessment of Site Contamination) Amendment Measure* 2013 (No. 1)), *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (2000) and guidelines and technical notes relating to the *Protection of the Environment Operations (Underground Petroleum*

Storage Systems) Regulation 2008 (made under the *Protection of the Environment Operations Act* 1997).

1.6 *FOLLOWING A PROCESS OF REVIEW BY TREASURY AND OTHER KEY ADVISORS, DRAFT REPORTS WERE FINALISED FOR ISSUE. REPORT STRUCTURE*

This report has been structured in order to align generally with the requirements for a Preliminary Environmental Site Assessment outlined with NSW EPA (2011) *Guidelines for consultants reporting on contaminated sites.* Where necessary, minor additions and modifications to the structure have been made to accommodate the fact that this assessment is being undertaken for a specific purpose (that being Vendor Environmental Due Diligence - VEDD).

2 SITE DESCRIPTION AND SURROUNDING ENVIRONMENT

2.1 SITE IDENTIFICATION

Eraring Power Station is owned and operated by Eraring Energy, a State Owned Corporation (SOC) that manages a diverse set of electricity generating assets located throughout NSW, Australia.

Eraring Power Station is situated adjacent to the western shore of Lake Macquarie, near the township of Dora Creek, south west of Newcastle, NSW. The approximate coordinates of the Power Station are 361834 m E and 6340642 m S. The Lot and Deposited Plan (DP) information relevant to the site, along with the current land zoning for each parcel of land as per The Lake Macquarie Local Environmental Plan 2004, is outlined in *Table 2.1* (below). A Site Location Map is provided as *Figure 1*, and land zoning information is provided as *Figure 2*.

Table 2.1 Lot, Deposited Plan and Land Zoning Information

Lot	Deposited Plan	Folio Identifier	Area (ha)	Zoning	Land Use
1612	587100	1612/587100	0.2014	4 (1) Industrial Core	Outlet Canal
3	548546	3/548546	15.3592	9 Natural Resources	Eraring Power Station
4	262501	4/262501	1.7920	7 (2) Conservation (Secondary)	Outlet Canal
19	262501	19/262501	5.5450	4 (1) Industrial Core	Lake Macquarie Centre
23	262501	23/262501	0.5382	1 (2) Rural (Living)	Vacant Land
24	262501	24/262501	1.5360	1 (2) Rural (Living)	Vacant Land
25	262501	25/262501	1.6610	1 (2) Rural (Living)	Vacant Land
26	262501	26/262501	1.7970	1 (2) Rural (Living)	Vacant Land
27	262501	27/262501	0.8358	1 (2) Rural (Living)	Vacant Land
1	817425	1/817425	10.7200	9 Natural Resources & 4 (1) Industrial Core	Eraring Power Station
100	828283	100/828283	32.4000	9 Natural Resources & 4 (1) Industrial Core	Eraring Power Station

Lot	Deposited Plan	Folio Identifier	Area (ha)	Zoning	Land Use
101	828283	101/828283	2.7140	9 Natural Resources & 4 (1) Industrial Core	Eraring Power Station
211	840670	211/840670	1.7800	4 (1) Industrial Core	Eraring Power Station
50	840671	50/840671	5.4360	4 (1) Industrial Core	Eraring Power Station
51	840671	51/840671	0.3371	4 (1) Industrial Core	Eraring Power Station
11	1050120	11/1050120	879.4000	4(1) Industrial Core & 9 Natural Resources & 7 (2) Conservation (Secondary)	Eraring Power Station
3	621697	3/621697	1.5980	4 (1) Industrial Core	Inlet Canal
2	621697	2/621697	14.3200	4 (1) Industrial Core	Inlet Canal
1	621697	1/621697	7.8900	4 (1) Industrial Core	Inlet Canal
1	816174	1/816174	11.5300	4 (1) Industrial Core	Inlet Canal
301	806475	301/806475	25.6300	4 (1) Industrial Core, 7 (1) Conservation (Primary) & 7 (2) Conservation (Secondary)	Outlet Canal
302	806475	302/806475	5.8780	4 (1) Industrial Core & 7 (2) Conservation (Secondary)	Outlet Canal
20	734860	20/734860	2.8580	9 Natural Resource & 4 (1) Industrial Core	Eraring Power Station
21	734860	21/734860	0.1307	9 Natural Resources & 4 (1) Industrial Core	Eraring Power Station

Lot	Deposited Plan	Folio Identifier	Area (ha)	Zoning	Land Use
1	1109558	1/1109558	23.6500	9 Natural Resources	Eraring Power Station
2	1109558	2/1109558	6.3730	9 Natural Resources	Eraring Power Station
318	39722	318/39722	12.5800	9 Natural Resources & 6 (1) Open Space	Coal Haul Road

2.2 *SITE DESCRIPTION*

The total site area of the Eraring Power Station is approximately 1147 hectares (ha), which includes water canals, but excludes areas for associated mines. The power station operational area itself occupies approximately 150 ha. A Site Layout Plan is provided as *Figure 3.*

The inventory at Eraring Power Station includes approximately 180 buildings which include:

- Administration buildings;
- Control rooms;
- Workshops;
- Warehouses; and
- Various plant buildings.

Eraring Power Station comprises four coal fired units (Units 1 to 4) which have a total generated output of 2,880 MW for the station. All four units were upgraded between 2009 and 2012 to raise the gross unit capacity of each unit from 660 MW to 720 MW and 750 MW under overload. The station employs a once through cooling system using salt water from Lake Macquarie. Four 330 kV and 500 kV transmission lines provide connection to the electricity grid.

A list of Eraring Power Stations major plant, systems and equipment is provided below, with more detailed descriptions on the operational nature of the Site provided in *Section 3.3:*

- Boilers
- Steam Turbines
- Boiler Feed Pumps

- Generators
- Generator Transformer
- Black Start Gas Turbine
- Coal Handling Plant
- Coal Mills
- Coal Combustion Product Management Facility (Ash Dam)
- Cooling Water System
- Stacks

Engineering inspections completed for the Site (Worley Parsons, 2013) have reported that plant, most of which was commissioned 30 years ago, is generally in good condition. The condition of individual equipment or systems ranges from very good (associated with key equipment of systems recently installed or refurbished as part of upgrade works) through to reasonable for its age. The Power Station area itself is completely sealed with concrete hardstand of sound integrity.

Outside of the Power Station area, the Site contains the following features:

- An open canal providing water to the Power Station is sourced from an inlet at Bonnells Bay, running along the eastern side of Lake Eraring, delivering water to a pumping station in the east of the Site.
- An Attemperation Reservoir located in the east of the Site.
- Cooling water from the Power Station is discharged via an outfall tunnel which runs from the southern corner of the Power Station area to Myuna Bay.
- To the north-east of the Power Station area is a Switchyard, settling basin and oil retention weir, and cooling towers.
- The Coal Storage Area is situated in the central portion of the Site, and includes a coal unloading bay, bulldozer fuelling area and two surface water retention ponds.
- Also within the central portion of the Site (to the south of the Coal Storage area) is a sewage treatment works, water reservoirs, and four 1ML fuel ASTs known as the Fuel Oil Installation.
- The northern portion of the Site includes the Former (Northern) Gas Turbine area, which includes two fuel ASTs (estimated at greater that 1ML capacity each), four transformers, oil water separators and an oil containment dam.

- Also within the northern portion of the Site is a weighbridge, truck wash-out pits, oil water separators, and a rail loop.

- The Coal Combustion Product (CCP) Management Facility (Ash Dam) is found in the eastern portion of the site, with waste disposal areas (including asbestos) located on the south-west and north-west of the dam.

- A large network of internal sealed and unsealed roads, coal conveyor belts and above ground pipelines for fuel and fly ash transfer are also located throughout the Site.

2.3 *TOPOGRAPHY*

The elevation of the Site ranges between approximately 30 m above sea level at the Power Station area, to 40 m above sea level at the CCP Management Facility. The Power Station area is flat and situated within a natural depression, with the remainder of the site sloping up to the north, east and south. The study area is broadly bounded to the west by the Watagan and Sugarloaf Ranges.

It was understood that the Ash Dam slopes from 137.2 Relative Level (RL) at the western end to to 131 RL at the eastern side, with the internal eastern embankment has been raised locally to 132 RL for the northern part only (Aurecon, 2013).

Between 1996 and May 2010, seepage from the toe drains (as measured at weirs TD1 and TD8) has generally decreased, with rates recorded between 650 L/min to 20 L/min In 2011, the seepage rate was fairly stable at approximately one third of the maximum rate measured since 1996, calculated between 50 L/min and 220 L/min (Aurecon, 2011). Seepage measured from the ash deposits downstream of the dam (at the Wangi v-notch) also recorded a general decline in the base flow rate from a high of about 1500 L/min towards the end of 1997, to about 500 L/min in early 2007 (Aurecon, 2011). No further information regarding slope or hydraulic gradient of the Ash Dam was identified during the Premilinary ESA.

2.4 *GEOLOGY*

Regional Geology

Newcastle Coalfield Regional Geology Geological Series Sheet 9231 and part of 9131,9132 and 9232 (Edition 1) 1995 indicates that the site overlies late Permian, early Triassic age sandstone and siltstone of the Terrigal Formation and conglomerate, sandstone, siltstone and claystone of the Clifton Subgroup, subsequently overlain by the Quaternary age gravel, sand, silt and clay.

Soil

The study area is located on the Lake Macquarie landscape map (1:100,000), *NSW Soil and Land Information System*. This landscape is derived from the Narrabeen Group, alluvium overlying muddy sand estuarine sediment that features moderately deep, sulfidic, extratidal, non gravelly, loamy and sandy Hydrosol soils.

From a review of previously completed intrusive soil and groundwater investigation completed (Geo-Logix, 2011 a, b and c), site soils were generally found to contain a layer of shallow (up to approximately 3.0 m depth) fill material consisting of gravel, silt, sand and clay overlying clayey sand with gravel and gravelly clay to 10.0 m below ground level (m bgl). The intrusive works also reported the presence of intermittent weathered conglomerate and weathered sandstone along with coal seams within the natural lithology.

A review of acid sulphate soil information (accessed at http://www.asris.csiro.au/mapping/viewer.htm on 24 May, 2013) indicated that there was a low probability (with very low confidence) of encountering acid sulphate soils at the site, however a high probability of encountering acid sulphate soils was reported for land immediately west and south of the site.

2.5 *HYDROGEOLOGY*

The NSW Natural Resource Atlas online bore register identifies groundwater bores within a 10 km radius of the site are registered for irrigation, farming, private domestic and stock use. The standing water level in the bores is recorded as The standing water level in the bores is recorded as less than 15 m bgl. Licensed bores located within a 5 km radius of the site are listed in Table 2.2 (below).

Table 2.2 ***Licensed Groundwater Bores within a 5 km radius***

Bore ID	Distance from Site (km)	Direction from site	Use
GW029567	0.34	North	Domestic Irrigation Stock
GW202325	3.58	North	Monitoring Bore
GW033618	4.07	North West	Stock
GW033619	4.17	North West	Stock
GW053438	2.8	West	Domestic Stock
GW064033	4.73	West	Domestic Stock
GW052111	2.77	South West	Domestic Stock
GW064143	4.1	South West	Domestic Stock
GW078608	3.77	South West	Domestic Stock

From a review of previously completed intrusive soil and groundwater investigation completed (Geo-Logix, 2011), groundwater was encountered beneath the Site at depths varying between approximately 4.1 m bgl and 9.0 m bgl. An assessment of groundwater conditions beneath the Unit 1 Turbine House indicated that groundwater conditions were following to the northeast at a gradient of 0.011 m/m (Geo-Logix, 2011b), an assessment of groundwater conditions beneath the stores building indicated that groundwater was flowing towards the southeast at a gradient of 0.027m/m (Geo-Logix, 2011a), whilst an assessment of groundwater conditions beneath the vehicle and mobile plant workshop indicated that groundwater flowed to the southwest at a gradient of 0.02 m/m. Based on a review of previous intrusive investigations undertaken at the site, the groundwater flow direction could not be confirmed. However based on the proximity of surface waters and local topography, it was likely to flow in a south easterly direction, towards Lake Eraring.

2.6 *HYDROLOGY*

The site surface water flows and drainage features are presented in suface water flow maps available from the dataroom (reference numbers 10.01.05.03.13 and 10.01.05.03.14) and provided as *Annex F*. Based on a review of these maps, site hydrological features can also be summarised as follows:

- A cooling water system intersects the site from the south, up to the power station and discharges into Myuna Bay;
- The contaminated water system is comprised of four collection pits, an oil water separator and several collection or retention ponds. The Boomerang Pond, the Demin Plant Effluent Pits and overflow from the oil water separator and holding pond discharge into the Ash Dam. Seepage water from the Ash Dam is collected south of the Ash Dam at the toe drain collection pond which ultimately drains to Myuna Bay. Emergency overflow from the Ash Dam seepage can also occur in to Crooked Creek; and
- Surface water flows have been identified at several locations across the site, and discharge to several surface water bodies including Muddy Lake and Whiteheads Lagoon / Myuna Bay.

2.7 *SURROUNDING ENVIRONMENT*

Eraring Power Station is sited in a natural depression on the western shore of Lake Macquarie, near the township of Dora Creek with tracts of vegetated land separating the power station from the neighbouring communities.

The surrounding environment includes:

- Myuna Bay to the east;
- Northern Railway along the western boundary. Based on discussions with site personnel, it was understood that a freshwater wetland (listed under *State Environmental Planning Policy 14*) was also located to the west of the site;
- Lake Eraring and Bonnells Bay to the south; and
- A mixture of private and Crown Lands to the north.

Principal landholders adjacent to the site include:

- NSW Department of Lands - Crown Land to the north;
- Centennial Coal - Coorabong Colliery to the west and Myuna Colliery to the north east;
- Rail Services Australia - rail corridor which is adjacent to the west of the power station;
- Transgrid and Energy Australia - electricity supply infrastructure;
- NSW Sport and Recreation - Myuna Bay Sport and Recreation Centre to the east;
- Private Residents - rural properties of Myuna Bay and Eraring to the east; and
- Private residents - residential properties of Dora Creek to the south.

Given the industrial land use, it is noted that the Centennial Coal properties, the railway corridor and the electricity supply infrastructure could present off-site sources of contamination to the surrounding environment, and potentially the Site. It is noted that a perimeter network of groundwater monitoring wells will be established as part of the Phase 2 work scope to allow for an assessment of background conditions and potential off-site sources of impact (refer to *Section 8* for further information regarding the sampling plan).

Given the proximity of Lake Macquarie, surface water run-off was likely to flow in an easterly direction, hence the Site generally intercepts the railway corridor and Centennial Coal properties from residential, ecological and recreational receptors. The potential for impact at the western site boundary from off-site sources could not be excluded, however it is noted that the magnitude of the industrial operations at the Site potentially presents a higher risk to surrounding land than the aforementioned industrial properties.

2.8 *SENSITIVE RECEPTORS*

A summary of sensitive receptors identified as relevant to the Site include:

- Indoor and outdoor human health receptors in the form of industrial on-site users.
- Indoor and outdoor human health residential receptors, the nearest of which comprise part of the Dora Creek residential community, located 480 metres south of the attemperation pond.
- Intrusive maintenance workers both on and on-site.
- Recreational users of Whiteheads Lagoon, and the Myuna Bay Sports and Recreational Centre located east of the site.
- Recreational users of Lake Macquarie, including Myuna Bay and its tributaries, located south and east of the site.
- Ecological receptors, including marine ecological receptors in Lake Macquarie, a freshwater wetland to the west and vegetated areas, particularly to the north and west.

3 SITE HISTORY AND REGULATORY SETTING

3.1 SUMMARY OF SITE HISTORY

Information provided by Eraring Energy management and a review of aerial photographs (refer below) indicates that prior to construction of the Eraring Power Station, the Site and surrounds were primarily occupied by a mixture of small farms and native vegetation. The primary exceptions to this were the western portion of the current ash dam and the area to the south of the current switchyard. The western portion of the current ash dam was previously utilised as an ash dam for the nearby former Wangi Power Station. The area to the south of the switchyard, was used for recreational purposes (playing fields and pony club grounds) prior to construction of Eraring Power Station. Playing fields remain present in the same area at the time of report.

Site works for the construction of Eraring Power Station commenced in 1977, with Units 1 and 2 entering commercial operation in 1982, Unit 3 in 1983 and Unit 4 1984. The 'black start' gas turbine was first introduced into the grid in 2009.

3.2 SUMMARY OF HISTORICAL AERIAL PHOTOGRAPHS

A review of historic aerial photographs was conducted by ERM and is summarised in *Table 3.1* (below) copies of the photographs reviewed are included in *Annex D*.

Table 3.1 *Aerial Photograph Review*

Year	Site	Surrounding Area
1950	The Site is largely undeveloped and vegetated with the exception of the area surrounding the current outlet canal and pockets of small cleared fields closer to the current operational area. A larger cleared area is located near the current coal stockpile area. The use of the cleared area is unable to be defined. There is no evidence of any significant built features within the Site. Undefined and unsealed tracks are located throughout the footprint of what is now the Site and buffer lands.	Generally vegetation becomes more scattered to the east of the Site. The Great Northern Railway corridor is located to the west of the site. Some limited residential development is evident along the foreshore of Lake Macquarie near the Site and around the township of Dora Creek.
1966	The area of the current power station has been further cleared to consist of small fields and pockets of vegetation. Small buildings appear to be located in the southern area of the site however their use is not able to be identified. The large cleared area identified in the previous aerial photograph has undergone further clearing however its use is still unable to be identified. Several tracks / roadways run in both a north/south and east/west direction throughout the site and have	The areas to the north and west of the Site remain predominantly vegetated with trees. Some further residential and other development along the foreshore of Lake Macquarie near the Site and around the township of Dora Creek is visible.

Year	Site	Surrounding Area
	become more formalised then the previous aerial photo. A body of water appears in the vicinity of the current ash dam (understood to be an ash disposal area associated with the Wangi Power station which operated from 1956 - 1986).	
1975	The Site has undergone further clearing with the majority of the southern half of the site comprising cleared open space and pockets of scattered vegetation. Apart from increased clearing the Site appears to be largely unchanged with exception of the ash dam which has increased in size. There are no clear signs of any activities associated with the Eraring Power Station at this stage, with the northern portion of the site still heavily vegetated. Previous informal dirt tracks are no longer visible.	The areas to the north and west of the site remain predominantly vegetated with trees. Residential and other development along the foreshore of Lake Macquarie near the Site and around the township of Dora Creek is visible.
1984	The previous fields and small buildings have been replaced with the Eraring Power Station. The main infrastructure of the power station is now visible including the main building, inlet and outlet canal, coal storage area, storage tanks and transmission lines. The site layout appears to be very similar to the current site arrangement. An increased portion of the ash dam now appears to be water.	The areas to the north and west of the site remain predominantly vegetated with trees. Residential and other development along the foreshore of Lake Macquarie near the Site and around the township of Dora Creek is visible.
1996	The infrastructure associated with the power station is largely the same as was seen from the previous aerial photograph. The ash dam contains significantly more water than previously shown, with capping appearing to have taken place on the eastern side of the dam. A rail loop to the north of the coal storage area that brings coal to the site has now been established.	The areas to the north and west of the site remain predominantly vegetated with trees. Residential and other development along the foreshore of Lake Macquarie near the Site and around the township of Dora Creek is visible.
2009 (reviewed via Google Earth)	The site layout is similar to 1996. The attemperation pond has been constructed to the south of the main operational area and adjacent to the inlet canal. Clearance works have also been undertaken across the canal from the attemperation pond however the purpose of this is unclear. Rehabilitation of the eastern portion of the ash dam has commenced with the area containing scattered vegetation. The active area of the ash dam appears considerably drier than in previous photographs.	The areas to the north and west of the site remain predominantly vegetated with trees. Residential and other development along the foreshore of Lake Macquarie near the Site and around the township of Dora Creek is visible.

3.3 *HISTORICAL TITLES SEARCH*

Historical title deeds are used to identify previous owners of the site, their inferred land use and the potential for contamination from these land uses. A summary of the title deed provided for the site is outlined below. The findings of the titles search is also provided in full in *Annex D.*

Based on discussions with the Land, Engineering & Surveying Investigational Searcher engaged to compile the findings of the historical titles search, it was understood that the site was originally a 2000 acre grant that was subdivided into hundreds of 'residental acreage lots' which were acquired by The Electricity Commission of NSW and consolidated in the 1970s.

Prior to the aquisition and consolidation by The Electricity Commission of NSW, the site was largely owned by individuals. Between 1920 and 1970 (approximately) land comprising the site was largely occupied by farmers, vegetable growers and an orchadists, confirming the previous agricultural use of the site. Occupations listed for previous owners of land comprising the site included mine workers (from 1922 to 1954 at Lots 15 & 24 Section R DP 6747, from 1927 to 1947 at Lots 10 & 11 Section K DP 6747, Lots 9 & 12 Section K DP 6747, from 1966 to 1970 at Lot 7 and part of Lot 6 Section R DP 6747, and from 1968 to 1970 at Lot 5 Section E DP 6747), a coach painter (from 1946 to 1949 at Lots 10 and 11 Section R DP 6747), a machinist (from 1923 to 1946 at Lot 10 and 11 Section R DP 6747), a motor mechanic (from 1972 to 1973 at Lots 15 & 16 DP 4800), a boiler maker (from 1978 to 1981 at Part of Lot 3 DP 590371 and Lots 2 & 3 Section E DP 6747) railway employees, a plumber, fisherman, an architect, theatre exhibitors, labourers and carpenters.

Prior to ownership of the land transferring to these individuals, site proprietors were listed as The Excelsior Land Investment and Building Company and Bank Limited, Closer Settlement Limited, Lake Lands Limited or otherwise was listed as Crown Land.

Based on the review of historic titles, there are no particular likely uses of land that indicate potential material contamination.

3.4 *COUNCIL INFORMATION*

According to Baker and McKenzie (2013), the Lake Macquarie Local Environmental Plan 2004 (LEP 2004) currently designates the zoning and regulates land use for the Eraring Power Station. Lake Macquarie City Council (LMCC) is in the process of preparing a new City-wide draft Lake Macquarie Local Environmental Plan 2013 (Draft LEP). The land use and zoning designations in the Draft LEP that are applicable to the Eraring Power Station and its associated activities are, in some instances, materially different to those that apply under LEP 2004. Eraring Energy has advised the LMCC of these differences in its submission on the Draft LEP dated 21 December 2012. Eraring Energy has also confirmed that as of 9 April 2013, LMCC was still in the process of reviewing the submissions made on the Draft LEP. Based on a review of online information provided by LMCC, the Draft LEP will not be published (finalised) until late 2013 or early 2014 and therefore will not form part of considerations for the proposed work scope.

Section 149 Certificates

The Section 149 certificates for each of the 26 parcels of land that comprise the site were requested from LMCC as part of the Preliminary ESA. Information relevant to potential contamination issues as prescribed by Section 59 (2) of the *Contaminated Land Management Act 1997* for each of the parcels of land is summarised in *Table 3.2* (below). Copies of the Section 149 certificates are presented in full in *Annex D.*

Table 3.2 ***Information relevant to potential contamination issues as prescribed by Section 59 (2) of the Contaminated Land Management Act 1997***

Identifier		Issues under the Section 149 relevant to potential contamination				
Lot	**DP**	**The land (or part of the land) is significantly contaminated**	**The land is subject to a management order**	**The land is the subject of an approved voluntary management proposal**	**The land is subject to an ongoing maintenance order**	**The land is the subject of a site audit statement.**
1612	**587100**	No	No	No	No	No
3	**548546**	No	No	No	No	No
4	**262501**	No	No	No	No	No
19	**262501**	No	No	No	No	No
23	**262501**	No	No	No	No	No
24	**262501**	No	No	No	No	No
25	**262501**	No	No	No	No	No
26	**262501**	No	No	No	No	No
27	**262501**	No	No	No	No	No
1	**817425**	No	No	No	No	No
100	**828283**	No	No	No	No	No
101	**828283**	No	No	No	No	No
211	**840670**	No	No	No	No	No
50	**840671**	No	No	No	No	No
51	**840671**	No	No	No	No	No
11	**1050120**	No	No	No	No	No
3	**621697**	No	No	No	No	No
2	**621697**	No	No	No	No	No
1	**621697**	No	No	No	No	No
1	**816174**	No	No	No	No	No
301	**806475**	No	No	No	No	No
302	**806475**	No	No	No	No	No
20	**734860**	No	No	No	No	No
21	**734860**	No	No	No	No	No
1	**1109558**	No	No	No	No	No

1. Refer to *Annex D* for copies of the certificates2

Based on a review of the Section 149 certificate information, there were no identified potential material contamination issues relevant to the site at the time of this Preliminary ESA.

3.5 *ENVIRONMENTAL APPROVALS, LICENSES AND MANAGEMENT*

Eraring operates under a range of State and Commonwealth Government environmental legislation, which is outlined in its register of applicable environmental legislation. It is noted that whilst a comprehensive review of planning approvals and general environmental management was beyond ERM's scope of work for this assessment, in some instances these approvals and management system provide context for potential contamination sources (eg ash disposal) and hence a summary of salient points in relation to these issues has been set out in this report.

3.5.1 *Planning Approvals*

The original Eraring Power Station Environmental Impact Statements were prepared by the Electricity Commission of NSW in August 1975 (comprising two 660MW generating units) and December 1977 (Eraring Power Station Units 3 and 4). Since the original development, a number of modifications and additional approvals have been granted by either the Minister of Planning and Infrastructure and/or Lake Macquarie City Council.

A summary of approvals issued under Part 3A Major Project Applications of the *Environmental Planning and Assessment Act 1979* include:

- Capacity Upgrade and Attemperation Reservoir (Approved 26 June 2008): Capacity increase and performance improvements at the existing Eraring Power Station, comprising; replacement upgrade of plant components such that the nominal capacity of each turbine is increased from 660 MW to 750 MW; and construction and operation of up to a 920 ML cooling water attemperation reservoir.

- Upgrade/Expansion of the Coal Combustion Product Management Facility (Approved 29 April 2008): Staged expansion of the CCP management facility in conjunction with changes in the CCP disposal method from lean phase to dense phase. The project also included the installation of new infrastructure comprising CCP collection, storage, conditioning and pumping facilities.

- Emergency Gas Turbine Generator and Ash Dam Expansion at the Eraring Power Station (Approved 14 December 2006): Construction and operation of a 42 MW emergency turbine generator.

In addition to these, a number of Part 4 applications have been approved for the Site generally relating to the construction or demolition of structures, tree removal or subdivision of land.

3.5.2 *Environmental Protection Licences*

Eraring Energy holds two Environmental Protection Licences (EPL) issued under Section 55 of the Protection of the Environment Operations (POEO) Act. Under the POEO Act, licences are required for "scheduled activities". Eraring Power Station's license to operate includes management and monitoring requirements, operational limits, criteria for limiting emissions and reporting requirements.

Eraring Energy holds EPL 1429 for the premise described as 3 and 28 Rocky Point Road and 45 Point Piper Road, Eraring, NSW, 2264. This includes Lot 3/8 DP6467, Lot 13/16 DP6747, Part Lot 13/16 DP 6747, Lot 11 DP105120, Lot 7/16 DP 262501, Lot 301 DP808475, and Lot 302 DP 808475. The EPL authorises the electricity generation as well as chemical storage, coal works and sewage treatment systems. Non-compliances reported under EPL 1429 as presented on the EPA website are summarised in *Table 3.3* (below). We note that most of these non-compliances are not relevant to contamination considerations but are noted for completeness.

Table 3.3 *Reported EPL Non-Compliances*

Date received	Licence condition number	Type of non compliance
Sep-11	M2.1	Only 11 of 12 results were available for sampling points 4 and 5 for particulates deposited matter due to vandalism. Poles now coated with material to discourage climbing.
Mar-06	M2.1	Testing for flouride and undifferentiated particles was carried out in accordance with prescribed methods to the extent permitted by the configuration of access galleries and ports at Monitoring Points 11, 12, 13 & 14.
Mar-06	M6.1	Daily discharge volumes were not available for a period of time during the control system changeover from the old analogue to the new digital ICMS. This included time taken after the changeover to calibrate and fine tune the data input system.
Mar-06	M point 16	Ambient Air monitoring station at Dora Creek - data for temperature at 2M and 10M, rainfall and solar radiation was not available until June 2005 due to delays by contractor in installing instrumentation
Mar-06	M point 13	Discharge and Monitoring Point 13 - Boiler 3 discharge to stack as shown on site plan ER328067A. Yearly analysis for Volatile Organic Compounds was not undertaken.
Mar-05	M6.1	Water discharge volumes not available due to lightning damage to instruments
Mar-05	M2.1	Fluoride and Particulates not measured strictly in accordance with approved methods

Date received	Licence condition number	Type of non compliance
Mar-05	O1.1(a)	Accidential release of R22 refrigerant gas 27/4/2004
Feb-04	M2.1	The location of AAQ monitoring sites do not comply with prescribed standard
Feb-04	M2.1	Stack emission test points do not comply with prescribed standard
Feb-04	M6.1	Water discharge volumes only reported monthly not daily as required due to operational problems with instrument data loggers
Feb-04	M21	June 2003 high rainfall caused dust deposition gauges to overflow. No results available
Feb-04	L3.3	January 2003 copper discharge 6.1 ug/L exceeded the limit 5 ug/L
Mar-01	M2.1	Multi point calibration completed late
Mar-01	M2.1	Two fluoride emission tests conducted using the old test method. Station is now using the correct method USEPA Method 13B
Mar-01	M3	NFR sampling procedure suspect, new procedure adopted

The non-compliances reported to the EPA largely relate to inadequacies in the sampling approach or methodology. Accidential release of R22 refrigerant gas was reported for 27 April, 2004 (receipt date March 2005) and copper discharge exceeding the allowable limit was reported for January 2003 receipt date February 2004). No further information regarding the nature or specific location of these non-conformances was available.

Eraring Energy also holds EPL 4279 for the premise described as Eraring Coal Delivery Facility, Eraring Power Station, Construction Road, Dora Creek, NSW 2264. This includes Lot 100 DP 828283, and Lot 50, 51 DP 840671. The EPL authorises Coal Works.

3.5.3 *Environmental Management*

Eraring Energy has an Environmental Management System (EMS) for the management of current and potential environmental issues. The Eraring EMS is certified to ISO 14001:2004 Environmental Management Systems - Specifications and Guidance for Use. The most recent recertification assessment was undertaken by NCS International in July 2012 and certification was reaffirmed.

In addition to the EMS, a Land Management Plan (AECOM, 2010) has been implemented at Eraring Power Station. This Plan documents the overarching strategy for management of the Site, including biodiversity, soil and groundwater contamination, rehabilitation, weed management and controlled burns. Relevant parts of the Land Management Plan have been summarised in *Section 5.2* of this report.

A Pollution Incident Response Management Plan has been prepared for both EPL 1429 and 4297 in response to the POEO Amendment (Pollution Incident Response Management Plans) Regulation 2012.

Eraring Energy undertakes internal and external audits to assess ongoing compliance and environmental performance at the station. Environmental audits undertaken include:

- ISO 14001 Audits;
- National Greenhouse and Energy Reporting Scheme Verification Audits; and
- Internal Compliance Audits.

4 OPERATIONS

4.1 GENERAL DESCRIPTION OF PROCESSSES

The facility consists of a four unit coal fired thermal power station and a black start gas turbine power plant, currently fired on distillate. The four coal fired units have a total generated output of 2,880 MW for the station as a whole, with all four units having been upgraded between 2009 and 2012 to raise the gross unit capacity of each unit from 660MW to 720MW. The gas turbine has a nominal output of 40MW and is located in a bunded area east of Unit 3.

Most relevant design and layout features of Units 1 to 4 at Eraring Power Station include:

- Unitised boilers and turbine generators.
- Two chimneys, each serving two boilers.
- Once through cooling using salt water from Lake Macquarie, supplemented with a large scale reservoir for outlet attemperation.
- A Yokogawa integrated control and monitoring system (ICMS) serving all units.
- Semi-clad balanced draught, natural circulation, sub-critical, type boilers incorporating reheat.
- Tandem compound, reheat, condensing steam turbines driving hydrogen cooled generators arranged longitudinally in a fully enclosed turbine building.
- 330kV electrical connection for units 1 and 2 and a 500kV connection for Units 3 and 4 into the Transgrid Switchyards via overhead conductors;
- Fabric filters for fly ash collection.
- Open and covered coal stockpiles.

4.1.1 *Turbine Generators*

Eraring Power Station's four Turbo Generators were originally rated at 660-megawatt each. The steam-driven turbines are of the tandem compound reheat type with single-flow high pressure, double-flow intermediate pressure and two double-flow low-pressure exhaust cylinders. Operating speed is 3,000rpm.

The four associated boilers are single-furnace, twin-drum type using natural circulation with divided back pass and balanced draught. A turbine steam by-pass system stabilises boiler firing at low load and enables easy matching of steam to turbine metal temperature during start-up reducing thermal stresses and start-up times.

Between 2009 and 2012, each Boiler and Turbine has been upgraded for 720 megawatt capacity.

4.1.2 *Fuel Supply*

Eraring Power Station receives black coal by road, rail and overland conveyor from three local coal mines. Annual consumption of coal is approximately 5.6 Mt.

4.1.3 *Transmission*

Each generator is connected to a pair of generator transformers. These raise the generated voltage of 23 kV to the transmission voltage of 330 kV in Units 1 and 2, and to 500 kV in Units 3 and 4. Electricity is transmitted overhead to the 330 kV and 500 kV switchyards which form part of the interconnected transmission system. Units 3 and 4 at Eraring Power Station were the first generators to be connected to a 500 kV switchyard. 500 kV has been established as the appropriate voltage to meet bulk power supply needs.

4.1.4 *Ash Disposal*

Eraring Power Station utilises dry pneumatic conveying equipment to collect and convey fly ash collected from the boiler flue gas to two storage silos; one for coarse, and one for fine, fly ash. The fine fly ash is a more saleable product, with a significant percentage (45% in 2011/2012) of the ash generated recycled for other purposes.

For the bottom furnace ash on Units 1, 2 and 4, dry Magaldi Ash Conveyors (MACs) have been installed over the past three years. Unit 3 is still operating with the original water-impounded ash hoppers. All units discharge their bottom ash into the ash sluice trenches which transfer the ash to an ash pit and then to the Eraring CCP Management Facility.

Fly ash that is not sold is transported from the fly ash storage silos to the CCP Management Facility as high concentration slurry. The current rate of ash production exceeds 1.2 Mt per year.

Further information on ash disposal is provided in *Section 4.5*.

4.1.5 *Water Supply*

The main cooling water supply for Eraring Power Station is from Lake Macquarie. Saltwater cools the turbines through the condensers via six 'once through' circulating water systems and is returned to Lake Macquarie via an outlet canal. This process is discussed further in *Section 3.12*. Routine inspections, condition monitoring and maintenance have resulted in the water supply infrastructure being in good condition (Worley Parsons, 2013).

Domestic potable water is supplied to the site from Hunter Water. This source supplies the site via a 375mm main and associated 300 mm water meter located at the intersection of Cross Street and Rocky Point Road. Water travels to the Break Pressure Tank, which provides a barrier between the power station and Water Supply. The site also contains a Water Reclamation Plant (WRP) that recycles effluent to provide feedwater for its boilers. The WRP is able to treat 4.7ML of effluent per day to create 3.75ML of reclaimed water. This effluent is sourced internally and externally and is discussed further in Section 3.12.

4.1.6 *Other Activities*

Associated with the operation and maintenance of the Eraring Power Station are a number of Maintenance Workshops located within the facility. The two main workshops included the 'Daywork Main Workshop' and 'Ash and Dust Common Workshop'. It is understood a range of materials were historically stored at these locations, including the chlorinated solvents (trichloroethylene (TCE)) used for degreasing and parts washing.

Truck wash-out pits were observed to the north of the aboveground distillate and sump oil tanks. At the time of the ERM Site visit, the pits were observed to be in poor condition with build-up of oil and waste in the base of the pits. Waste water from these pits is transferred to the oil retention lagoon prior to transfer into the CCP. Based on a review of a Contaminated Water Briefing Paper prepared by Ring (2004), it was understood that oily sludge retrieved from the oil water interceptor is dried out and then stockpiled on unsealed hardstand adjacent to the truckwash bays, prior to being buried on site (location unspecified). However it is noted that based on discussions with Eraring environmental staff, this material is disposed at an off-site, licenced facility. Given the elevated hydrocarbons concentrations generally associated with this sludge, the stockpiling activities could pose as as a potential point source of contamination, and a potential breach of licencing conditions. It is noted that four sampling locations have been designated for this area, to assess for potential soil and groundwater impact (refer to *Section 8*).

4.2 *INVENTORY OF CHEMICALS & WASTES*

Eraring Energy issued a 'Notice of Dangerous Goods on the Premises' on 12 January 2012 that included details of dangerous goods held on site, figures indicating their locations and as dangerous goods and combustible materials manifest including photographs and description of each location/depot.

External audits of hazardous materials are understood to be undertaken every two years by an external consultant, and secondary containment and signage of dangerous goods has found to be suitable.

The dangerous goods notification indicated the presence of 35 above ground storage tanks (ASTs) ranging in volume from 1000L to 1.2ML, with the largest associated with the storage of distillate and fuel oil for start ups. The smaller ASTs were reported to store a range of liquids including:

- Liquid Carbon Dioxide (2 x 7000 L ASTs);
- Sodium Hydroxide (1 x1000 L, 1 x 6000 L, 2 x 115 000 L ASTs);
- Ferrous Chloride (2 x 30 000 L, 2 x 100 000 L ASTs);
- Sulphuric Acid (2 x 80 000 L, 1 x 13 000 L ASTs);
- Sodium Hypochlorite (1 x 9200 L, 1 x 10 000 L AST);
- Aqueous Ammonia (1 x60 000 L AST);
- Nitrogen Gas (1 x 200L AST);
- Fuel Farm Overflow (1 x 36 000 L AST);
- Diesel (4 x 6000 L, 1 x 10 450 L ASTs);
- Transformer Oil (4 x 25 000 L ASTs); and
- HPU Turbine Hydraulic Fluid (4 x 4500 L ASTs).

While not documented within the Site's dangerous goods and combustible materials manifest, two formerly operational but now decommissioned ASTs of an estimated 1.5 ML are located within the Former (Northern) Gas Turbine area of the site. It is understood these tanks are now empty, but historically contained fuel oil servicing the twin gas turbines that were operated using a combination of distillate and sump oil.

An additional four underground storage tanks (USTs) are also indicated on the current dangerous goods notification, containing diesel, petrol and combustibles. USTs are understood to be approximately 30 years old and of single steel wall construction. Based on previous investigations completed by Geo-Logix (2011a, b and c), details of the USTs currently present on site are summarised in *Table 4.1*.

Table 4.1 *Summary of USTs present on site*

Location	Capacity (litres)	Product	Status
Stores Building[1]	58,900	None currently, previously ULP	Previously used for refuelling site vehicles. Understood to have been decommissioned in-situ.
Stores Building[1]	33,500	None currently, previously diesel	Previously used for refuelling site vehicles. Understood to have been decommissioned in-situ.
Stores Building[1]	Unknown	LP	Temporarily decommissioned with rust inhibitor solution.
Unit 1 Turbine House[2]	20,000	Waste Oil	In use.
Unit 1 Turbine House[2]	50,000	Lubrication Oil	In use.
Vehicle and Mobile Plant Workshop[3]	4,500	Waste Oil	In use.

1. Geo-Logix (2011a).
2. Geo-Logix (2011b).
3. Geo-Logix (2011c).

Decommissioning reports were not available for any of the USTs abandoned in-situ, hence no further comments could be made regarding the suitability of the decommissioning works undertaken on the site. It is noted that under the Underground Petroleum Storage Systems (UPSS) Regulation 2008, USTs should be preferentially decommissioned by removal unless in-situ decommissioning can be adequately justified. Based on a review of the Geo-Logix (2011a) report, the diesel and ULP USTs previously used for refuelling on-site could not be decommissioned by removal due to the potential risk to subsurface services. Based on discussions with Eraring Energy personnel, it was understood that integrity tests have been completed on the main turbine refuse oil UST and the garage refuse oil storage that remain in use. Groundwater sampling is proposed for the existing monitoring wells currently surrounding the USTs. Additional, grid based sampling has also been designated for areas surrounding the stores building, Unit 1 turbine house and the workshop (refer to *Section 8*).

Polychlorinated Biphenyls (PCBs) have historically been widely used throughout the transmission network in transformers, capacitors and light fittings at the Site. Eraring Energy has a procedure for the use, handling and disposal of PCBs, and a PCB removal program was undertaken during the late 1990s. Equipment containing PCBs was recorded in a PCB register to facilitate management phase out and disposal, which indicates that there are currently twelve transformers with between 2.1 and 4 ppm of PCBs in transformer oil. Eraring Energy plans to manage the transformers with these low level PCBs through appropriate disposal at the end of the equipment's life. Based on discussions with the Eraring Energy environmental team, PCBs on site were stored within the transformers and no other separate, storage area was used.

Scheduled and non-scheduled PCBs that were identified were reported by Eraring Energy to be managed via disposal at an appropriately licenced, off-site facility. Historic handling, disposal and operational loss of PCBs may have resulted in soil and groundwater contamination.

Eraring Energy has developed an asbestos register that identified the location, condition and management of known asbestos at Eraring Power Station (Version 3, dated June 2011). This register is presented as *Annex* G of this report. Based on a review of the asbestos register, the presence of asbestos containing material on site can be summarised as follows:

- Gaskets and stop valves associated with pipeworks and cylinders at the turbine and associated plant;
- Cell diaphragms in the hydrogen plant;
- Asbestos containing waste water from the air removal pumps at the turbine;
- Gaskets associated with the boiler;
- Electrical insulation material at switchboards, transformers, rotors and stators across the site;
- In brake linings;
- Asbestos containing sealing gaskets at the bulk caustic and acid tanks;
- Bonded asbestos cement pipework associated with the contaminated water system;
- Bonded asbestos cement pipework associate with ash, duct and slurry management;
- The toe drain foundation of the Ash Dam contain asbestos;
- Asbestos sheeting used in the construction of residential houses; and
- The northern and southern asbestos disposal areas (refer to *Section 4.5*).

The asbestos containing material identified in the register were generally considered to pose a low to negligible exposure risk. The register also identified inspection and management strategies for the asbestos material identified.

Due to the presence of asbestos in building materials and equipment there is the potential for asbestos to have resulted in soil contamination. Given the asbestos pipework associated with the ash, dust and contaminated water treatment systems, there was potential for asbestos fibres to be associated with material in the Ash Dam as well as waste water and stormwater drainage.

4.3 *PRODUCT SPILL AND LOSS HISTORY & OTHER DISCHARGES*

Eraring Energy has implemented an Incident Management Procedure as part of its EMS, which sets out the requirements for the management and reporting of environmental incidents and complaints. Reportable incidents are documented in EPL Annual Returns. A summary of non-conformances available in the data room is provided below:

- October 2011 - 2B Generator Failure and Fire: A failure of the 2B Generator Transformer resulted in a rupture of the transformer casing and fire. As a consequence, an unknown volume of transformer oil was released on-site. The application of water during fire fighting resulted in a quantity of oil being washed into drains and into the outlet canal, and subsequently quantities of oil were visible in Lake Macquarie following the incident. A slight oil sheen was observed on the shoreline of local communities in the Silver Water and Sunshine areas (refer also to *Section 4.6.2*).

- December 2011 - Oil Release to Stormwater: Following fire protection deluge tests, oil was observed in a stormwater drain leading to the outlet canal (refer also to *Section 4.6.2*).

- December 2011 - Ferrous Chloride Release to Outlet Canal: Several hundred litres of ferrous chloride was discharged to the outlet canal following the return to service of the 4A condenser. Monitoring of Myuna Bay did not report any impacts (refer also to *Section 4.6.2*).

- January 2012 - Minor Contaminated Water Leaks: Reported into the stormwater at contaminated water pit 2. The pump was stopped and the coupling repaired.

- January 2012 - Discharge at Outlet Canal: Approximately 500 litres of ferrous chloride solution was discharged at the outlet canal, due to Unit 4 being out of service.

- February 2012 - A Leaking Fly Ash Pipeline: A fly ash reject pipeline to the coal combustion plant was leaking on the western side of the Hill Road Bridge. The pipe was repaired and realigned, with longer term plans to replace the pipe. No environmental harm was reported for this incident.

- February 2012 - Oil Leak: An undisclosed amount of oil was reported as having leaked from the temporary transfer lines connecting contaminatied pit 1 to contaminated pit 2. The spill was cleaned up and no environmental harm was reported.

- February 2012 - Foam Discharged to Lake Macquarie: Foam was reported as having discharged from the power station outlet canal to Lake Macquarie, because pump B had been switched off for no apparent reason. The pump was restarted and no environmental harm was reported as a result of this incident.

- March 2012 - Minor Oil Spill at the Warehouse: A minor oil spill (less than one litre) occurred when a pall filter was delivered to the warehouse. The spill was contained and cleaned.

- March 2012 - Hydraulic Hose Failing: A hydraulic hose failed on the back of an oil truck causing an oil leak approximately 0.6 to 1.0 km long. The oil spill was contained and cleaned with oil sorb equipment.

- March 2012 - Operation of Diesel Generator Cooling Towers: Foam built up in the tower basin and spilt into surrounding areas when the diesel generator cooling towers were put into service. The spill was contained with a chemical spill kit.

- March 2012 - Ferrous Chloride Spill: A ferrous chloride bulk storage spill occurred during delivery by bulk tanker. Product was noticed coming from the overflow line of Tank A. Unloading ceased when the spill was noticed.

- April 2012 - Overflow from Drainage Testing: Overflow occurred during deluge testing into stormwater drains. No environmental harm was reported.

- June 2012 - Foam Observed at Outlet Canal: Foam was reported at the cooling water outlet canal in Myuna Bay. The antifoam flow was restored and the issue resolved.

- June 2012 - Oil Slick on Canal Road: An oil slick from a vehicle was found adjacent to a stormwater drain on Canal Road. Absorbant matting was applied to spill as part of clean up efforts.

- July 2012 -Chemical Waste Leak: Reported for the pipework leading from the polisher regeneration plant to the ask dam. The discharge occurred to the stormwater drain behind the Daywork Maintenance workshop.

- August 2012 - Oil Leak at Ash Plant: Approximately 100L of oil was reported in the ash plant. The leak was isolated and repaired and no further environmental harm was reported.

- August 2012 - Coal Combustion Silo Overflow: A coal combustion product silo overflow was reported, with dry dust spilling onto the bunded floor below. The dust sprayed with water to prevent airborne dust escaping and then removed using a vaccuum truck.

- September 2012 - Oil Release: Approximately 300L of oil was released due to a flange failure on the 4A auxiliary cooling pump, with some oil reaching the low level cooling water canal. No observable oil was found upon inspection of the outfall.

- September 2012 - Overfilling and Oil Release from Refuse Tank: The failure of the number four generating unit resulted in the overfilling of the refuse oil tank, with oil being emitted from the tank vent. Approximately 200L of oil was lost to the surrounding concrete surface external to the bunded area. Some oil reached the stormwater drains, however inspection of the outlet canal, lake and foreshore found no evidence of oil.

- October 2012 - Ferrous Chloride Release to Outlet Canal: Approximately 500L of ferrous chloride was released to the outlet canal following the return to service of Unit 3.

- October 2012 - Hydraulic System Leak: The unit 3 hydraulic system was found to have been continually leaking onto the basement floor outside the bunded area. The leak was repaired and visual spills was cleaned.

- October 2012 - Overflow of the Hazardous Disposal Area: The hazardous disposal area was reported to be overflowing with waste substances being stored outside the bunded area.

Based on a review of the recordable incidents outlined above, the issues were generally managed immediately (i.e. cleaned up), and ongoing management measures were not implemented. A combination of targeted as well as a 50 metre, grid-based sampling approach was proposed for the operational area of the site. It is envisioned that this would suitably characterise the operational area, as well as any significant contamination hot spots that may have resulted from past spills and loss. Sediment and surface water sampling is also proposed for Lake Macquarie, Whiteheads Lagoon the Return Water Pond and Crooked Creek, to assess for off-site migration of contaminants.

4.4 *FUEL MANAGEMENT*

Eraring Power Station uses light fuel oil for its boiler auxiliary fuel requirements but is also able to use refined recycled oil. The main consumption of oil is for:

- Lighting of burners when starting up the boilers;
- Warming and initial steam raising in the boiler during start-up;
- Additional capacity;
- Supporting combustion at low load and/or when coal quality dictates; and
- Mill changes.

The fuel oil installation for Eraring Power Station known as Depots 23 to 26 (Fuel Oil Tanks #1 to #4) are 1,200,000 L steel ASTs used for the storage of diesel (Depot 23) and Fuel Oil (Depots 24, 25 and 26). Fuel stored within these ASTs is delivered to the Site via road tanker. These depots supply fuel oil via an above ground 300mm (estimated) diameter pipeline to the Gas Turbine, the bulldozer refuelling station, the two 6000L ASTs for the diesel generators (depots: H7 & H8) and the two 6000L ASTs for the fire pumps (depots: H9 & H10). Each of the four tanks are individually bunded with drainage from the bund draining to one of two oil/water separators. Tank levels are checked weekly and reconciled against delivery and usage records. No other information regarding potential fuel loss was available in the form of fuel reconciliation assessments or the results of formal integrity testing.

A summary of ASTs located within the site, including content and volume is supplied within *Section 4.2*. A summary of USTs located within the site, including construction, content and volume is supplied within *Section 4.2*.

4.5 *WASTE AND ASH DISPOSAL*

The *Eraring Power Station Waste Register* classifies wastes produced onsite and details storage and disposal requirements. Veolia is the licenced contractor that undertakes waste, liquid waste and recycling management at the site. Suitably licenced contractors are used to remove and dispose hazardous waste off site. A breakdown of waste produced at Eraring Power Station from 2010/2011 includes:

- 1 296 041 tonnes of ash;
- 16 182 tonnes of vegetation and construction material waste; and
- 4 tonnes of oily rags and filters.

It should be noted that based on discussions with Eraring Energy environmental personnel, these oily rags were unlikely to have come in contact with transformer oil, hence the oily rags were likely to have been from general maintenance activities.

Historically refuse was dumped onsite. A review of site drawings and visual confirmation during the Site visit indicates a capped general waste dump is located to the western edge of the ash dam. Firm historic information regarding this facility is unavailable however it is suggested in previous reports by Worley Parsons (2013) that the area may contain scrap metal, builders waste and construction waste and empty drums. Most waste is currently removed from site by Veolia. Waste currently stored onsite include crushed concrete, wood, cardboard, and seaweed collected from the inlet screens, which is used for rehabilitation surrounding the Ash Dam. An historic sewage disposal event has been recorded, which is not permitted in the EPL. Based on discussions with Eraring Energy environmental personnel, diposal of drums (or similar) containing chemicals was not undertaken at the site.

Asbestos disposal has been reported in two designated landfill areas adjacent to the Ash Dam, as described below:

- Northern Asbestos Disposal - Located west of the Ash Dam. Based on a review of a Pacific Power site drawing (dated 2000; Dataroom reference 10.01.03.01.02), this disposal site was closed in 1997 and was bound by a gate and fence which carried identification and signage of the former disposal site. This area was understood to be capped and vegetated.

- Southern Asbetos Disposal - Located south west of the Ash Dam, immediately north of an internal access road. Based on a review of a Pacific Power site drawing (dated 2000; Dataroom reference 10.01.03.01.02), this disposal site was closed and had been capped with used fabric filter bags. The former disposal site was identified by four corner posts and warning sites. A review of an Eraring Energy site drawing (dated 2005; Dataroom reference 10.01.03.01.01) indicated that the southern disposal area covered a total area of approximately 6330 m^2, and was comprised of 19 trenches which had likely been progressively filled from 1987 to 2005.

Due to the general waste disposal surrounding the southern asbestos disposal area, and the capping of this areas with filter bags, sixteen sampling lcoations were proposed for this area to better delineate any known sources and contaminants present in this area. Given that the contents of the northern asbestos disposal area were perceived as being consistent, with clear fencing around the boundary, one down gradient groundwater monitoring well has been proposed for this area to characterise any potential migration of contaminants (refer to *Section 8*).

Ash is currently not deposited on these areas however would receive ash as the dam nears capacity. A capped general waste dump is also located to the western edge of the ash dam. The disposal of such products is permitted under the EPL 1429. Asbestos waste is now removed from the site by a licenced contractor and taken to Lake Macquarie City Council's Awaba Tip. An asbestos register for the site has been created that lists the location, condition and management of known site asbestos.

The Ash Dam is located on the northeast side of the facilities' footprint. Inputs into the dam include ash slurry, water from Boomerang Pond (dirty water), rainfall, and runoff. Underground mine water is also discharged into the dam from the neighbouring Awaba mine to the north of the site. During periods of extended rain, overflow from the oil retention lagoon enters the dam. A Selenium Pollution Reduction Program was completed in 2005, which involved diversion of rain water into the dam, and hence also minimised discharge from the dam and which also involved capping and revegetating more than 60 hectares of the Ash Dam. As a result of the program, selenium discharges from the dam were reduced by approximately 45% to approximately 150 kilograms per year.

Approval to upgrade and expand the CCP was obtained in 2008. Ash was previously pumped into the dam at a ratio of approximately 30:70 solids to water. A dryer product is now pumped into the dam at a ratio of approximately 70:30 solids to water. Flyash placed into the ash dams is recycled at an adjacent plant operated by Flyash Australia. It is used in construction as a cement substitute. Boral also operates a facility to mine and recycle bottom ash (from coal combustion processes) which is used in various industries. A goal of 80% reuse by 2015 has been set as part of the dam's long-term strategy. Current reuse rates are approximately 47%. The capacity of the ash dam is forecast to be reached by 2032 if recycling targets can be met.

Monthly groundwater monitoring undertaken by Aurecon identified elevated levels of selenium in groundwater down gradient of the CCP since January 2012 peaking at 0.0402 mg/L in February 2012. Results are in excess of ANZECC 95% protection levels for freshwater (0.011 mg/L). No EPL specific limits are given for groundwater analytes.

4.6 *WATER AND WASTEWATER MANAGEMENT*

4.6.1 *Water Supply*

Cooling water is taken directly from Lake Macquarie, which is Australia's largest coastal lake. Water enters the inlet canal in Bonnells Bay and piped below Dora Creek towards the generators.

The site is connected to the town water supply, while also utilising wastewater that is treated onsite. This water is sourced from both internal sources and external sources including the Myuna Bay Sport and Recreation Facility and Hunter Water's Dora Creek Wastewater Treatment Works.

Approximately 3.5 ML of non-potable water is recycled per day. Recycled water is used for fire servicing, plant washing, or further demineralisation to make suitable for use in the Power Station boilers.

4.6.2 *Water Discharges And Treatment*

A Surface Water Management Plan has been developed for the site (AECOM, 2008) that guidelines for the management of surface water across the site. This plan is summarised in *Section 5.1*.

The key legislative requirement for water management at Eraring Power Station is the EPL (1429) which requires monitoring of: water discharges; ambient water quality in Lake Macquarie; and water discharge from the CCP to the 'Glory Hole' (then outlet canal). Section 5 and 9 of the EPL also list water management requirements and cooling water discharges.

No non-compliances were recorded between 2009 and 2011. Four water related non-compliances were recorded during the 2011/2012 reporting period. Of these four, three were related to major incidents including:

- The failure of 2B Generator transformer in October 2011;
- An oil spill resulting from fire protection deluge tests in December 2011; and
- The discharge of ferrous chloride to the outlet canal in December 2011.

These incidents were documented as environmental incidents (as discussed previously in *Section 4.3*) and investigated accordingly. The other non-compliance was the exceedance of the EPL limit for Copper at the outlet canal. This was caused by errors in sampling and analysis at trace levels (Worley Parsons, 2013). Other recent reported incidents include:

- Failure of the 4A auxiliary cooling water pump resulting in 300 L of oil was lost due to pipe flange failure (2 September 2012). A small amount of oil entered the cooling water canal;
- The failure of a generating unit causing allowing water to enter the refuse oil tank causing overfilling and emitting oil from the tank vent; and
- The return to service of unit three causing the release of 500 L of ferrous chloride to the outlet canal.

Laboratory analytical data for surface and groundwater sampling undertaken between 2006 and 2013 was made available to ERM during the course of this investigation. This data was compared against the EPL limits, ANZECC (2000) ecological criteria and the Australian Drinking Water guidelines. A summary of the exceedences reported for this review is included in *Section 5.1.1*.

Cooling Water System Discharges

Cooling water is returned to Lake Macquarie via the outlet canal in Myuna Bay. The water is generally limited to temperatures below 35°C, as stated in the EPL. Water may be discharged at temperatures up to 37.5°C for 131 hours over the annual reporting period. These hours were not used during 2012, which has been linked to reduced demands and outages from unit upgrades and the construction of the attemperation reservoir. Ambient water monitoring has shown that temperature variation at the discharge point is consistent with natural variations within Lake Macquarie.

Ash Dam Water System Discharges

A toe drain collects seepage from the dam, which is recirculated, back into the dam. Emergency discharge of the Ash dam water enters Crooked Creek at EPL Discharge Point 17 via a weir. Under non-emergency conditions, water levels in the Ash Dam are controlled using water from the outlet canal. Water is pumped via the Outlet Canal Make up Pump if the Ash Dam becomes too dry resulting in dust. Water from the Ash Dam is pumped into the Glory Hole and into the outlet canal if the water level of the Ash Dam becomes too high. The water is filtered to remove cenospheres using floating booms in three underflow weirs. A vacuum truck is used to remove the cenospheres.

4.6.3 *Stormwater and Contaminated Water System*

A stormwater system for the site exists which is separated from the site's contaminated water systems. A clean water diversion surrounds the Ash Dam to minimise the amount of rain water from entering the area and hence to minimise the amount of ash dam water discharging to Lake Macquarie. A catchment to the north of the site (*"No Name Creek Catchment"*) enters the site at the coal loading facility and is diverted to a wetland via the Muddy Lake Settling Pond, which contains an oil detector with an automatic alarm.

A Demineralisation Plant and Reclaimed Water System are located adjacent to the Glory Hole which are bunded and alarmed. Minor incidents have occurred in the past which have resulted in uncontained discharges in this area.

A Contaminated Water Briefing Paper was prepared by Ring (2004) that outlines the treatment process and system issues. This report indicates that the contaminated water drains that are serviced by this system are located in all areas where drainage has the potential to be contaminated with oil. These drains are gravity fed to four contaminated water pits. System issues identified in this report include:

- Coal fines and fly ash are present in the system which traps oil and forms a sludge that accumulates in the oil water separator and impedes its performance;

- There is no formal process for disposing contaminated sludge. The sludge is dried out and then stockpiled on unsealed hardstand adjacent to the truckwash bays. Based on the findings of this briefing paper this dried sludge is ultimately buried on site, however based on discussions with Eraring Energy environmental personnel this material is ultimately disposed off-site at a licenced facility. Given the elevated hydrocarbons concentrations generally associated with this sludge, the stockpiling activities were identified as a potential point source of contamination, and a potential breach of licencing conditions;

- The amount of oil currently received by the drainage system exceeds the limitations of the original design specifications, and carry over from the oil water separator to the retention lagoon has been observed from time to time. These conditions can potentially increase the likelihood of oil discharge from this system;

- The structural integrity of the contaminated water tanks was described as poor, however the report suggests imminent repair or replacement of the tanks;

- Bunding associated with the oil water separator system were observed to be in poor condition, providing inadequate containment; and

- The process for disposing waste oils is unclear, increasing the potential for spills and the potential for oil to reach the stormwater system.

No further recommendations or details of potential system upgrades are provided in this report.

An audit undertaken by AECOM (2011) recommended that *"the clean and contaminated water circuits at Eraring are confusing with respect to location, drainage and flow. A full site revision is required."* Works to address this recommendation are reported to be still being scoped and implemented. Corroded pipes in the stormwater system were identified and repaired in November 2012. Works to repair a pump and level controls at the Muddy Lake contaminated water inlet seepage weir and pump were commenced in November 2011. Further upgrades are planned for 2013 including the installation of hydrocarbon, acid and alkalis detection systems, including shut-off valves (Civil Budget, Projects and Asset Management, November 2012) and bunding improvements. Other future projects include chemical sewerage plant upgrade, civil stormwater improvements long Canal Road, oil trap facilities at stormwater outlets and modifications to reduce the overflow of contaminated water.

An audit undertaken by AECOM (2011) reported that oil had been recorded on the surface of the treated water lagoon (final settling pond), and recommendations were made to remove this oil when observed. This audit also recommended more proactive action for overflowing bunding in the drum storage area. Oil was also reported for the stormwater drain behind the water reclamation plant.

Based on subsequent discussions with Eraring Energy environmental personnel, the contaminated water treatment system was recently subject to a multi-million dollar upgrade, which included improvement works to the contaminated water pits, pumping system, bypass lines, expansion of the oil and water separator system and upgrade of the retention ponds. It was understood that these works were completed in 2011 (approximately). Upgrade of the stormwater system is also currently in progress. It is anticipated that the combined targeted and grid-based sampling approach, as well as sediment and surface water sampling in Lake Macquarie, Whiteheads Lagoon, the Return Water Pond, drainage channels flowing toward Lake Eraring and Crooked Creek will be sufficient to characterise any significant impact associated with historic and current operation of this system.

4.6.4 *Sewage*

The site treats effluent sourced from both internal sources and external sources including the Myuna Bay Sport and Recreation Facility and Hunter Waters Dora Creek Wastewater Treatment Works. Wastewater from the Myuna Bay Sport and Recreation Facility enters the site via the Pasveer Channel and moves to the Effluent Holding Pond where it is combined with oily water from the Oil Retention Lagoon Transfer Pond. Micro filtration chlorination and reverse osmosis is undertaken in the Reclamation Plant. Waste effluent is separated and directed through two sludge-settling ponds and treaded again. Concentrated salts are directed to the Ash Dam.

A soil testing program has been undertaken from audit recommendations (AECOM 2010, 2012) to identify whether the soil at the site's spray irrigation area had the capacity to absorb effluent and to assess the potential for off site migration of effluent contaminated soil or water. The investigation found that some metals were above site criteria. The soil bund to the north was effective in limiting offsite migration of the surface runoff.

4.6.5 *Sediment*

Regular surface water sampling has been undertaken by Eraring Energy at various locations surrounding within Lake Macquarie as part of their EPL (1429) requirements. With the exception of the oil sheen observed in Lake Macquarie following the 2B Generator failure in 2011, no documentation or other information provided by Eraring Energy employees was identified about major incidents that resulted in significant environmental issues from the outlet canal.

Experiments on the benthic bivalve *Anadara trapezia* (Sydney Cockle) indicated that Lake Macquarie had significantly higher concentrations of trace metals in its sediment than compared to other NSW estuarine systems. Elevated metals concentrations above background levels were attributable to the Site, in particular selenium concentratioms at Whiteheads Lagoon which were associated with the overflow channel from the ash dam (Burt et. al., 2006). Selenium, cadmium, copper, and zinc concentrations were measured in tissue samples collected from mullet (*Mugil cephalus*) at the southern basin of Lake Macquarie. Selenium, cadmium, and copper in Lake Macquarie mullet tissue were considered elevated when compared to those in mullet collected from the Clyde River estuary, a relatively pristine location. Furthermore, selenium concentrations in mullet are above recommended acceptable limits for safe human consumption (Kirby et. al., 2001). Elevated concentrations of cadmium and selenium were also detected in the muscle and gonad tissues of five species collecgted in Whitehead's Lagoon in a separate study undertaken by Roach et. al. (2008).

Trace metals in surficial sediments were significantly more elevated than background concentrations (selenium 3-19 times background levels, cadmium 14-42 times background, copper 1.5-3.6 times background, and zinc 0.77-2.2 times background). Selenium concentrations in surficial sediments were expected to be related to fly ash from the power station, whilst the remaining heavy metal concentrations were likely from power generation activities as well as urban and sewage inputs (Kirby et. al., 2001, Lake Macquarie City Council, 1995).

A study undertaken by Batley (1987) also identified increased copper concentrations in waters and sediments from Lake Macquarie, attributable to fly ash. However, elevated concentrations of zinc, lead, cadmium and copper detected in surface sediments and waters from the northern end of the lake were attributable to discharges from the (former) lead-zinc smelter on Cockle Creek (Batley, 1987). A study completed by Carroll (1995) revealed considerably lower concentrations of selenium that were consistent with reported reductions of selenium discharged into the lake from the lead-zinc smelter. The study found that 44% of selenium in surficial sediments from the lake is associated with sediment phases in which selenium has the potential to become remobilized and hence possibly bioavailable. The investigation also acknowledges that overflow from ash dams as well as atmospheric deposition of fly ash from their stacks, may also be potential contributors of heavy metals to the lake (Carroll, 1995).

Based on an Eraring Energy (2008) publication, prior to 1991, ash dam seepage was discharged directly into Crooked Creek and Whitehead's Lagoon resulting in elevated concentrations of selenium in the Lake Macquarie catchment. Whilst selenium is naturally occurring, at the time of the direct discharge levels of selenium in local fish was three times higher than average concentrations. Management of seepage water was subsequently altered so that water containing selenium is recirculated several times in a closed system as a slurry.

5 SITE CONTAMINATION HISTORY

The provision of a detailed account of the contamination history at the Eraring Power Station is limited based upon the absence of previously conducted environmental assessments into potential gross contamination issues at the Site. The current processes being undertaken upon the Site have not changed greatly since operation of the Site commenced in 1982. Therefore potential and actual areas of contamination can be assessed based upon current operations, in conjunction with chemical and waste inventory (*Section 4.2*), spill and incident information (*Section 4.3*), and a review of the limited soil and groundwater investigations completed to date (*Section 5.1*). Potential and actual soil and groundwater areas of concern are presented in *Section 6.1*.

The Eraring Power Station site does not appear on the Contaminated Land Management Record database managed by NSW EPA. It is also noted that Eraring Power Station has not been reported to NSW EPA under Section 60 of the CLM Act. One neighbouring site (the Myuna Colliery - located on Wangi Point Road to the south east of the Site) has been reported to NSW EPA. Given the location of this site relative to Eraring Power Station and anticipated groundwater flow direction, it is not expected that this site would present a significant risk of contaminant migration onto the Site.

5.1 SITE MANAGEMENT PLANS

Groundwater Management Plan - Coal Combustion Product Management Facility, Eraring Power Station, Rocky Point Road, Eraring. (AECOM, 2009)

A Groundwater Management Plan (GMP) was developed as part of the project approval for the upgrade of the Coal Combustion Product (CCP) Facility by ENSR Australia Pty Limited (AECOM). It was developed for the ongoing management of the groundwater that is potentially affected by the CCP Facility, with the primary objective being the protection and maintenance of groundwater quality in the catchment of the CCP Facility. The site's EPL does not have any requirements to monitor groundwater, however it is understood that the Development Consent conditions for the CCP include the requirement of an ongoing groundwater monitoring program.

The upgrade involved an increase in the capacity of the CCP Facility and the introduction of a more concentrated CCP mix of 70% CCP and 30% water (dense phase), as compared to the original CCP mix of 30% CCP and 70% water (lean phase).

Based on a review of available information, AECOM recommended the following for the revised GMP. The inclusion of monitoring wells GM/D1, GM/D2, D26, D29, MW01, MW02, MW03, MW05 and MW06 for future monitoring events. Heavy metals (arsenic, cadmium, chromium, copper, selenium, lead and zinc), total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAHs), Sulphide, chloride and fluoride should be monitored biannually. Cations (calcium, magnesium, sodium, potassium), boron, manganese, alkalinity, pH, conductivity, temperature, total dissolved solids, nitrate, phosphorus and anion/cation balance should be monitored quarterly. Monitoring for iron is no longer necessary as the concentrations have remained generally consistent and naturally occurring. Based on a review of the most recent round of monitoring data made available to ERM (data from the 2011 monitoring rounds), whilst most of these measures appear to have been implemented, the additional sampling locations were not incorporated into the program.

A representative of Eraring Energy stated that one groundwater monitoring location was upstream of the ash dam. This location and information regarding the quality of the groundwater was unable to be located at this reported point.

Groundwater Management Plan – Attemperation Reservoir, Eraring Power Station, Rocky Point Road, Eraring (AECOM, 2009)

The GMP was developed as part of the project approval process for the construction of the Attemperation Reservoir (AR) facility, and sought to produce a program for the protection and maintenance of groundwater quality in the catchment of the facility. It was understood that the site's EPL does not have any requirements to monitor groundwater however it is understood that the Development Consent conditions for the Attemperation Reservoir include the requirement of an ongoing groundwater monitoring program.

The design of the AR Facility required that it not intercept the underlying groundwater and that it be lined with at least 0.75 m of clay (or an equivalent lining). All seepage was to be collected by the piped underdrainage system , and must be returned to either the reservoir or the salt water intake canal, and not directly to the environment. The operation of the AR Facility was therefore not expected to adversely impact the groundwater beneath the site.

The scope of works included a review of the groundwater monitoring regime prior to construction and commissioning of the AR Facility. The conceptual hydrogeological model for the investigation anticipated groundwater to flow to the south southeast, towards Lake Macquarie. The five monitoring wells were assessed for adequacy. AECOM concluded that the location of the wells (GW1-GW5) were adequate for monitoring groundwater conditions at the AR Facility and provide reasonable coverage. No monitoring wells located further down gradient from the AR Facility (toward Myuna Bay, which is considered to be a potential receptor) were currently included in the monitoring program.

AECOM stated that this is not considered to be a significant issue as GW3 to GW5 are located on the down gradient side of the AR Facility. It was recommended that additional down gradient wells may need to be added to the monitoring well network if in future these wells are found to be impacted.

The five groundwater sampling locations are monitored monthly. A number of analytes have been sampled for including dissolved metals, unfiltered metals, PAHs, TPH/BTEX and Phenolic Compound Surrogates. Analisis was undertaken by ALS. Eleven one page reports were made available for review, dated between January 2010 and September 2012.

Based on review of the available data, the recommendation for the future groundwater monitoring program for the wells in the vicinity of the AR Facility catchment (GW1 to GW5) involved six monthly monitoring for pH, conductivity, temperature, standing water level (SWL), total dissolved solids (TDS), chloride, fluoride, sulfate, alkalinity, major ions, boron, metals (arsenic, cadmium, chromium, copper, selenium, manganese, iron, lead, mercury and zinc), total anions, total cations, nitrate, nitrite, phosphorus. Analysis of polycyclic aromatic hydrocarbons (PAHs) and total petroleum hydrocarbons (TPH) was also recommended following 12 months of operation of the attemperation reservoir, to confirm that ongoing analysis for these potential contaminants of concern is not required. Due to naturally elevated background concentrations of several parameters, historical data and background concentrations were considered a more appropriate gauge of elevated concentrations than comparing data to the guidline values provided by ANZECC (2000).

Surface Water Management Plan, Eraring Energy Lands, Eraring Power Station, NSW. (AECOM, 2008)

The surface water management plan (SWMP) was developed to identify and provide guidelines for the management of surface water across Eraring owned lands. The primary objective of the SWVP is to protect clean waterways and improve the management of used waterways resulting from site activities, and is guided by the requirements of the Environmental Protection Licence (EPL) 1429.

Surface water has been identified and divided into two groups, clean water and used water. Routine water monitoring is conducted to satisfy the requirements of the EPL at sites both within the Power stations boundaries and around Lake Macquarie and Whiteheads Lagoon.

The surface water monitoring protocol is shown in Table 3 of the document and outlines what analytes are tested, and how often they are tested at each sampling point.

5.1.1 *Qualitative Assessment of Monitoring Data*

Historical monitoring data was made available to ERM by Eraring Energy environmental personnel for review as part of the Preliminary ESA. The following monitoring data was reviewed as part of this investigation:

- Groundwater monitoring wells GW1 to GW5 surrounding the Attemperation Reservoir, with data from between August 2009 to March 2013.
- Groundwater monitoring wells GM/D1, GM/D2, D26, D29, MW01, MW02, MW03, MW05 and MW06 surrounding the CCP facility, with data from between January 2010 to December 2011.
- Surface water monitoring at various locations across the site, with data from between January 2006 to April 2013.

Baseline levels were not available for review for either location hence the data could not be compared against background concentrations, which were understood to be naturally elevated. Based on a visual, qualitative assessment of the data against the ANZECC ecological screening criteria (which were more conservative than the recreational and protection of 95% of marine ecosystem criteria), relevant criteria presented in the Australia Drinking Water guidelines, and acceptance criteria presented in the EPL, the following trends were noted. A summary of the exceedences observed as part of the review are also presented in *Annex D*.

- Elevated concentrations of copper, lead and zinc exceeding the ANZECC criteria were commonly observed immediately surrounding the Attemperation Reservoir. Lead and arsenic concentrations also exceeded the Australia Drinking Water criteria.
- Elevated concentrations of copper, lead and zinc exceeding the ANZECC criteria were commonly observed immediately surrounding the CCP. Lead and arsenic concentrations also exceeded the Australia Drinking Water criteria.
- Concentrations of suspended solids and selenium regularly exceeded the EPL acceptance limit at surface sampling locations, particularly at the Ash Dam toe drain sampling location, at the Ash Dam return canal sampling location and at the utilisation area sampling point adjacent to the sewerage treatment works. Selenium concentrations also commonly exceeded the adopted ANZECC criteria and the Australia Drinking Water guideline value, however it is noted that concentrations of selenium decreased from 2006 to 2013.

5.2 PREVIOUS ENVIRONMENTAL INVESTIGATIONS

The Eraring Power Station has undergone a limited amount of intrusive soil and groundwater assessments to date as set out below. No comprehensive or systematic assessment of Site conditions has been undertaken, with works generally completed to achieve compliance with underground petroleum storage system (UPSS) legislation, or the Land Management Plan employed at the site (targeting the Attemperation Reservoir and CCP Management Facility). The following section summarises the relevant reports reviewed by ERM. *Contamination Investigation Report - Stores Building UPSS (Geo-Logix, August 2011)*

An investigation of soil and groundwater conditions surrounding the UPSS adjacent to the Stores Building at Eraring Power Station was undertaken in March 2011. The objective of the investigation was to assess the contamination status of soil and groundwater surrounding the UPSS and determine the appropriate method of decommissioning the UPSS infrastructure. The UPSS comprised three USTs and associated delivery piping and two dispensers. Two USTs (58 000 L unleaded petrol (ULP) and 33 500 L diesel) were being used for the storage of fuel for Eraring Energy work vehicles at the time of the investigation. A leaded petrol (LP) UST of unknown size was understood to have been temporarily decommissioned by filling with rust inhibitor solution. The USTs were located to the west of the Stores Building.

Investigation of soils surrounding the USTs via the advancement of four test pits to a maximum depth of 2.5 m below ground level (bgl) identified petroleum contamination to UST backfill sands. Based on results of the investigation and limitations encountered due to site geology, further investigation was completed in May 2011. The scope of work comprised the drilling of six additional soil borings surrounding the USTs, installation of four groundwater monitoring wells (screened between 7.5 and 10 m bgl) and collection and laboratory analysis of soil and groundwater samples for contaminants of potential concern comprising petroleum hydrocarbons, polycyclic aromatic hydrocarbons and heavy metals.

Petroleum hydrocarbons were detected at concentrations greater than the assessment criteria in shallow soil in the immediate vicinity of the dispensers. The impact was considered likely to be limited in extent, however it is noted that deeper samples were not analysed at locations where shallow soil impact was detected. Elevated concentrations of petroleum hydrocarbons were detected in groundwater immediately down-gradient of the USTs. Groundwater was calculated to be flowing to the southeast beneath the office space in the Stores Building and towards a manmade outfall canal, south of the Stores Building.

In order to assess the potential for contaminated groundwater to discharge into the canal two additional wells were installed downgradient of the USTs. Petroleum was not detected in the two wells. The potential for intrusion of volatile vapours emanating from groundwater into overlying office space of the stores building was assessed through the installation and sampling of four shallow soil vapour wells. Petroleum related compounds were not detected in soil gas.

Based on the results of the investigation and limitation of UST removal by high risk subsurface infrastructure, the report concluded the USTs are suitable for in-situ decommissioning as current conditions are not presenting a risk to human health or the environment. The conclusions drawn were subject to ongoing monitoring requirements to ensure conditions are not worsening over time, including semi annual groundwater sampling for a period of two years, and sampling of soil vapour wells in the event an increasing trend was established to assess vapour intrusion pathway. Additional monitoring data was not available for groundwater monitoring wells installed in the vicinity of the Stores Building UPSS, hence current groundwater conditions and the potential presence of ongoing impact could not be verified.

Groundwater Monitoring Well Installation Report – Unit 1 Turbine House Basement (Geo-Logix, August 2011)

This investigation involved the installation of three wells surrounding the UPSS, in the Unit 1 Turbine House basement. The UPSS infrastructure targeted as part of this investigation was identified as a 20,000 litre waste oil UST and a 50,000 litre lubrication oil UST.

Four monitoring wells (EPSMW8 to EPSMW11) were advanced to between 4.1 metres below ground level (mbgl) and 9.0 mbgl. Standing water levels were recorded between 2.918 and 4.173 mbgl. Phase Separated Hydrocarbon (PSH) was not detected at any of the locations, however it is noted that the monitoring wells generally did not screen across the water table. An organic odour was recorded during groundwater sampling at EPSMW11, however no other visual or olfactory evidence of impact was recorded for the field work.

A review of the analytical data concluded that concentrations of petroleum hydrocarbons and polycyclic aromatic hydrocarbons were not detected in soil or groundwater samples above the laboratory limit of reporting.

Groundwater Monitoring Well Installation Report - Vehicle and Mobile Plant Workshop (Geo-Logix, June 2011)

An investigation of soil and groundwater conditions surrounding the waste oil storage tank adjacent to the Vehicle and Mobile Plant Workshop on the north-western portion of the main power station area was undertaken in May 2011. The UPSS consisted of a 4500 L UST and associated delivery piping. The wells were installed in order to complete the groundwater monitoring well network at the site as per the requirements of the UPSS Regulation (2008).

Three groundwater monitoring wells (EPSMW1 to EPSMW3) were installed in the completed soil borings to depths between 4.5 and 5.0 metres below grade. Soil and groundwater samples collected from monitoring wells were analysed for contaminants of potential concern, comprising petroleum hydrocarbons, polycyclic aromatic hydrocarbons, and dissolved heavy metals.

Petroleum hydrocarbons and polycyclic aromatic hydrocarbons were not detected at concentrations greater than the laboratory reporting limits in soil samples from all borings, or in groundwater samples from all monitoring wells. Dissolved metals were detected at concentrations greater than the assessment criteria in the groundwater sample taken from the monitoring well. The elevated concentrations were considered likely to be naturally occurring.

UPSS infrastructure adjacent to 23 000 L refuse oil UST

Based upon the observations of groundwater monitoring infrastructure made during the site visit, and interviews with site personnel, it is understood a report on UPSS infrastructure installed adjacent to 23,000L refuse oil UST (collects all lubricating oil drainage and refuse oil within the turbine building) was produced, but could not be located for review.

6 SUMMARY OF FINDINGS

Based upon a review of current and historic site operations, previously completed environmental assessments, and chemicals and wastes stored and/or disposed of on the Site, a number of actual and/or potential areas of environmental concern have been identified. The following sections provides an assessment of each of these areas.

6.1 AREAS OF ENVIRONMENTAL CONCERN

6.1.1 Coal Combustion Product (CCP) Management Facility (Ash Dam)

The CCP is approximately 150 ha in area and is located in the eastern portion of the Site (refer to *Figure 2*). Potentially contaminating activities for this AEC are associated with inputs to, and migration from, the CCP such as ash slurry, water and fines from the dirty water collection/treatment system, mine water from the adjacent Awaba Mine and overflows from the oil retention lagoon.

As discussed previously in *Section 5.1.1*, results of surface and groundwater monitoring in the vicinity of the CCP indicate that seepage from the CCP is saline and contains heavy metals which can be attributed to the nature of the ash material stored within the CCP. Given the nature of inputs to the CCP, seepage also has the potential to contain petroleum hydrocarbons. Seepage from the toe of the CCP is collected and recirculated back into the CCP. Identified receptors include underlying groundwater and Lake Macquarie.

Groundwater monitoring is undertaken in the area between the toe of the CCP and Lake Macquarie for a range of potential constituents of concern including heavy metals, total recoverable hydrocarbons, polycyclic aromatic hydrocarbons (including BTEX constituents) and phenols, with inferred groundwater flow direction from the CCP towards the Lake. Selenium concentrations in groundwater exceed the ANZECC 95% protection levels for freshwater. However, while some environmental assessment has been undertaken in this area, it is not considered that suitable characterisation of environmental conditions has been established, and further investigation would be required rule out potential material environmental issues associated with soil and groundwater conditions.

In addition to the issues associated with the inputs to discharge from the CCP, potential areas of concern are also located within the CCP related to the disposal of waste materials (other than fly ash), including;

- Asbestos Disposal Areas (Northern and Southern) - Prior to 1997 asbestos materials from the site were dumped in two areas within the CCP. These areas are understood to not have been used since 1997, since which time any asbestos materials have been disposed of off-site by licenced contractors. Both of the on-site disposal areas have been capped (non-engineered capping) and are marked with some signage. Sketches of the locations were available however it does not appear that survey plans showing the extent of these disposal areas have been created, or that any physical marker layers or overarching asbestos management plans are in place.

- Filter Bag Disposal Area - The filter bag disposal area remains active and is located on top of the southern asbestos disposal area.

- General Waste Disposal Area near Ash Dam - A general waste area has been identified south west of the Ash Dam. The extent of the general waste disposal area could not be confirmed based a review of the information available during the current investigation. An assessment of the extent of the general waste disposal area will be undertaken as part of the Phase 2 scope of work.

The disposal of these waste materials, and lack of definition or delineation of the extent potential impact, add to the potential for material environmental issues in this area to exist, and require further assessment.

6.1.2 *Transformer Area*

The Transformer Area houses the main transformers for the Site and is located immediately west of the boiler and turbine units. In addition to the potentially contaminating activity of transformer operation, also located within this area are four current 25,000L ASTs and two decommissioned ASTs of similar size, used for the storage of transformer oil. It is also understood that while a PCB removal program was undertaken during the late 1990s, PCB oil was used extensively prior to this and currently used transforer oil in twelve transformers still contains low concentrations of PCBs.

While the transformers are now contained within new bund systems that drain to the water treatment system, there have been reports of transformers leaking and replacements have been undertaken over time. In addition to this, a failure of the 2B Generator Transformer and associated fire in 2011 resulted in the release of transformer oil to the surrounding environment. The use of fire fighting foam containing perfluorooctane sulfonate (PFOS) also represents a potentiual contaminant of concern for this area. These release events have the potential to impacts soils and groundwater beneath the Site.

There have been no soil and groundwater investigations completed within the Transformer Area to achieve an appropriate degree of environmental characterisation for the purposes of this assessment. Given the absence of previous environmental investigations, historic release events and the volume and content of transformer oils curremtly and historically contained within the area, further investigation would be required rule out potential material environmental issues associated with soil and groundwater conditions.

6.1.3 *Coal Storage Area*

The coal storage area is approximately 25 ha in size and is used for stockpiling of coal prior to being transferred via conveyor to the boilers. Potential contamination sources or activities include the refuelling of equipment (bulldozers) used to move coal around, and contaminated stormwater runoff from this area which is captured in the 'Dirty Water' collection/treatment system (known as the 'Boomerang' and 'Sausage' retention ponds). These retention ponds are lined with reclaimed, natural clays of low permeability. The retention ponds are also cleaned out on a regular basis and any fines collected are deposited in the CCP.

While there have been no soil and groundwater investigations completed within the Coal Storage Area, based upon the potential sources of contamination and low likelihood of receptor exposure, and that this area will continue to be used for coal storage, considered to be relatively low risk in the context of this assessment.

6.1.4 *Fuel Oil Installation and Associated Pipeworks/ASTs*

The Fuel Oil Installation comprises four 1,200,000L steel ASTs installed in the early 1980s, and used for the storage of diesel and fuel oil. These ASTs supply fuel oil via an above ground 300mm (estimated) diameter pipeline to the Gas Turbine, the bulldozer refuelling station, and various smaller ASTs across the Site. The volume of fuel being stored and transferred across the site represents a significant source of potential contamination.

Each of the four tanks are individually bunded with drainage from the bund draining to one of two oil/water separators. Tank levels are checked weekly and reconciled against delivery and usage records. However given the limitations of wet stock reconciliation when dealing with such large volumes, and that leaks from above ground piping have been reported, with a replacement program undertaken in 2010/2011, there is a potential for leaks to have caused the migration of contaminants to the underlying soil and groundwater.

There have been no soil and groundwater investigations completed in the area of the Fuel Oil Installation or adjacent to any of the associated pipeworks or site ASTs to achieve a suitable degree of environmental characterisation. Given the absence of previous environmental investigations, the age of infrastructure, volume of stored and transferred fuel, and the potential for historic release events to impact soil and groundwater receptors, further investigation would be required rule out potential material environmental issues associated with soil and groundwater conditions.

6.1.5 *Operational and Decommissioned USTs*

A total of six USTs are indicated as being present on site, which contain or have previously contained diesel, petrol and combustibles. USTs are understood to be approximately 30 years old and of single steel wall construction. Eraring Energy site personnel reported that USTs have either been decommissioned or that integrity tests have been completed on the main turbine refuse oil UST and the garage refuse oil storage that remain in use. Documentation was not available to confirm management advice.

Soil and groundwater investigations have been completed in the areas of below ground tank infrastructure to ensure compliance with relevant underground petroleum storage system (UPSS) legislation, and ensure protection of soil and groundwater receptors. During a previous investigation (Geo-Logix, 2011a) additional groundwater monitoring was recommended to assess ongoing trends for existing contamination detected in the vicinity of the UPSS infrastructure. It was understood that this sampling had not been undertaken. Documentation relevant to the decommissioning works was also not available, hence the suitability of the rememdiation works could not be confirmed. Based upon the environmental characterisation achieved, the USTs were considered to be relatively low risk in the context of this assessment. However, monitoring should be undertaken in the vicinity of the USTs, in particular the stores building, to delineate potential impact.

6.1.6 *Attemperation Reservoir*

The attemperation reservoir has the potential for seepage and off-site migration of saline water, however a number of groundwater monitirng wells have been installed around the reservoir to monitor conditions.

Based upon the environmental characterisation achieved to date, this area is considered to represent a relatively low risk in the context of this assessment.

6.1.7 *Truck Wash-Out Pits*

Truck wash-out pits located north of the Coal Storage Area and Fuel Oil Installation were observed to be in poor condition with build-up of oil and waste in the base of the pits. Waste water from these pits is transferred to the oil retention lagoon prior to transfer into the CCP. It was also understood that sludge from the contaminated water treatment system has been dried out and then stockpiled on unsealed hardstand adjacent to the truckwash bays (Ring, 2004), hence given the elevated hydrocarbon concentrations likely associated with this material there was potential for impact to surrounding soils due to these activities.

There had been no soil and groundwater invesitgations previously completed within the area of the Truck Wash-Out Pits. Oil and waste accumulated at the base of the pits, as well as stockpiling of sludge from the contaminated water treatment system on an area of unsealed hardstand adajacent to the pits, presents potential sources of contamination. Hence further investigation would be required rule out potential material environmental issues associated with soil and groundwater conditions in this area.

6.1.8 *Workshops*

Maintenance workshops are located throughout the Site, with two main workshops located to the east of the boiler and turbine units and in close proximity to the black start gas turbine. Other workshops are located adjacent to the north-east, and north west corner of the turbine building. In their current configuration and use appear to be managed well and have little potential to cause significant soil and/or groundwater impacts. Parts washing facilities were observed and all appeared to be in good order and are regularly serviced by third party contractors. It was discussed that previously (1980s and 1990s), potentially contaminating activities including the storage and use of TCE and other solvents for degreasing and parts washing was undertaken. Based on discussions with Eraring Energy environmental personnel, whilst TCE and other solvents were used in workshop areas, no further information was available regarding any other storage or disposal measures.

Historic spills and releases of solvents and the potential for inappropriate disposal have the potential to impacts soils and groundwater beneath the Site. There were no records available to demonstrate whether these solvents were disposed of appropriately, however it was indicated that it is unlikely they would have been disposed of to ground.

There have been no soil and groundwater investigations completed within the Workshop areas to achieve an appropriate degree of environmental characterisation for the purposes of this assessment. Given the absence of previous environmental investigations, and the known presence of chlorinated solvent use on site, further investigation would be required rule out potential material environmental issues associated with soil and groundwater conditions.

6.1.9 *Former (Northern) Gas Turbine Location*

The Former (Northern) Gas Turbine area, located in the north of the Site, is the historical location of twin gas turbines that were operated using a combination of distillate and fuel oil, with the fuel supplied from two 1.5ML ASTs (approximate). The area also includes four transformers (decommissioned) and one space for a former transformer is understood to have been removed due to leakage, oil water separators and an oil containment dam.

There have been no soil and groundwater investigations completed in the area of the Former (Northern) Gas Turbine, and limited information was avaiable with respect to tankage or former operations. Given the absence of previous environmental investigations, the age of infrastructure, volume of stored and transferred fuel, and the potential for historic release events to impact soil and groundwater receptors, further investigation would be required rule out potential material environmental issues associated with soil and groundwater conditions.

6.1.10 *Sewage Treatment Works*

The site treats effluent sourced from both internal sources and external sources, utilising an Effluent Holding Pond, and micro filtration chlorination and reverse osmosis which is undertaken in the Reclamation Plant. Waste effluent is separated and directed through two sludge-settling ponds and treated again, with concentrated salts directed to the CCP. A soil testing program has been undertaken from audit recommendations (AECOM 2010, 2012) to identify whether the soil at the site's spray irrigation area had the capacity to absorb effluent and whether this effluent contaminated soil or water left site. The investigation found that the some metals were above site criteria. The soil bund to the north was effective in limiting offsite migration of the surface runoff.

While there have been limited soil and groundwater investigations completed related to the Sewage Treatment Works, based upon the potential sources of contamination and low likelihood of receptor exposure, this area is considered to represent a relatively low risk in the context of this assessment.

6.1.11 *Sediments in Lake Macquarie, Whiteheads Lagoon, Crooked Creek, the Return Water Pond and Drainage Channels*

Current water monitoring does not indicate a significant potential for impacts within Lake Macquarie as a result of the warm water outfall.

Previous incidents have resulted in the loss of contaminants that have entered the Lake, and there is the potential for legacy issues related to historical operation of the Power Station (and potentially other off-site sources). Given the large cost associated with any clean-up or studies of sediments, an investigation is considered to be required to address this issue and assess whether potential material environmental issues exist. It is also considered that sediment sampling is more likely to provide an indication of potential off-site impacts potentially related to the Site than sampling of surface water. This is due to the significant dilution which is likely to occur when such large volumes of water pass through the outfall and also the potential for alternate sources of impacts to surface water.

It was understood that prior to 1991, ash dam seepage was discharged directly into Crooked Creek and Whitehead's Lagoon. It was further understood that emergency overflow can still be potential discharged to Crooked Creek. Hence sediment sampling has also been proposed for Whiteheads Lagoon and Crooked Creek and the Return Water Pond to assess for potential impact. Sediment samples from drainage channels flowing to Lake Eraring will also assist in characterising any potential off-site migration of contaminants.

6.2 *SUMMARY OF KEY ISSUES*

Of the potential areas of concern identified in *Section 4*, the following issues have been identified as being potentially the most significant in the context of the transaction:

- Coal Combustion Product Management Facility (Ash Dam) and associated waste disposal areas
- Transformer Area;
- Fuel Oil Installation and Associated Pipeworks and ASTs;
- Workshops;
- Former (Northern) Gas Turbine Location; and
- Lake Macquarie, Whiteheads Lagoon, Return Water Pond and Crooked Creek sediments and sediments associated with drainage channels to Lake Eraring.

Decommissioned and operational USTs, as well of the truck washout pits and immediate surrounds, were also considered secondary areas of potential concern.

7 *PRELIMINARY REMEDIATION COSTINGS*

Based on the information available at the time of preparation of this report, ERM has not identified any actual or known material contamination issues which are currently undergoing or likely to require remediation. Preliminary remediation costs have not therefore been prepared at this point in time. It is proposed that remedial costs be revisited following completion of the proposed Stage 2 investigations.

8 RECOMMENDATIONS FOR STAGE 2 ASSESSMENT

Based on the results of the Preliminary ESA undertaken by ERM and consideration of Government's intended approach to the assignment of liability relating to soil and groundwater contamination issues, a programme of intrusive (Phase 2) assessment of potential soil, groundwater, sediment and surface water contamination issues is proposed to assess current conditions at the site and relevant off-site receiving environments.

The following sections set out the proposed scope for the Phase 2 works in general accordance with the requirements set out in NSW EPA (2011).

It is noted that the Phase 2 scope of work presented herein is preliminary, and the final agreed scope of works for the Phase 2 assessment will be detailed in a separate Sampling Analysis and Quality Control Plan (SAQP that is in preparation at the time of writing) which should be viewed in conjunction with this report.

8.1 DATA QUALITY OBJECTIVES

Prior to commencement of the Phase I works, Data Quality Objectives (DQOs) were established for the project in line with the requirements and process outlined in NSW DEC (2006) *Guidelines for the NSW Site Auditor Scheme (2nd edition).*

These DQOs were developed to define the type and quality of data required from the site assessment program to achieve the project objectives outlined in Section 1. 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 application of the seven-step DQO approach identified in NSW DEC (2006) is presented in full in *Annex C.*

8.2 SAMPLING RATIONALE

Based on a review of the available data, the most appropriate sampling design is considered to be a combination of systematic (grid based) and judgemental (targeted) sampling. It is noted that intrusive investigations may be limited to areas where access and site activities enable investigations to occur without unacceptable health and safety risks to personnel and / or unacceptable disruption to site operations. The sampling plan will be discussed with site management prior to the commencement of works to assess this risk.

Given the scale of the site (greater than 1000 ha), a tiered systematic sampling approach is proposed with different sampling densities to be adopted relative to the contamination risk and logistical constraints in different areas of the site. ERM proposes to divide the site into four general areas with sampling approaches to be adopted as outlined in *Table 8.1*.

Table 8.1 ***Proposed Systematic Sampling Approach***

Area	Approach
Accessible operational areas	Boreholes to be advanced on a 50 x 50 m grid in areas not covered by targeted sampling (see below).
Inaccessible operational areas	Boreholes to be advanced around perimeter where possible and in areas not covered by targeted sampling (see below).
Non-operational areas	Visual inspection and additional soil bores / monitoring wells focused primarily on assessing background conditions and identifying potential for migration both on and off-site (including Lake Macquarie and Wangi Wangi Colliery
Waterways	Targeted sampling only (see below)

8.2.1 *Systematic Sampling Locations*

Boreholes will be advanced on an approximately square grid pattern (50 x 50 m) across the accessible operational area in order to establish an adequate baseline assessment of soil and groundwater conditions where one does not currently exist. The accessible operational area (Area EI) is shown *Figure 2.3, Annex A* and includes the central area of the Site excluding hazardous operational areas.

8.2.2 *Targeted Sampling Locations*

It is proposed that additional targeted sampling locations will be advanced in or adjacent to the areas of potential concern identified during the Preliminary ESA and site visits. The areas of potential concern are shown in *Figure 3, Annex A,* and the proposed targeted sampling locations are shown in *Figures 2.1 to 2.7, Annex A*. The rationale for the targeted sampling locations in each area of potential concern is summarised below in *Table 8.1*.

Table 8.2 ***Proposed Targeted Sampling Approach***

Area of Environmental Concern	Issue	Analytes	Proposed Boreholes & Monitoring Wells
Coal Combustion Product Management Facility	Contamination of soil and groundwater from CCP leachate and waste disposal in landfills.	Standard Suite* plus PCBs and VOC suite targeted in waste disposal areas.	• 13 Soil/groundwater wells • 8 Soil Bores • Sampling of 13 existing wells • Survey of waste disposal areas
Transformer Area	Contamination of soil and groundwater from transformer oil	Standard Suite*plus PCBs & PFOS/PFOA	• 9 Soil/groundwater wells • 15 Soil Bores
Fuel Oil Installation	Contamination of soil and groundwater from loss of fuel and oil	Standard Suite*	• 8 Soil/Groundwater Wells
Fuel Pipelines and Site ASTs	Contamination of soil and groundwater from loss of fuel and oil	Standard Suite*	• 8 Soil/Groundwater Wells
Workshops	Contamination of soil and groundwater from loss of parts washing solvents	Standard Suite*plus VOCs (TCE)	• 8 Soil/Groundwater Wells • 16 Soil Bores
Former (Northern) Gas Turbine Location	Contamination of soil and groundwater from loss of fuel and transformer oil	Standard Suite*plus PCBs	• 10 Soil/Groundwater Wells
Lake Macquarie Sediments & Surface Water	Contaminants within discharge	Standard Suite*plus PCBs, TOC# and PSD##	• 18 Sediment locations (up to 4 samples per core) .
Whitehead Lagoon, Return Water Pond & Crooked Creek Sediments & Surface Water	Contaminants within discharge	Standard Suite*plus PCBs, TOC# and PSD##	• 22 Sediment locations (up to 4 samples per core) .
Coal Storage Area	Potential leaching of contaminants from stockpiled coal and retention ponds	Standard Suite*	• 10 Soil/Groundwater Wells

Area of Environmental Concern	Issue	Analytes	Proposed Boreholes & Monitoring Wells
Operational and Decommissioned USTs	Contamination of soil and groundwater from loss of fuel	Standard Suite*	• Sampling of 13 existing wells
Non Operational Areas (incl. Sewage Treatment Works, Acid Sulfate Soils, Former Fire Training Area, and Truck Washout Pits)	Contamination of soil and groundwater from leaks and overflows.	Standard Suite* plus 10 samples for PSD, TOC, pH, CEC.	• 43 Soil/Groundwater Wells • 3 Soil Bores • Sampling from 5 existing at the Attemperation Reservoir. • 4 sediment samples north of Wangi road • Measurement of field parameters in surface water at up to 14 locations near Attemperation Reservoir and borrow pit in relation to acid sulfate soils.

Notes:
* - Standard Suite is as set out in *Section 8.3.1*
# - TOC - Total Organic Carbon
- PSD – Particle Size Distribution.

8.2.3 *Waterways*

Sediment sampling is proposed to target potential contamination from cooling discharges or other potential instances of off-site migration of contaminants from the Site and includes sampling in two aquatic zones of 'putative effect' including:

- within the Whitehead Lagoon downgradient from the southern boundary of the Site, including within Crooked Creek (one of the potential transmission pathways) and Myuna Bay (a potential depositional zone; receptor); and

- within Lake Macquarie within an area beyond the high energy of the outlet canal (potential depositional zone), including allocation of "unaffected" control sites further away.

The proposed design would be sufficiently robust as a Control-Impact statistical framework which is spatially-nested (meaning sites are within putative impact 'close to'; 'nearby' or 'far from' zones of potential effect). It is presumptive at the outset of this screening exercise to propose that contamination has occurred and, if it had in a linear way, so the need for transect sampling is not yet warranted in ERM's opinion (but may be based on significantly elevated results from this screening program).

With regard to potential sampling within Lake Eraring, a review of the topography of the area indicates that Lake Eraring falls within a separate catchment to the vast majority of the Power Station infrastructure and lands. ERM therefore considers the potential for impacts from other sources to be significantly greater that potential impacts from Eraring Power Station. To further assess this issue it is proposed that sediment samples be collected from the base of four drainage channels on Eraring land to the north of Wangi road which drain to Lake Eraring, this will allow for assessment of potential impacts with a lower chance of confounding effects associated with external sources and will inform the requirement for further sampling within Lake Eraring.

8.2.4 *Potential Acid Sulfate Soils*

Surface water sampling including pH and redox potential has been proposed at a total of ten locations in the vicinity of the Attemperation Pond and Borrow Pit and four downgradient locations. Two groundwater monitoring wells have also been proposed in areas adjacent to the Attemperation Pond, in cleared areas north and south of the canal. I It is further noted that all wells included in the Stage 2 ESA will have field parameters (including pH and redox potential) measured prior to sampling. Should these measurements or other field observations indicate that acid sulfate soil conditions may be present further assessment of these issues will be considered.

8.2.5 *Existing Groundwater Wells*

It is proposed that existing groundwater monitoring wells will be sampled during Phase II soil and groundwater investigation works. Where existing groundwater monitoring wells have been identified the locations of these wells is presented on *Figures 2.1 to 2.7, Annex A.*

Sampling will only occur where the groundwater monitoring wells are deemed to be suitable. The suitability of the existing groundwater monitoring wells will be assessed based on the following steps:

- ground truthing of the groundwater monitoring wells;
- bore logs will be reviewed to confirm that the wells were appropriately constructed and screened within the groundwater bearing strata; and
- the groundwater monitoring wells will be gauged to confirm the total depth of the well against the bore logs and the depth of groundwater.

If the existing monitoring wells cannot be located, or their condition not deemed fit for the purposes of this investigation (e.g. not screened at the appropriate depth or if the well casing presents with a blockage or obstruction),then these wells will be replaced during the Phase 2 drilling program.

The sampling process and analytical suite for existing wells deemed suitable will be in accordance with that adopted for newly installed wells.

8.3 PROPOSED SAMPLING METHODOLOGIES

The soil, sediment and groundwater investigation works will generally involve the following key steps:

- underground service location and mark-out;
- proposed borehole location mark-out;
- coring of hard standing surfaces;
- drilling and soil sampling of subsurface material using push tube and / or auger drilling;
- installation of 50 mm diameter groundwater monitoring wells in selected boreholes screened appropriately to intersect the aquifer of interest and facilitate measurement of NAPL (if present);
- backfilling of boreholes;
- reinstatement of hardstanding surfaces;

- surveying the location of boreholes and monitoring wells; and
- development, measurement of water levels and sampling of the groundwater monitoring wells.
- Where required, sediment samples will be collected using a remotely operated stainless steel grab unit lowered from a sampling vessel or other equivalent method as deemed appropriate based on site conditions.

A comprehensive methodology providing further details of the intrusive site works investigation process is outlined in *Annex C*.

8.3.1 *Laboratory Analysis*

Primary samples will be couriered under chain of custody documentation to ALS Environmental Pty Ltd (ALS), a NATA accredited analytical laboratory. Inter-laboratory duplicate samples will be couriered under chain of custody documentation to Envirolab Services Pty Ltd (Envirolab) also a NATA accredited analytical laboratory. Soil and groundwater samples will be analysed for a suite of potential contaminants of concern listed below with some samples in specific areas being secheduled for additional analysis as outlined in *Table 8.2*.

- metals and metalloids (arsenic, cadmium, chromium, copper, nickel, lead, mercury, selenium and zinc);
- Total Recoverable Hydrocarbons (TRH);
- Polycyclic Aromatic Hydrocarbons (PAHs);
- Phenols;
- Volatile Organic Compounds (including benzene, toluene, ethylbenzene and xylenes -BTEX); and
- asbestos (presence / absence - soil only).

Additional contaminants of concern may be analysed if required based on observations made in the field.

8.4 *PROPOSED FIELD SCREENING PROTOCOLS*

The following field screening protocols are proposed for the Phase 2 works:

8.4.1 *Soil and Sediment*

Soils and sediments will be logged by an appropriately trained and experienced scientist/engineer to record the following information: soil/sediment type, colour, grain size, sorting, angularity, inclusions, moisture condition, structure, visual signs of contamination (including staining and fragments of fibrous cement sheeting or similar) and odour in general accordance with AS 1726-1993.

A duplicate of each soil sample will be collected for field screening and will be placed in a sealed zip lock bag and screened in accordance with ERM Standard Operating Procedures (SOPs - available upon request) using a Photo Ionisation Detector (PID) fitted with a 10.6 eV lamp, calibrated at the beginning of each working day. Where the presence of VOCs or other impact is indicated by field screening, additional laboratory analysis may be undertaken.

8.4.2 *Groundwater*

Prior to sampling or gauging each monitoring well, the well cap will be partially removed to allow the headspace to be screened using a calibrated PID over a period of one minute. The presence of odours will also be noted following removal of the well cap and described by reference to their intensity and character. Following a period of no pumping (as a minimum 24 hours) all wells will be dipped to gauge the depth to groundwater and, if necessary, the presence and thickness of Non-aqueous Phase Liquids (NAPLs). Wells will be purged using a thoroughly decontaminated peristaltic pump under low flow conditions and during this process a calibrated water quality parameter meter will be used to record field measurments of pH, conductivity, redox potential, temperature and dissolved oxygen.

8.5 *Basis For Selection Of Assessment Criteria*

The adopted assessment criteria have generally been sourced from guidelines made or approved under the Contaminated Land Management (CLM) Act 1997 where alternative sources have been utilised appropriate justification has been provided.

8.5.1 *Soil*

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

- National Environmental Protection Council (NEPC) (2013) *National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No. 1)* Schedule B1 Guideline on the Investigation Levels for Soil and Groundwater (NEPM). Health Investigation Level (HIL) 'D' - Commercial/Industrial, HIL 'C' - Public Open Space and Ecological

Investigation / Screening Levels (ESLs) (as applicable). It is noted that whilst the HIL 'C' screening criteria are generally not applicable to undeveloped, urban bushlands and reserves, they will be adopted at sampling locations in non-operational areas considered to present a more sensitive land use category. Application of the HILs will be considered on a case by case basis in accordance with the new NEPM to reflect local conditions encountered at the time of the intrusive works. Health Screening Levels for Vapour Intrusion and Direct Soil Contact (HSL) 'D' - Commercial/Industrial and Health Screening Levels for Vapour Intrusion and Direct Soil Contact Intrusive Maintenance Worker (Shallow Trench) will also be adopted;

- NSW Environment Protection Authority (EPA) (1994) *Guidelines for Assessing Service Station Sites*. Threshold concentrations for sensitive land use - soils; and

- Where no Australian endorsed assessment criteria is available reference to the National Institute of Public Health and the Environment (RIVM) (2001) *Technical Evaluation of the Intervention Values for Soil/sediment and Groundwater: Human and Ecotoxicological Risk Assessment and Derivation of Risk Limits for Soil, Aquatic Sediments and Groundwater* - Human Toxicological Serious Risk Concentrations in soil (SRC_{human} soil) will be made it is noted that these guideline values have no regulatory standing in NSW and hence further assessment of any exceedences of these criteria may be required.

8.5.2 *Groundwater*

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

- 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 and Trigger values for marine water, level of protection 99% species (for bioaccumulation of mercury);

  National Health and Medical Research Council (NHMRC) and National Resource Management Ministerial Council (NRMMC) (2011) *Australian Drinking Water Guidelines Paper 6 National Water Quality Management Strategy*, Commonwealth of Australia, Canberra;

- 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*. Health Screening Levels for Vapour Intrusion (HSL) 'D' -

Commercial/Industrial and Health Screening Levels for Vapour Intrusion Intrusive Maintenance Worker (Shallow Trench); and

- Where no Australian endorsed assessment criteria is available reference to the National Institute of Public Health and the Environment (RIVM) (2001) *Technical Evaluation of the Intervention Values for Soil/sediment and Groundwater: Human and Ecotoxicological Risk Assessment and Derivation of Risk Limits for Soil, Aquatic Sediments and Groundwater*. Human Toxicological Serious Risk Concentrations in Groundwater (SRC_{human} groundwater). It is noted that these guideline values have no regulatory standing in NSW and hence further assessment of any exceedences of these criteria may be required.

8.5.3 *Sediment*

Sediment quality data will be assessed against investigation criteria published in:

- ANZECC / ARMCANZ (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* - Interim Sediment Quality Guidelines (ISQGs).

9 *CONCLUSIONS*

The Preliminary ESA undertaken by ERM has identified that limited previous intrusive ESAs appear to have been completed on the sites and a number of potential contamination sources were identified as follows:

- CCP management facility (ash dam) and associated waste disposal areas;
- transformer area;
- coal storage area;
- fuel oil installation;
- operational and decommissioned USTs;
- attemperation reservoir;
- truck wash out pits;
- workshops;
- former northern gas turbine area;
- sewage treatment area;
- sediments in Lake Macquarie, Whiteheads Lagoon, the Return Water Pond and Crooked Creek, and sediments associated with drainage channels to Lake Eraring

Based on the results of the Preliminary ESA and consideration of Government's intended approach to establishing a baseline of soil and groundwater contamination, a programme of intrusive (Phase 2) assessment of potential soil and groundwater contamination issues is provided. The most appropriate sampling design is considered to be a combination of systematic (grid based) and judgemental (targeted) sampling of soil, groundwater and sediments at locations across the Sites.

Based on the information available at the time of preparation of this report, ERM has not identified any actual or known material contamination issues which are currently undergoing or likely to require remediation. Preliminary remediation costs have not therefore been prepared at this point in time. There is however the potential for contamination arising from identified areas of concern to give rise to material cost, which can be confirmed following the proposed Stage 2 investigations. It is proposed that remedial costs be revisited following completion of the proposed Stage 2 investigations.

10 *LIMITATIONS*

This report is based solely on the scope of work described in *Section 1.3* and performed pursuant to a contract between ERM and NSW Treasury ("Scope of Work"). The findings of this report are solely based on, and the information provided in this report is strictly limited to the information covered by, the Scope of Work.

In preparing this report for the Client, ERM has not considered any question, nor provides any information, beyond the Scope of Work.

This report was prepared between 15 March 2013 and 27 June 2013 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.

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 structural conditions of any buildings on the subject property, 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.

This report is based on one or more site inspections conducted by ERM personnel 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).

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.

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).

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 environmental works.

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.

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.

This report:

a) has been prepared and is intended only for the Client and any party that ERM has agreed with the Client in the Scope of Work may use the report;

b) has not been prepared nor is intended for the purpose of advertising, sales, promoting or endorsing any client interests including raising investment capital, recommending investment decisions, or other publicity purposes;

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d) does not purport to provide, nor should be construed as, legal advice.

11 *REFERENCES*

AECOM (2010) **Land Management Plan.** Earing Power Station 10.01.01.02.49

AECOM (2010) **Effluent Irrigation Soil Testing Program.** Eraring Energy 10.01.05.03.01

AECOM (2011) **Environmental Process Hardware Audit Report.** Eraring Energy. 10.01.04.02.03

AECOM (2013) **Review of Environmental Compliance - 2012.** Eraring Energy. 10.01.04.02.04

Aurecon (January 2010 - September 2012) **Eraring Attemporating Reservoir Groundwater Report.** January, April, October 2010; April, July 2011; and January, April, July, August, September 2012. 10.01.05.04.01 - 10.01.05.04.11

Aurecon (January 2010 - September 2012) **Coal Combustion Project Groundwater Report.** January, April, July 2010; April, July 2011; and January, September 2012. 10.01.05.04.12 - 10.01.05.04.19

Aurecon (2011) **Five Yearly Surveillance Report - Eraring Ash Dam.** 04.01.04.04.08.

Aurecon (2013) **Ash Dam: Review of Water Storage During Maximum Rainfall Events.** 04.01.04.03.40.

Australia and New Zealand Environmental and Conservation Council (ANZECC) (2000) **Australia and New Zealand Guidelines for Fresh and Marine Water Quality**

Batley G. (1987) **Heavy metal speciation in waters, sediments and biota from Lake Macquarie, New South Wales.** Australian Journal of Marine and Freshwater Research, 1987, 38, 591-606.

Burt, A. Maher, W. Roach, A. Krikowa, F. Honkoop, P. Bayne, B. (2006) **The Accumulation of Zn, Se, Cd, and Pb and Physiological Condition of Anadara trapezia Transplanted to a Contamination Gradient in Lake Macquarie, New South Wales, Australia.**

Carroll, B. (1995) **Microbial and geochemical aspects of selenium cycling in an estuarine system - Lake Macquarie, NSW.** PhD thesis. University of Sydney.

CRC CARE (2011) **Technical Report No. 10, Health Screening Levels for Petroleum Hydrocarbons in Soil and Groundwater**

Eraring Energy (2005) **Eraring Power Station Asbestos Disposal Dump Trench Location and Fill Dates Record Chart - Site Layout.** 10.01.03.01.01

Eraring Energy (2008) **Fact Sheet No. 22 - Selenium.** 10.01.05.03.17

Eraring Energy (2012) **EPL Annual Return 2011-2012.** 10.01.03.01.12

Eraring Energy (January 2012) **Eraring Energy Power Station Environmental Hardware Audit 2011 Action Plan.** 10.01.04.01.03

Eraring Energy (January 2012 - October 2012) **Environmental Incident and Complaints Report.** January, February, March, April, June, July, August, September, October 2012. 10.01.04.04.01 - 10.01.01.01.09

Eraring Energy (April 2012 to October 2012) **Environmental Monitoring Data.** Prepared for the EPA 10.01.05.03.04 - 10.01.05.03.10Eraring Energy (2011) **Waste Reduction and Purchasing Policy Report 2010/2011.** 10.01.05.06.01

Geo Logix (2011a) **Contamination Investigation Report** - Stores Building UPSS Eraring Power Station 04.01.03.04.11

Geo Logix (2011b) **Groundwater Monitoring Well Installation Report -** Unit 1 Turbine House Basement. 10.01.05.04.22

Geo Logix (2011c) **Groundwater Monitoring Well Installation Report -** Vehicle and Mobile. 04.01.03.04.12

Indicative Surface Water Flows Map, 1of 2 and 2 of 2. 10.01.05.03.13 and 10.01.05.03.14.

Kirby, J. Maher, W. Krikowa, F (2001) **Selenium, Cadmium, Copper, and Zinc Concentrations in Sediments and Mullet (Mugil cephalus) from the Southern Basin of Lake Macquarie, NSW, Australia.**

Lake Macquarie City Council, **Local Environmental Plan 2004** (LEP 2004)

Lake Macquarie City Council, **Local Environmental Plan 2013** (Draft LEP 2013)

Lake Macquarie City Council (1995) **Lake Macquarie Estuary Process Study, Volume I - Report,** Prepared by Australian Water and Coastal Studies Pty. Ltd. and JH&ES Laxton, Pty. Ltd.NEPC (1999) National Environmental Protection (Assessment of Site Contamination) Measure

NEPC (2013) National Environment Protection (Assessment of Site Contamination) Amendment Measure (No. 1)

NHMRC and NRMMC (2011) **Australian Drinking Water Guidelines Paper 6 National Water Quality Management Strategy**

NSW DEC (2006) **Guidelines for the NSW Site Auditor Scheme (2nd edition)**

NSDW EPA (1994) **Guidelines for Assessing Service Station Sites**

NSW EPA (2008) **Protection of the Environment Operations (Underground Petroleum Storage Systems) Regulation**

NSW EPA (2011) **Guidelines for Consultants Reporting on Contaminated Sites.**

Office of Environment and Heritage **Environmental Protection Licence 1429.** 10.01.03.02.03

Pacific Power (2000) **Eraring Power Station Environmental Closed Asbestos Disposal Sites and Used Fabric Filter Bag Disposal Area Site Area Map.** 10.01.03.0.1.02

Ring, E. (2004) **Contaminated Water System Briefing Paper** 10.01.05.03.22

RIVM (2001) **Technical Evaluation of the Intervention Values for Soil/sediment and Groundwater: Human and Ecotoxicological Risk Assessment and Derivation of Risk Limits for Soil, Aquatic Sediments and Groundwater**

Roach A. C, Maher W, Krikowa F. (2008) **Assessment of metals in fish from Lake Macquarie, New South Wales, Australia.** Archives of Environmental Contamination and Toxicology. 2008 Feb;54(2):292-308.

Worley Parsons (2013) **Independent Engineer's Report** Eraring Power Station

DOCUMENT 2b

Eraring Power Station

Stage 2 Environmental Site Assessment – Part 1

Environmental Resources Management

December 2015

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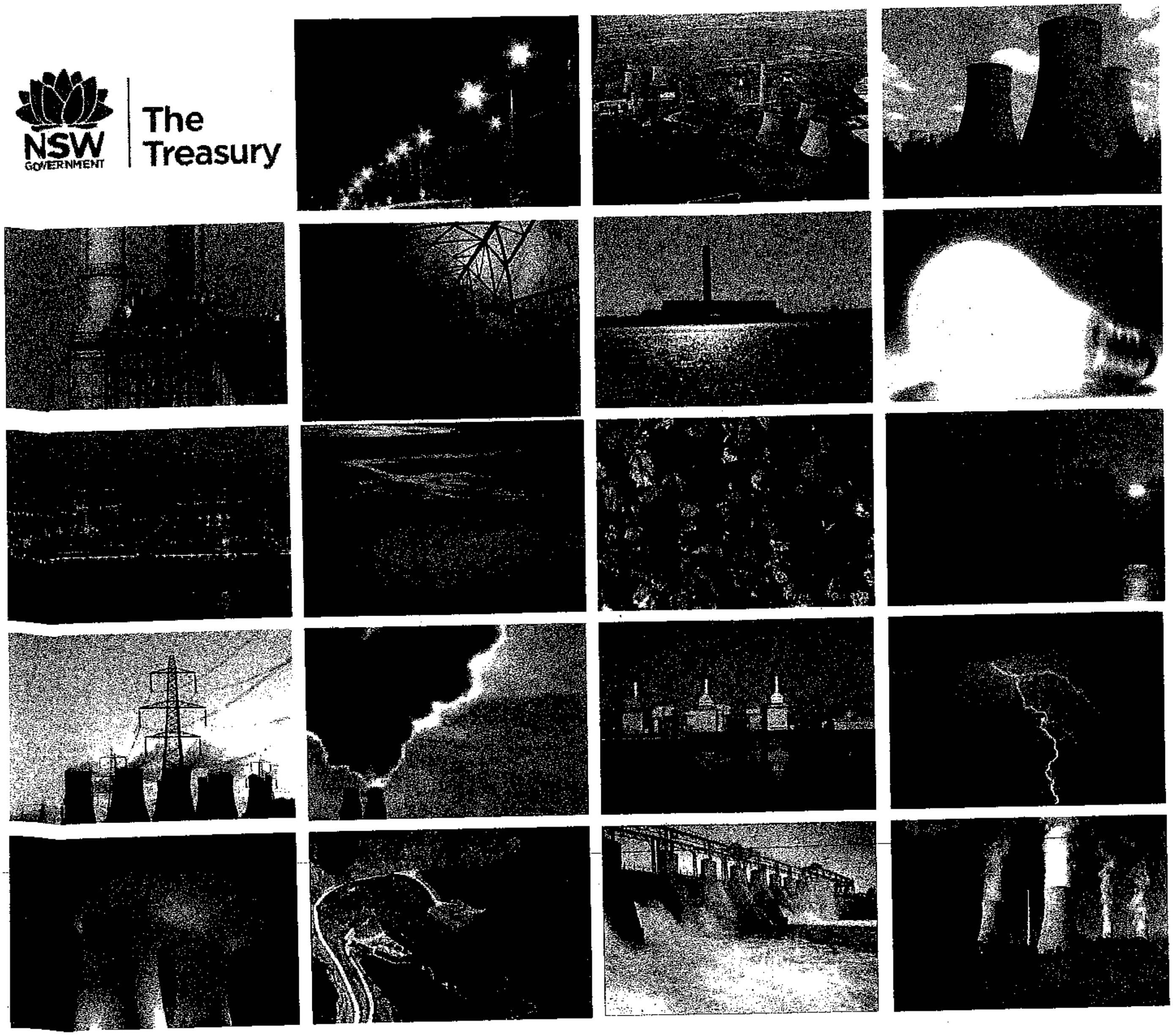

COMMERCIAL IN CONFIDENCE

Delta Electricity

Eraring Power Station

Stage 2 Environmental Site Assessment

Ref: 0207419RP03_Final V05

December 2015

ERM

The world's leading sustainability consultancy

Approved by:	Hamish Campbell
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Environmental Resources Management Australia Pty Ltd Quality System

Eraring Power Station

Stage 2 Environmental Site Assessment

Delta Electricity

December 2015

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EXECUTIVE SUMMARY

Environmental Resources Management Australia Pty Ltd (ERM) was retained by Delta Electricity Pty Ltd (Delta) on behalf of New South Wales Treasury (NSWT) to undertake a Stage 2 Environmental Site Assessment (Stage 2 ESA) at Eraring Power Station (herein referred to as 'the Site'), in accordance with the work scope presented in the Preliminary Environmental Site Assessment (PESA - ERM Reference: 0194708RP02 Eraring, 2013), the Sampling Analysis and Quality Plan (SAQP; ERM Reference: 0207419RP02_SAQP FinalRev02, 2013) prepared by ERM for the Site and the proposal presented for the additional Stage 2 ESA (ERM Reference: P0199535 Eraring Additional Investigations 250814).

The objective of this Stage 2 ESA was to gather soil, sediment, surface water and groundwater data in order to develop a baseline assessment of environmental conditions at the site and within relevant surrounding receiving environments (including water, land and sediments), as at or near the time of the sale of the Site to Origin Energy Pty Ltd in accordance with the SAQP (0207419RP02_SAQP FinalRev02, 2013) and the PESA (ERM Reference: 0194708RP02 Eraring, 2013). Secondary objectives were to assess whether a risk to human health or the environment was present and to assess whether impact at the Site warranted notification (to the NSW EPA) and / or regulation.

Investigation Methodology

To achieve the stated objectives, ERM collected soil, groundwater, sediment and surface water samples and submitted those collected samples to environmental laboratories for analysis of Constituents of Potential Concern (COPCs). A Conceptual Site Model (CSM) developed for the Site during the PESA was further refined and the analytical data was compared against published environmental screening values to provide a tier one assessment of potential risks to human health and the environment.

Investigation Outcomes

The data presented in the ESA was considered to be of a suitable quality and completeness to provide a baseline of environmental conditions at the Site and immediate surrounding receiving environments.

Evaluation of Potential Risks to Human Health and/or the Environment

Based on the results of this investigation, the majority of the impacts identified in soil, sediment, surface water and groundwater at the Site were not considered likely to represent a potential risk to human health and/or the environment based on the current and continued use of the Site as a Power Station and for associated activities, in line with the current zoning as outlined within the revised 2014 Local Environment Plan (LEP). Exceptions to this are:

- *A potential risk to the environment from metals concentrations in groundwater at certain site boundaries above ecological screening values;*

- *Elevated selenium concentrations within sediments in offsite surface water bodies down-gradient of the Coal Combustion Products Management Facility (CCPMF) also represent a potential risk to the environment (ecological exposure and ingestion of fish); and*
- *Asbestos identified in soils and acid sulfate soils within the Site represent a potential risk to human health and the environment, if disturbed, although in their current state and if left undisturbed, this risk is considered to be minimal.*

Requirements under the Contaminated Land Management (CLM) Act (1997).

- *With regard to onsite soil contamination, the triggers for the duty to report have not been met.*
- *With regard to foreseeable contamination of neighbouring land, a duty to report may exist in relation to offsite contaminated sediments.*
- *With regard to Asbestos in, or on, soil, a duty to report exists however it is considered unlikely that the NSW EPA would consider regulation based on the limited risk of exposure.*
- *With regard to groundwater, a duty to report exists for exceedences of drinking water guideline values due to elevated concentrations of arsenic, nickel, selenium, benzo[a]pyrene and vinyl chloride.*
- *With regard to groundwater a duty to report exists for exceedances of ecological guideline values due to elevated concentrations of cadmium, copper, lead, nickel, selenium and zinc.*

1 *INTRODUCTION*

1.1 *BACKGROUND*

Environmental Resources Management Australia Pty Ltd (ERM) was commissioned by Delta Electricity Pty Ltd (Delta) on behalf of New South Wales Treasury (NSWT), to undertake a Stage 2 Environmental Site Assessment (Stage 2 ESA) at Eraring Power Station (herein referred to as the "Site"). Eraring Power Station is situated adjacent to the western shore of Lake Macquarie, near the township of Dora Creek, south west of Newcastle, NSW, Australia.

The works detailed herein are required to support the recently completed sale of Eraring Power Station to Origin Energy Pty Ltd (Origin), in accordance with the work scope presented in the Sampling Analysis and Quality Plan (SAQP; ERM Reference: *0207419RP02_SAQP FinalRev02, 2013*) and the Preliminary Environmental Site Assessment (Preliminary ESA; ERM Reference: *0194708RP02 Eraring, 2013*). The PESA identified a number of Areas of Environmental Concern (AECs) which were subject to further investigation based on the potential for impacts (as defined in the PESA).

A site location plan is presented as *Figure 1* of *Annex A*. The general site layout is presented in *Figures 2* to *4* of *Annex A*.

The works detailed herein were initially commissioned by Eraring Energy (a former State Owned Corporation (SOC)) which, at the time was wholly owned by the State of NSW. Following the completion of the sale of Eraring Energy's assets to Origin, ERM's contract for the works was novated to Green State Power (GSP). Green State Power was a company owned by the New South Wales Government and was registered on 4 June, 2013. GSP became operational on 1 August, 2013 following the sale of Eraring Energy to Origin and was subsequently deregistered following the completion of the sale to Origin and divestment of some other assets. All remaining assets, and related liabilities of GSP were transferred to Delta under a vesting order made under the Enabling Legislation (which took effect on 8 December 2014). As such, Delta (as the remaining SOC) has responsibility (on behalf of NSWT) for overseeing the completion of the Stage 2 ESA.

1.2 *OBJECTIVES*

The primary objective for the Stage 2 ESA was to gather soil, sediment, surface water and groundwater data in order to develop a baseline assessment of environmental conditions at the Site and immediate surrounding receiving environments (including water, land and sediments), as at or near the time of the transaction.

The secondary objectives of the Stage 2 ESA were to:

- assess whether impact at the Site (if present) represents an acceptable risk or poses a risk to human health and/or the environment based on the current and continued use of the Site (in line with the current zoning (as noted in *Figure 8* of *Annex A*)); and
- assess whether impact at the Site (if present) is likely to warrant notification and / or regulation (under the *Contaminated Land Management Act 1997*) and remediation.

Data obtained during completion of the Stage 2 ESA may also be used to inform potential future management of contamination issues both at the Site and in relation to the relevant receiving environments. Speculation in relation to the potential management of the identified issues in the future is not included within this report.

1.3 *APPROACH AND SCOPE OF WORK*

The adopted approach and scope of works for the Stage 2 ESA works comprised the following general tasks, in accordance with the requirements set out in the SAQP (ERM Reference: *0207419RP01 Final Rev02, 2013*) and agreed in subsequent discussions and correspondence between Origin, ERM and NSWT (as noted in *Annex Q* and *Table 1b* of *Annex B*):

Preliminaries

- prepare a Health and Safety Plan (HASP) and Environmental Management Plan (EMP);
- assess the suitability and integrity of the current groundwater monitoring well network, and whether they could be sampled as part of this investigation;
- identify additional areas or chemicals of concern as previously identified within the Preliminary ESA interviews/Site visits;
- review and amend the SAQP, if deemed necessary;
- engage subcontractors including underground utility locator, drillers, laboratories and surveyors;
- schedule soil, sediment, surface water and groundwater investigation works with GSP and Origin; and
- complete Site specific inductions and permitting, as required.

Site Works

- ground-truth proposed sampling locations including clearance of underground services as noted below;
- identify above and below ground services through the commissioning of a qualified underground utility locator, attain Dial Before You Dig (DBYD) plans, Site engineering drawings and specific Site knowledge to clear proposed sampling locations;
- complete intrusive drilling works, including shallow soil and sediment sampling, and water sampling (both ground and surface water) on and off-site in accordance with the requirements of the SAQP and subsequent scope for the Additional Stage 2 works (as agreed with Origin) and documented in *Table 1b* of *Annex B*. The investigation locations are presented in *Figures 3.1 to 3.8* of *Annex A*;
- laboratory analysis of selected soil, sediment, ground and surface water samples for a combination of Constituents of Potential Concern (COPC) in accordance with the requirements of the SAQP and as outlined in Section 4.9;
- complete visual inspections of non-operational areas within lands which formed part of the transaction but were not subject to a lease in accordance with the requirements of the SAQP, as presented in *Figure 4* of *Annex A* and listed within *Annex K*; and
- the survey of newly installed monitoring wells by a registered surveyor to Australian Height Datum (AHD) and Map Grid of Australia (MGA).

Reporting

- Submission of weekly project management progress reports to GSP (now Delta) and NSWT (which related primarily to commercial, schedule and other project management issues); and
- Submission of sampling summaries to Origin and GSP and NSWT during the course of the works which included technical detail of the works being undertaken.

At the completion of the investigation works, this Stage 2 ESA report was prepared as detailed in the following section.

1.4 *REPORT STRUCTURE*

This Stage 2 ESA report has been prepared in general accordance with the NSW Environmental Protection Agency (EPA) (1997) *Guidelines for Consultants Reporting on Contaminated Sites,* as follows:

- *Section 1* - Introduction, background, objectives and scope of works;
- *Section 2* - Site setting including a summary of the Site history and Site conditions;
- *Section 3* - Data Quality Objectives (DQOs) for the works conducted;
- *Section 4* - Sampling and works methodologies for completing the investigation;
- *Section 5* - Results of the Stage 2 ESA works and Site-specific discussion; and
- *Section 6* – Conclusions.

Other guidelines utilised during completion of this Stage 2 ESA included, but were not limited to:

- Australian Standard AS 4482.1-2005 (2005) *Guide to the Sampling and Investigation of Potentially Contaminated Soil. Part 1 – Non-volatile and Semi-volatile Compounds;*
- Australian Standard AS 4482.2-1999 (1999) *Guide to the Sampling and Investigation of Potentially Contaminated Soil. Part 2 –Volatile Substances;*
- Australia and New Zealand Environmental and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000) *Australia and New Zealand Guidelines for Fresh and Marine Water Quality;* and
- National Environment Protection Council (NEPC) (April 2013) *National Environment Protection (Assessment of Site Contamination) Measure 1999, NEPC, Canberra.*

A full list of all references is also appended to this report.

1.5 *LIMITATIONS*

The findings of this report are based on the client-approved SAQP (ERM Reference: *0207419RP01 Final Rev02, 2013*), the Additional Stage 2 scope of works agreed with Origin (refer to *Table 1b* of *Annex B*) and the scope of work summarised in *Section 1.3* of this report. These works were undertaken in consideration of the Consultancy Agreement for professional services as Site Contamination Adviser in relation to *Generation Assets and Cobbora Mine Development* (dated 23 March, 2013), ERM's response to Request for Proposal (dated 25 February, 2013), and the *Draft Scope for State's Contamination Consultant (as provided by the State to Origin on 20 March 2013) Origin Comments (as at 25 March 2013).*

ERM performed the services in a manner consistent with the normal level of care and expertise exercised by members of the environmental assessment profession. No warranties, express or implied, are made.

Although normal standards of professional practice have been applied, the absence of any identified hazardous or toxic materials on the subject Site should not be interpreted as a guarantee that such materials do not exist on the Site.
This assessment is based on Site inspections conducted by ERM personnel, sampling and analyses described in the report, and information provided by people with knowledge of Site conditions.

All conclusions and recommendations made in the report are the professional opinions of the ERM personnel involved with the project and, while normal checking of the accuracy of data has been conducted, ERM assumes no responsibility or liability for errors in data obtained from regulatory agencies or any other external sources, nor from occurrences outside the scope of this project.

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2 SITE SETTING

2.1 SITE IDENTIFICATION

Eraring Power Station is situated adjacent to the western shore of Lake Macquarie, near the township of Dora Creek, southwest of Newcastle, NSW. The approximate coordinates of the Power Station are 361834 m E and 6340642 m S. A Site Location Map is provided as *Figure 1 of Annex A*.

The total area of the Eraring Power Station is approximately 1147 hectares (ha), including water canals but excluding associated coal mines. The power station operational area itself occupies approximately 150 ha. Subsequent to completion of the Preliminary ESA, the Eraring to Newstan Coal Haul Road (Coal Haul Road) and an additional 67 non-operational parcels of land, not subject to lease agreements were added to the scope of the assessment. It is noted that the Coal Haul Road was not wholly under the direct ownership of Eraring Energy prior to the transaction but occupied and operated under a series of leases, licenses and agreements. It is noted that non-operational parcels of land which were occupied and / or subject to a lease agreement were assessed by Origin personnel and did not form part of the scope of this assessment, however copies of the Origin inspection reports are included within *Annex L*.

The Lake Macquarie Local Environmental Plan (LEP) 2014 (LEP 2014) currently designates the zoning and regulates land use for the Eraring Power Station. The zoning within the site is presented in *Figure 8* of *Annex A* and is summarised as follows:

- SP2 (Special Infrastructure) - the majority of the site including operational areas of the Eraring Power Station;
- E2 (Environmental Conservation) - vegetated areas west of the Accessible Operational Area (and adjacent to Muddy Lake), south of the Attemperation Reservoir, east of the Accessible Operational Area and adjacent to the intake canal; and
- E3 (Environmental Management) – a small portion of land adjacent to the Intake Canal and Dora Creek).

It is noted that a number of non-operational lots (both vacant and tenanted land) are present south of Wangi Road. The zoning within these lots is shown in *Figure 4* of *Annex A* and consists of E3 (Environmental Living) or RU4 (Primary Production Small Lots).

For the purpose of this assessment, the Site was divided into 12 individual Work Areas, (referred to hereafter as AECs), according to usage and the presence of potential sources of contamination, as follows;

- EA - Coal Combustion Product Management Facility (CCPMF, also known as the ash dam);
- EB - Transformer Area;
- EC - Fuel Oil Installation, Fuel Pipelines and ASTs;
- ED - Operational and Decommissioned Underground Storage Tanks (USTs);
- EE - Workshops;
- EF - Former Northern Gas Turbine Location (non-operational);
- EG - Whiteheads Lagoon, Return Water Dam, Crooked Creek, Drainage Channels and Lake Macquarie Sediments and Surface Waters;
- EH - Coal Storage Area;
- EI - Accessible Operational Area;
- EJ - Non-Operational Areas including Non-Operational Lots;
- EK - Coal Haul Road; and
- EL - Asbestos Containing Pipework.

A Site layout plan is provided as *Figure 2 of Annex A*. The locations of the AECs are illustrated in *Figure 3.1* to *4* of *Annex A*.

The extent of the coal haul road and non-operational parcels of land, not occupied or subject to a lease are not shown in *Figure 2*, but are presented separately in *Figures 3.8 and Figure 4* of *Annex A*.

Eraring Power Station comprises four coal fired units (Units 1 to 4) which have a total generated output of 2880 MW. The station employs a once through cooling system using salt water from Lake Macquarie. Four 330 kV and 500 kV transmission lines provide connection to the electricity grid. Outside of the Power Station area, the Site includes the following features:

- an open canal providing water to the Power Station is sourced from an inlet at Bonnells Bay, running along the western side of Lake Eraring and delivering water to a pumping station in the east of the Site, located within Area EJ and presented on *Figure 3.6* of *Annex A*;

- an Attemperation Reservoir located in the south of the Site, located within Area EJ and presented on *Figures 3.4* to *3.5* of *Annex A;*
- cooling water from the Power Station is discharged via an outfall tunnel which runs from the southern corner of the Power Station area to Myuna Bay, located within Area EJ and presented on *Figures 3.3* to *3.5* of *Annex A;*
- a switchyard, settling basin and oil retention weir, and cooling towers, located within Area EJ and presented on *Figure 3.4* and *Figure 3.5* of *Annex A;*
- a coal storage area, located within Area EH and presented on *Figure 3.1* of *Annex A;*
- sewage treatment works and water reservoirs, located within Area EJ and presented on *Figure 3.1* of *Annex A;*
- four 1 ML fuel Aboveground Storage Tanks (ASTs) known as the Fuel Oil Installation, located within Area EC and presented on *Figure 3.1* of *Annex A;*
- the former (Northern) Gas Turbine area (not currently operational), including two fuel ASTs, four transformers, oil water separators and an oil containment dam, located within Area EF and presented on *Figure 3.1* of *Annex A;*
- the Coal Combustion Product Management Facility (CCPMF) is located in the eastern portion of the Site, with waste disposal areas (including asbestos) located on the south-west and north-west fringes of the dam, located within Area EA and presented on *Figures 3.1* to *3.2* of *Annex A;*
- also within the northern portion of the Site is a weighbridge, truck wash-out pits, oil water separators, and a rail loop and presented on *Figure 3.1* of *Annex A;*
- a large network of internal sealed and unsealed roads, coal conveyors, above ground pipelines for fuel and fly ash transfer and a variety of overhead and underground services are also located throughout the Site.

A Conceptual Site Model (CSM) identifying sources, pathways and receptors along with cross sections through selected areas of the site is presented in *Annex C.* The CSM identifies the sources (as discussed within *Section 2.4*) and the relevant receptors (as discussed within *Section 2.10*) as well as the complete pathways linkages.

2.2 *SITE HISTORY*

The construction of Eraring Power Station commenced in 1977, with Units 1 and 2 entering commercial operation in 1982, Unit 3 in 1983 and Unit 4 1984. The 'black start' gas turbine was first introduced into the grid in 2009.

Information provided by Site management and a review of aerial photographs indicates that prior to construction of the Eraring Power Station, the Site and surrounds were primarily occupied by a mixture of small farms and native vegetation. The primary exceptions to this were the eastern portion of the current CCPMF and the area to the south of the current switchyard. The eastern portion of the footprint of the current CCPMF was previously utilised as an ash dam for the nearby former Wangi Power Station, the approximate extent of the Wangi Ash Dam is shown in *Figure 3.2* of *Annex A*. The area to the south of the switch yard is currently used for recreational purposes (playing fields and pony club grounds) and these were present in this location prior to construction of Eraring Power Station.

2.3 *SURROUNDING ENVIRONMENT*

Eraring Power Station is sited in a natural depression on the western shore of Lake Macquarie, near the township of Dora Creek with tracts of vegetated land generally separating the power station from the neighbouring communities.

The surrounding environment includes:

- Myuna Bay to the east;
- the Great Northern Railway along the western boundary. A freshwater wetland (Muddy Lake) (listed under *State Environmental Planning (SEPP) Policy No. 14*) is also located to the west of the Site;
- Lake Eraring and Bonnells Bay to the south; and
- a mixture of private and Crown Lands to the north.

Principal landholders adjacent to the Site include:

- NSW Department of Lands - Crown Land to the north;
- Centennial Coal - Cooranbong Colliery to the west and Myuna Colliery to the north east;
- Rail Services Australia - rail corridor which is adjacent to the west of the Power Station;

- Transgrid and Energy Australia - electricity supply infrastructure;
- NSW Sport and Recreation - Myuna Bay Sport and Recreation Centre to the east;
- private residents - rural properties of Myuna Bay and Eraring to the east; and
- private residents - residential properties of Dora Creek to the south.

2.4 *POTENTIAL AND KNOWN SOURCES OF CONTAMINATION*

The Preliminary ESA identified that limited previous intrusive ESAs appear to have been completed on the Site, and a number of potential contamination sources were identified (as noted in *Table 2.1* below).

The current and former fire training areas were identified as areas of concern requiring further investigation, based on information made available to ERM subsequent to the completion of the Preliminary ESA. The former fire training area was identified north west of the Attemperation Reservoir (refer to *Figure 3.5* of *Annex A*). It is understood that both fire accelerants (petroleum hydrocarbons) and fire retardants (also known as Aqueous Film Forming Foam (AFFF) chemicals) potentially containing Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA) may have been used in association with these training activities. The current fire training area (located east of the coal stockpile) was not identified during the initial Stage 2 ESA. This area was subsequently investigated during the Additional Stage 2 Investigation work completed between 27 October and 7 November 2014 (and as such results are presented within this report).

Previous investigations at the Site have identified the following contamination issues:

- previous surface and groundwater results show seepage from the CCPMF is saline and contains heavy metals. Selenium concentrations in groundwater downgradient of the CCPMF have been shown to exceed ANZECC (2000) 95% trigger levels for freshwater;
- there are also two asbestos (disposal) landfill areas within the CCPMF that have been capped and signposted, as well as a general waste landfill;
- low pH in groundwater in the vicinity of the Attemperation Reservoir and the associated borrow pit;
- monitoring wells installed for Underground Petroleum Storage Systems (UPSS) monitoring downgradient of USTs identified some soil and groundwater impact near the Stores Building (*Geo-Logix, August 2011*) as presented in *Figure 3.7* of *Annex A*;

- areas of known asbestos contamination in soils beneath the return water and dust slurry pipes, as described in data room document *01.13.01 Incident Notification - Asbestos Under Return Water Piping - 22-7-1*; and
- metals concentrations elevated above background levels have been attributed to the Site, in particular selenium concentrations in sediments within Whiteheads Lagoon which may be associated with the overflow channel from the current CCPMF and /or the former Wangi Ash Dam.

The Centennial Coal properties, railway corridor and electricity supply infrastructure could present potential offsite sources of contamination to the surrounding environment and the western boundary of the Site.

Based on the potential sources of known and unknown contamination across the AECs, the associated Constituents of Potential Concern (COPCs) are noted below in *Table 2.1*.

Table 2.1 Identified Sources and COPCs

Area of Environmental Concern	AEC Description	Constituents of Potential Concern
EA	Coal Combustion Product (CCP) Management Facility (Ash Dam and Surrounds)	Metals, TRH, PAHs, Phenols, BTEX, asbestos, pH#, salinity#, PCBs, VOCs and PFOS/PFOA.
EB	Transformer Area	Metals, TRH, PAHs, Phenols, BTEX, asbestos, pH#, salinity#, PCBs, VOCs and PFOS/PFOA.
EC	Fuel Oil Installation and associated pipelines and Site ASTs	Metals, TRH, PAHs, Phenols, BTEX, asbestos, pH#, salinity#, PCBs, VOCs and PFOS/PFOA.
ED	Operational and Decommissioned USTs	Metals, TRH, PAHs, Phenols, BTEX, VOCs, pH#, salinity#.
EE	Workshops	Metals, TRH, PAHs, Phenols, BTEX, asbestos, pH#, salinity#, PCBs and VOCs.
EF	Former (Northern) Gas Turbine Location	Metals, TRH, PAHs, Phenols, BTEX, asbestos, pH#, salinity#, PCBs and VOCs.
EG	Whiteheads Lagoon, Return Water Dam & Crooked Creek Sediments & Surface Water, Lake Macquarie Sediments & Surface Water	Metals, TRH, PAHs, Phenols, BTEX, pH#, salinity# and PCBs.
EH	Coal Storage Area	Metals, TRH, PAHs, Phenols, BTEX, asbestos, pH#, salinity#, PCBs, VOCs and PFOS/PFOA.
EI	Accessible Operational Area incorporating Contaminated Water System (CWS) pits and pipelines	Metals, TRH, PAHs, Phenols, BTEX, asbestos, pH#, salinity#, PCBs, VOCs and PFOS/PFOA.

Area of Environmental Concern	AEC Description	Constituents of Potential Concern
EJ	Non Operational Areas, including Attemperation Reservoir, truck washout pits, sewage treatment area, current and former firefighting training area	Metals, TRH, PAHs, Phenols, BTEX, asbestos, pH#, salinity#, PCBs, VOCs and PFOS/PFOA.
EK	Coal Haul Road	Metals, TRH, PAHs, Phenols, BTEX, asbestos, pH#, salinity#, PCBs and VOCs.
EL	Known or suspected Asbestos Containing Pipework, including underneath return water lines	Asbestos

1. Standard Suite includes Metals and Metalloids (arsenic (As), mercury (Hg), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), Nickel (Ni), Zinc (Zn) and Selenium (Se)), Total Recoverable Hydrocarbons (TRH), Benzene, Toluene, Ethylene Benzene and Xylene (BTEX), Polycyclic Aromatic Hydrocarbons (PAHs) and Phenols, Asbestos (presence / absence – soil only)
2. Selected Additional Analysis includes Polychlorinated Biphenyls (PCBs), Volatile Organic Compounds (VOCs), Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA)
3. # Physio-chemical properties.

2.5 *TOPOGRAPHY*

The elevation of the Site ranges between approximately 30 m above sea level at the Power Station area, to 40 m above sea level at the CCPMF. The Power Station area is flat and situated within a natural depression, with the remainder of the site sloping up to the north, east and south. The study area is broadly bounded to the west by the Watagan and Sugarloaf Ranges.

It was understood that the Ash Dam slopes from 137.2 Relative Level (RL) at the western end to 131 RL at the eastern side, with the internal eastern embankment has been raised locally to 132 RL for the northern part only (Aurecon, 2013).

2.6 *GEOLOGY*

Regional Geology

The Site is located within the Sydney Geological Basin and the 1:100 000 Gosford-Lake Macquarie geological map (Geological Survey of New South Wales, 2003) indicates that the Site is underlain by late Permian to early Triassic age conglomerate, pebbly sandstone and shale of the Munmorah Conglomerate, Narrabeen Group. The Munmorah Conglomerate is in turn underlain by late Permian age conglomerate, tuff, siltstone, claystone and coal of the Moon Island Beach Formation.

While the Munmorah Conglomerate covers the majority of the Site, the Moon Island Beach Formation daylights in the north eastern section of the Site in the vicinity of the CCPMF. In this area, Holocene age sediments consisting of sand and gravel overlies the Moon Island Beach Formation directly adjacent to Lake Macquarie in the vicinity of Myuna Bay.

The central and northern section of the Coal Haul Road crosses deposits associated with the Moon Island Beach Formation described above, Quaternary age gravel, sand, silt and clay and sandstone and minor siltstone of the Triassic age Hawkesbury Sandstone (Geological Survey of New South Wales, 1995).

Local Geology

A review of the intrusive soil and groundwater investigations completed by Geo-Logix) (2011a, 2011b and 2011c) indicates that the areas of the Site subject to their investigation were generally found to be underlain by a layer of shallow (up to approximately 2 m depth) fill material consisting of gravel, silt, sand and clay overlying clayey sand with gravel and gravelly clay to 10 m below ground level (bgl). The intrusive works also reported the presence of intermittent underlying weathered conglomerate (from > 3 m bgl where encountered) and weathered sandstone (3.4 - 4.3 m bgl in EPS MW7) along with coal seams (> 8 m bgl in EPS MW6 and EPS MW7).

The site characterization works undertaken as part of this Stage 2 ESA expanded significantly on the geological information available for the Site, and a description of local geological conditions encountered during the latest site characterization works is provided in *Section 5.1*.

Soil

The study area is located on the Lake Macquarie landscape map (1:100,000), *NSW Soil and Land Information System*. This landscape is derived from the Narrabeen Group, alluvium overlying muddy sand estuarine sediment that features moderately deep, sulfidic, extratidal, non-gravelly, loamy and sandy Hydrosol soils.

2.7 HYDROGEOLOGY AND EXISTING GROUNDWATER WELLS

Existing groundwater monitoring wells are present across the Site in a number of locations as follows:

- eleven existing monitoring wells associated with the CCPMF (AEC EA);
- thirteen existing monitoring wells associated with operational and decommissioned USTs (AEC ED); and

- five existing monitoring wells associated with the operational areas including workshop, turbine house and stores (AEC EI).

The locations of these monitoring wells are presented within *Figures 3.1* to *3.7* in *Annex A*.

During the previously completed intrusive soil and groundwater investigation (Geo-Logix, 2011a to 2011c), groundwater was encountered beneath the Site at depths between approximately 4.1 m bgl and 9.0 m bgl within unconsolidated sediments described as ranging between silty clays to sand (Geo-Logix 2011a and 2011b) and within weathered conglomerate (Geo-Logix 2011c).

Field parameters measured during groundwater sampling conducted as part of the Geo-Logix investigations (2011a to 2011c) indicate that the electrical conductivity (EC) of groundwater generally ranges between 400 to 4 000 µS/cm. Based on an applied conversion factor of 0.65 to convert µS/cm to mg/L, indications are that salinity levels of groundwater range between approximately 260 mg/L to 2 600 mg/L (indicating that groundwater varies from fresh to moderately saline).

The Stage 2 ESA expanded significantly on the Site specific hydrogeological information available, and a description of local hydrogeological conditions encountered during the latest Site characterisation works is provided in *Section 5.2* with the conceptual hydrogeological model for the site presented in *Section 5.4*.

2.7.1 *Historical Monitoring Data*

Prior to completion of the Stage 2 ESA, historical monitoring data was made available to ERM by Eraring Energy (at that time) environmental personnel for review as part of the PESA. The following monitoring data was reviewed as part of PESA:

- Groundwater monitoring wells GW1 to GW5 surrounding the Attemperation Reservoir, with data from between August 2009 to March 2013.

- Groundwater monitoring wells GM/D1, GM/D2, D26, D29, MW01, MW02, MW03, MW05 and MW06 surrounding the CCPMF, with data from between January 2010 to December 2011.

- Surface water monitoring at various locations across the site, with data from between January 2006 to April 2013.

Based on a review of the data against the ANZECC ecological screening values (which are more conservative than the relevant recreational screening values), relevant screening values presented in the Australia Drinking Water guidelines, and acceptance criteria presented in the EPL, the following trends were noted. A detailed summary of the data reviewed and exceedences noted was also presented in the PESA (ERM, 2013a)

- Elevated concentrations of copper, lead and zinc exceeding the ANZECC criteria were commonly observed immediately surrounding the Attemperation Reservoir. Lead and arsenic concentrations also exceeded the Australia Drinking Water Guidelines.

- Elevated concentrations of copper, lead and zinc exceeding the ANZECC criteria were commonly observed immediately surrounding the CCPMF. Lead and arsenic concentrations also exceeded the Australia Drinking Water Guidelines.

Concentrations of suspended solids and selenium regularly exceeded the EPL acceptance limit at surface sampling locations, particularly at the Ash Dam toe drain sampling location, at the Ash Dam return canal sampling location and at the utilisation area sampling point adjacent to the sewerage treatment works. Selenium concentrations also commonly exceeded the adopted ANZECC criteria and the Australia Drinking Water Screening value, however it is noted that concentrations of selenium decreased from 2006 to 2013.

2.8 *GROUNDWATER USE*

The NSW Natural Resource Atlas online bore register identifies that groundwater bores within a 5 km radius of the Site operational area (excluding the Coal Haul Road) are registered for irrigation, farming, private domestic and stock use. The standing water level in the bores was recorded as less than 15 m bgl.

Licensed bores located within a 5 km radius of the Site operational area identified in a bore search conducted on 5 November 2013 are listed in *Table 2.1* (below). One bore (GW029567) was located within the operational area of the Site (as shown in *Figures* 3.4 and 3.7 of *Annex A*). This bore was registered for domestic farming irrigation stock purposes. Based on initial discussions with site personnel, ERM was advised that this bore was not in use and the specific location was not known. It is noted that given the reported location of this bore (within the operational area), the construction date of the power station (circa 1977), the construction date of the bore (1968) and the lack of onsite knowledge regarding the bore, it was considered likely that the bore is redundant. Further thorough inspections undertaken by ERM and Origin representatives in the reported location of the bore did not identify the bore, or any evidence that the bore may still be present, in either a used or unused state.

Table 2.2 ***Licensed Groundwater Bores within a 5 km radius***

Bore ID	Distance from Site (km)	Direction from Site	Depth Screened (m bgl)	Screened Lithology	Registered Use
GW029567	0.34	North (onsite)	3.0 [1]	Sandstone	Domestic Irrigation Stock (understood to be redundant)
GW202325	3.58	North	1.5 – 3.0	Silty Clay / Sand	Monitoring Bore
GW033618	4.07	North West	18.2 - 21.2	Shale / Sandstone	Stock
GW033619	4.17	North West	18.2 – 21.2	Shale / Sandstone	Stock
GW053438	2.8	West	16.0 – 53.0 [2]	Shale with Coal seam [3]	Domestic Stock
GW064033	4.73	West	12.2 – 12.8 18.3 – 18.6 48.2 – 49.4 [2,4]	Sandstone / Conglomerate [3]	Domestic Stock
GW052111	2.77	South West	21.0 – 23.0 44.0 – 46.0 [2,4]	Coal / Sandstone / Conglomerate [3]	Domestic Stock
GW064143	4.1	South West	10.6 – 18.6	Gravel	Domestic Stock
GW078608	3.77	South West	5.6 – 60.0 [2]	Claystone / Shalestone / Sandstone / Conglomerate [3]	Domestic Stock

1 = Not Available

2 = Open bore section

3= lithology straddling open bore

4 = multiple water bearing zones

Bores identified within a 2 km radius of the Coal Haul Road as per the NSW Natural Resource Atlas database review conducted on 5 November 2013 are summarised in *Table* 2.2. These groundwater bores were largely registered for domestic / farming usage and as monitoring bores

Table 2.3 ***Licensed Groundwater Bores within a 2 km radius of the Coal Haul Road***

Bore I.D.	Approximate Distance from Site (km)	Depth Screened (m bgl)	Screened Lithology	Direction from Site	Use
GW029567	1.5	3.0 – 3.0[4]	Sandstone	south	domestic farming
GW202325	1	1.5 – 3.0	Silty Clay/Gravelly Sand	west	monitoring bore
GW202559	0.7	NA[1,5]	NA[1,5]	east	monitoring bore
GW202328	1.7	2.2 – 3.7	Silty Sand	south east	monitoring bore
GW202327	1.9	1.6 – 3.1	Silty Sandy Clay	south east	monitoring bore
GW064214	2	20.4 - 23.4	Sandstone	south east	monitoring bore
GW202326	0.5	0.5 – 1.5	Sandy Clay	north west	monitoring bore
GW201480	0.5	8.6 – 11.6	Sandstone	south east	monitoring bore
GW202331	0.3	1.3 – 2.8	Sandy Clay/Clayey Gravel	north	monitoring bore
GW202324	1.4	15.2 – 74.14	Coal/Mudstone/ Sandstone/Conglomerate	north west	dewatering groundwater mining - monitoring bore
GW080494	0.1	NA[1]	NA[1]	east	domestic stock

2.9 *HYDROLOGY*

The Site surface water flows are presented graphically in *Annex O*. The hydrological features of the Site can be summarised as follows;

- a cooling water system draws water from an inlet at Bonnells Bay to the power station and discharges of warm water into Myuna Bay via the outfall tunnel. Surface water discharges are monitored as a licensing requirement of the facility;
- the CWS is comprised of four collection pits, an oil-water separator and several collection or retention ponds connected via a network of pipes. The Boomerang Pond, the Demineralisation Plant Effluent Pits and overflow from the oil water separator and holding pond discharge into the CCPMF;
- seepage water from the CCPMF is collected south of the CCPMF at the toe drain collection pond prior to recirculation back to the dam. Emergency overflow from the CCPMF seepage can also occur to Crooked Creek via a weir;
- under non-emergency conditions, water levels in the CCPMF are controlled using water from the outlet canal, with water being pumped into the CCPMF if conditions become too dry and water being pumped from the CCPMF into the Glory Hole and outlet canal if the water level in the CCPMF becomes too high. The Boomerang Pond may also discharge to the outlet canal under overflow conditions. Both sources of discharge are noted to be a potential pathway. The water in the outlet canal is filtered to remove cenospheres in three underflow weirs. Site personnel noted that there is no specific routine monitoring of water quality at this discharge (the water quality is assumed to be that of the ash dam) and it is further noted that this is a licensed discharge point for quantity;
- a clean water diversion surrounds the CCPMF to minimise the amount of water discharging from the CCPMF into Lake Macquarie. A sub-catchment to the north of the Site enters the Site at the coal loading facility and is diverted to the wetland via the Muddy Lake Settling Pond. It is noted that whilst there is a potential during high rainfall events for the 'megalitre pond' to overflow into this clean water diversion to Muddy Lake, there is no interconnection between the ash dam sub-catchment and the sub-catchment up-gradient of the coal plant. Surface water from the sub-catchment to the north of the ash dam is diverted away from the dam itself and discharges at the northern abutment eventually finding its way to Myuna Bay. As noted previously, surface (storm) water to the north enters the Site at the coal loading facility and is diverted to the creek diversion, which flows through to the oil retention weir and into the Muddy Lake Settling Pond (refer to *Annex O*). It is also noted that an oil detector is present within the oil retention weir;

- surface water flows have been identified at several locations across the Site and those not captured in the stormwater system are likely to predominantly flow in an easterly or south easterly direction towards Lake Macquarie; and
- stormwater run-off along the Coal Haul Road is channelled through drainage channels along the edge of the roadway and directed to the natural surface water courses via gross pollutant traps surrounding the area, which are understood to ultimately discharge into Lake Macquarie.

An audit undertaken by AECOM in 2011 identified a number of issues with the contaminated water and stormwater management systems at the Site. It is understood that an upgrade of the CWS was completed at the Site in 2011 and that an upgrade of the stormwater management system was in progress at the time of reporting.

2.10 *SENSITIVE RECEPTORS*

There are a number of sensitive receptors located in the areas surrounding the Site, as presented in *Figure 2*, *Figures 3.1 – 3.8* and *Figure 4* of *Annex A*, *Annex C* and as discussed below.

2.10.1 *Ecological Receptors*

The operational portion of the Site (being Areas EB to EE and EI as presented on *Figures 3.1 – 3.8* of *Annex A*), is primarily covered by concrete/asphalt hardstand and buildings. Small isolated areas of the operational portion of the Site are occupied by a well-maintained grass cover and isolated vegetated areas. Areas EF and EH comprise open/vegetated areas as well as concrete/asphalt and buildings.

The areas immediately adjacent to the Site and surrounding the operational portion of the Site (being Areas EA, EG, EJ and EK as presented on *Figures 3.1 – 3.8* of *Annex A*), are a combination of open and/or dense bushland including creeks and ephemeral streams discharging into Lake Macquarie. These areas are intersected by a number of roads, electricity easements and structures as detailed in *Section 2.3*. Muddy Lake Wetland, which is a SEPP 14 Wetland, exists immediately adjacent to the south (and southwest) of the Site.

There are a number of open water bodies located on the Site, including the CCPMF, Return Water Dam, Attemperation Reservoir and water intake/outlet canals. These water bodies are not considered to be sensitive aquatic environments of concern for the purposes of this assessment, as they form part of the Power Station operations.

The water outlet does however discharge warm water from the Power Station Glory Hole and Outlet Tunnel via the Outlet Canal and into Myuna Bay. Seepage water from the CCPMF is also collected within the toe drain collection pond which ultimately drains to Myuna Bay. Emergency overflow from the CCPMF seepage can also occur to Crooked Creek. It should be noted that emergency discharge or contaminated water discharge does not occur from the Site to Muddy Lake.

There are no National Parks, State Parks, wilderness areas or designated terrestrial conservation areas in the immediate vicinity of the Site.

The primary sensitive ecological receptors in the area include;

- aquatic receptors offsite including estuarine ecological receptors in Lake Macquarie and Whiteheads Lagoon and the Muddy Lake freshwater wetland to the west;
- aquatic receptors onsite, primarily including Glory Hole/outlet canal and other tributaries discharging into offsite marine and freshwater bodies;
- terrestrial organisms in open-space areas onsite (Areas EA, EG, EJ and EK), including open grasslands, open bushland and dense bushland areas; and
- terrestrial organisms in open grasslands, open bushland and dense bushland surrounding the Site, particularly to the north and west.

2.10.2 *Human Receptors*

Current and future onsite employees are considered to be potential receptors for contaminated soil and groundwater. In addition, employees undertaking intrusive trenching/excavation works are potential receptors, although ERM understands that intrusive excavation works are not undertaken on a routine basis on the Site. Onsite employees and intrusive workers may come into direct contact with contaminated soil or be exposure to vapours derived from volatile constituents in soil and/or groundwater. Intrusive workers may also come into direct contact with groundwater within an excavation/trench. Onsite power station employees or contracted workers completing ongoing groundwater and surface water monitoring may also come into direct contact with contaminated waters as part of these works.

There are a number of residential and rural properties located in the area surrounding the Site, however the closest residential property is located approximately 480 m to the south of the Site within the township of Dora Creek.

Myuna Bay Sport and Recreational Centre are located approximately 100 m to the east of the Site on the shores of Myuna Bay. Lake Macquarie and its tributaries, including Whiteheads Lagoon, Bonnells Bay and Dora Creek, are also frequently used for recreational purposes including water sports and fishing.

A number of licensed groundwater bores were identified within a 5 km radius of the Site through a bore search of the NSW Office of Water national groundwater database and the locations of these bores are provided in *Figure 7*. While bore GW029567, reportedly drilled in 1968 for water supply purposes, was identified through the bore search with location coordinates at the power station the purported location of this bore has been inspected on-site and it's absence has been verified. ,. Licensed groundwater bores located to the north and west of the Site are all located more than 2 km from the Site. The closest licenced groundwater bores are located to the south and south west of the Site, and are considered unlikely to be impacted by groundwater seepage from the Site given their locations to the south west of Muddy Lake and to the south of Lake Eraring. .

The primary sensitive human receptors identified for the Site therefore include:

- onsite employees, including intrusive workers labouring within shallow (<1 m) trenches. These receptors may be directly exposed to impacts in soil or to vapour derived from soil or groundwater impacts;

- onsite employees completing routine groundwater and surface water monitoring; These receptors may be directly exposed to impacted groundwater or surface water;

- recreational users of the Myuna Bay Sports and Recreation Centre and Lake Macquarie, including Whiteheads Lagoon, Myuna Bay, Bonnells Bay and their tributaries, who may be directly exposed to impacts in sediment or surface water; and

- residents of Dora Creek who may be exposed to dust derived from shallow onsite soil impacts (although it is noted that this residential area is located approximately 480 m from the Site boundary).

Potential receptors include onsite employees and intrusive workers within shallow excavations (depth <1 m). It should be noted that onsite employees or contractors who may be required to enter and/or work within confined spaces (such as an area deficient in atmosphere or non-normal place of work) on the site have not been included as potentially sensitive receptors as confined space entry is an operational Work Health and Safety (WHS) issue which is regulated within NSW under the WHS Regulation which includes clauses such as:

- No worker enters a confined space to carry out work unless the employer has provided a system of work that includes continuous communication with the worker from outside the space and monitoring of conditions within the space by a standby person who is in the vicinity of the space and, if practicable, observing the work being carried out. (Work Health and Safety Regulation 2011, Clause 69)

- When work is carried out in a confined space, the confined space has been purged or ventilated of any contaminant in the atmosphere, so far as is reasonably practicable, and pure oxygen or gas mixtures in which oxygen exceeds a concentration of 21% by volume are not used for purging or ventilation. (Work Health and Safety Regulation 2011, Clause 71(1)).

Given that such management and monitoring controls are legally required to be implemented at the Site under the WHS regulation and the potential which exists for temporal variation in gas concentrations within confined spaces, further assessment of potential health risks associated with confined spaces present at the Site are considered to be beyond the scope of this assessment. This approach is endorsed within the CRC Care (2011) *Technical Report No. 10* in relation to scenarios for intrusive maintenance workers, specifically:

- *"HSLs have been derived for utility workers involved in shallow trenches (max trench depth of 1 m). Maintenance workers involved in subsurface works (also referred to in this report as 'intrusive maintenance workers') may be exposed to contamination inside trenches.*

- *Deep trench works (such as deep sewer) have not been included in the development of HSLs. These works usually require health and safety procedures to be followed for protection in confined space situations." CRC Care (2011) Technical Report No. 10 Part 1 (Section 6.3.4 page 22)*

2.11 *PREVIOUS ENVIRONMENTAL INVESTIGATIONS*

The Eraring Power Station has undergone a limited amount of intrusive soil and groundwater assessments to date as set out below. No comprehensive or systematic assessment of Site conditions has been undertaken, with works typically completed to achieve compliance with UPSS legislation, or the Land Management Plan employed at the site (targeting the Attemperation Reservoir and CCP Management Facility). The following section summarises the relevant reports reviewed by ERM.

Contamination Investigation Report – Stores Building UPSS (Geo-Logix, August 2011)

An investigation of soil and groundwater conditions surrounding the UPSS adjacent to the Stores Building at Eraring Power Station was undertaken in March 2011. The objective of the investigation was to assess the contamination status of soil and groundwater surrounding the UPSS and determine the appropriate method of decommissioning the UPSS infrastructure. The UPSS comprised three USTs and associated delivery piping and two dispensers. Two USTs (58 000 L unleaded petrol (ULP) and 33 500 L diesel) were being used for the storage of fuel for Eraring Energy work vehicles at the time of the investigation.

A leaded petrol (LP) UST of unknown size was understood to have been temporarily decommissioned by filling with rust inhibitor solution. The USTs were located to the west of the Stores Building.

Investigation of soils surrounding the USTs via the advancement of four test pits to a maximum depth of 2.5 m bgl identified petroleum contamination to UST backfill sands. Based on results of the investigation and limitations encountered due to site geology, further investigation was completed in May 2011. The scope of work comprised the drilling of six additional soil borings surrounding the USTs, installation of four groundwater monitoring wells (screened between 7.5 and 10 m bgl) and collection and laboratory analysis of soil and groundwater samples for COPC comprising petroleum hydrocarbons, polycyclic aromatic hydrocarbons and heavy metals.

Petroleum hydrocarbons were detected at concentrations greater than the assessment criteria in shallow soil in the immediate vicinity of the dispensers. The impact was considered likely to be limited in extent, however it is noted that deeper samples were not analysed at locations where shallow soil impact was detected.

Elevated concentrations of petroleum hydrocarbons were detected in groundwater immediately downgradient of the USTs. Groundwater was calculated to be flowing to the southeast beneath the office space in the Stores Building and towards a manmade outfall canal, south of the Stores Building.

In order to assess the potential for contaminated groundwater to discharge into the canal two additional wells were installed down-gradient of the USTs. Petroleum was not detected in the two wells. The potential for intrusion of volatile vapours emanating from groundwater into overlying office space of the stores building was assessed through the installation and sampling of four shallow soil vapour wells. Petroleum related compounds were not detected in soil gas.

Based on the results of the investigation and limitation of UST removal by high risk subsurface infrastructure, the report concluded the USTs are suitable for in-situ decommissioning as current conditions are not presenting a risk to human health or the environment. The conclusions drawn were subject to ongoing monitoring requirements to ensure conditions are not worsening over time, including semi-annual groundwater sampling for a period of two years, and sampling of soil vapour wells in the event an increasing trend was established to assess vapour intrusion pathway. Additional monitoring data was not available for groundwater monitoring wells installed in the vicinity of the Stores Building UPSS, hence current groundwater conditions and the potential presence of ongoing impact could not be verified.

Groundwater Monitoring Well Installation Report - Unit 1 Turbine House Basement (Geo-Logix, August 2011)

This investigation involved the installation of three wells surrounding the UPSS, in the Unit 1 Turbine House basement. The UPSS infrastructure targeted as part of this investigation was identified as a 20,000 litre waste oil UST and a 50,000 litre lubrication oil UST.

Four monitoring wells (EPSMW8 to EPSMW11) were advanced to between 4.1 m bgl and 9.0 m bgl. Standing water levels were recorded between 2.918 and 4.173 m bgl. Phase Separated Hydrocarbon (PSH) was not detected at any of the locations, however it is noted that a number of the monitoring wells were not screened across the water table. An organic odour was recorded during groundwater sampling at EPSMW11, however no other visual or olfactory evidence of impact was recorded for the field work.

A review of the analytical data concluded that concentrations of petroleum hydrocarbons and polycyclic aromatic hydrocarbons were not detected in soil or groundwater samples above the laboratory Limit of Reporting (LOR).

Groundwater Monitoring Well Installation Report - Vehicle and Mobile Plant Workshop (Geo-Logix, June 2011)

An investigation of soil and groundwater conditions surrounding the waste oil storage tank adjacent to the Vehicle and Mobile Plant Workshop on the north-western portion of the main power station area was undertaken in May 2011.

The UPSS consisted of a 4500 L UST and associated delivery piping. The wells were installed in order to complete the groundwater monitoring well network at the site as per the requirements of the UPSS Regulation (2008 now 2014).

Three groundwater monitoring wells (EPSMW1 to EPSMW3) were installed in the completed soil borings to depths between 4.5 and 5.0 metres below grade. Soil and groundwater samples collected from monitoring wells were analysed for COPC, comprising petroleum hydrocarbons, polycyclic aromatic hydrocarbons, and dissolved heavy metals.

Petroleum hydrocarbons and polycyclic aromatic hydrocarbons were not detected at concentrations greater than the laboratory reporting limits in soil samples from all borings, or in groundwater samples from all monitoring wells. Dissolved metals were detected at concentrations greater than the assessment criteria in the groundwater sample taken from the monitoring well. The elevated concentrations were considered likely to be naturally occurring.

UPSS infrastructure adjacent to 23 000 L refuse oil UST

Based upon the observations of groundwater monitoring infrastructure made during the site visit, and interviews with site personnel, it is understood a report on UPSS infrastructure installed adjacent to 23,000L refuse oil UST (collects all lubricating oil drainage and refuse oil within the turbine building) was produced, but could not be located for review.

Assessment of Historical Monitoring Data

Historical monitoring data was made available to ERM by Eraring Energy environmental personnel for review as part of the Preliminary ESA. The following monitoring data was reviewed as part of that investigation:

- Groundwater monitoring wells GW1 (EJ_X_GW1) to GW5 (EJ_X_GW5) surrounding the Attemperation Reservoir, with data from between August 2009 to March 2013.

- Groundwater monitoring wells GM/D1 (EA_X_GM/D1), GM/D2 (EA_X_GM/D2), D26 (EA_X_D26), D29 (EA_X_D29), MW01 (EA_X_MW01), MW02 (EA_X_MW02), MW03 (EA_X_MW03), MW05 (EA_X_MW05) and MW06 (EA_X_MW06) surrounding the CCP facility, with data from between January 2010 to December 2011.

- Surface water monitoring at various locations across the site, with data from between January 2006 to April 2013.

Baseline levels (prior to the power station construction) were not available for review for either location hence the data could not be compared against background concentrations, which were understood to be naturally elevated. Based on a visual, qualitative assessment of the data against the ANZECC ecological screening values (which were more conservative than the recreational and protection of 95% of marine ecosystem criteria), relevant criteria presented in the Australia Drinking Water guidelines, and acceptance criteria presented in the EPL, the following trends were noted. A summary of the exceedences observed as part of the review are also presented in *Annex D* of the PESA (ERM, 2013a).

- Elevated concentrations of copper, lead and zinc exceeding the ANZECC criteria were commonly observed immediately surrounding the Attemperation Reservoir. Lead and arsenic concentrations also exceeded the Australia Drinking Water criteria.

- Elevated concentrations of copper, lead and zinc exceeding the ANZECC criteria were commonly observed immediately surrounding the CCPMF. Lead and arsenic concentrations also exceeded the Australia Drinking Water criteria.

- Concentrations of suspended solids and selenium regularly exceeded the EPL acceptance limit at surface sampling locations, particularly at the Ash Dam toe drain sampling location, at the Ash Dam return canal sampling location and at the utilisation area sampling point adjacent to the sewerage treatment works. Selenium concentrations also commonly exceeded the adopted ANZECC criteria and the Australia Drinking Water guideline value, however it is noted that concentrations of selenium decreased from 2006 to 2013.

The review and results of these previous environmental investigations were utilised in the development of the Sampling, Analysis and Quality Plan (SAQP) (ERM, 2013b).

3 DATA QUALITY OBJECTIVES

The Data Quality Objectives (DQO's) were developed to define the type and quality of data required to achieve the project objectives outlined in *Section 1.2*. The DQOs were developed with reference to relevant guidelines published by the NSW EPA, ANZECC/ARMCANZ, NEPC and others, 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 the NSW DEC (2006) document, as applied to this assessment, is described in the following sections.

The DQOs are also described in the corresponding Eraring Power Station SAQP (ERM Reference: *0207419 RP01 SAQP Final Rev02, 2013*).

The DQO process is validated in part by Quality Assurance/Quality Control (QA/QC) assessment. This assessment is summarised in *Section 5.5* and presented as *Annex F*.

3.1 STEP ONE: STATE THE PROBLEM

The objectives of the assessment are as stated previously in *Section 1.2*. The problem is the potential presence of contamination onsite due to historical activities. The objective of this assessment was therefore to gather soil, sediment, surface water and groundwater data in order to develop a baseline assessment of environmental conditions at the Site and within surrounding receiving environments (including water, land and sediments), as at or near the time of the transaction. The secondary objectives of the Stage 2 ESA were to:

- assess whether impacts at the Site (if present) represent a risk to human health and/or the environment based on the current and continued use of the Site (in line with the current zoning (as noted in *Figure 8* of *Annex A*)); and
- assess whether impacts at the Site (if present) are likely to warrant notification and / or regulation (under the *Contaminated Land Management Act 1997*)..

3.2 *Step Two: Identify The Decision*

3.2.1 *Decision Statements*

The principal decision to be made was to develop an environmental baseline at Eraring Power Station at (or as close as practicable to) the date of completion of the sale of the power generation assets to Origin. Additional decisions to be made included:

- Was there sufficient data to provide an environmental baseline at or around the time of the transaction?
- What was the nature and extent of soil, sediment and/or groundwater impact on/beneath the Sites and in relation to neighbouring sensitive receptors?
- Did the impact at the Sites (if present) represent an acceptable risk or pose a risk to human health and/or the environment, based on the current and continued use of the Site in line with the current zoning?

  Was the impact at the Sites (if present) likely to warrant notification and / or regulation under the *Contaminated Land Management Act 1997* and remediation?

3.2.2 *Assessment Criteria*

The adopted Site assessment criteria (screening values) are presented in *Section 3.5.2*. It is noted that these screening values are Tier 1 values and as such are conservative and not intended for use as remediation criteria or values which trigger the need for remediation, but rather further assessment and consideration.

3.2.3 *Waste Classification for Off-Site Disposal*

Any excess soil or groundwater generated during the Stage 2 program was classified in accordance with the NSW Department of Environment, Climate Change and Water (DECCW) (2009) *Waste Classification Guidelines* and relevant associated Chemical Control Orders.

3.3 *Step 3: Identify Inputs To Decision*

The inputs used to make the above decisions were as follows:

- existing relevant environmental data;

- direct measurement of environmental variables including soil type, soil gas concentrations, odours, staining, water strike and groundwater level and water quality parameters;
- laboratory measurement of soil, sediment and water samples for one or more of the identified potential constituents of concern;
- field and laboratory quality assurance/quality control data;
- the relevant soil, sediment and water quality screening values outlined in *Section 3.5.2*; and
- assessment of whether the concentrations of the constituents of concern are greater than, equal to or less than the adopted screening values.

3.4 *STEP 4: DEFINE THE STUDY BOUNDARIES*

3.4.1 *Spatial Boundaries*

The spatial boundaries of the Site were described in *Section* 2 and are presented in *Figures 3, 3.8* and *4* of *Annex A*.

The study also included consideration of potential impacts to off-Site receptors within relevant receiving environments including sampling in Myuna Bay, Whiteheads Lagoon and drainage lines leading to Lake Eraring.

3.4.2 *Temporal Boundaries*

Temporally, the study was intended to provide a baseline assessment of the nature and extent of contamination at the Site, and in relevant receiving environments, as at or near the time of completion of the transaction to the extent practicable. The initial Stage 2 ESA (including associated sample collection) was conducted between 5 July 2013 and 8 October 2013. Field works associated with the additional Stage 2 ESA were conducted between 27 October 2014 and 4 December 2014.

3.4.3 *Constraints within the Study Boundaries*

Constraints on the delivery of the Stage 2 program within the study boundaries included:

- location of underground or overhead services or infrastructure (including buildings); and
- constraints associated with other safety issues or causing unacceptable disruption to Site operations.

3.5 *STEP FIVE: DEVELOP A DECISION RULE*

The DQOs were developed to facilitate the collection of adequate soil, sediment and water data to address the decisions outlined in Step Two of the DQO process. Some project constraints impacted on the implementation of the Stage 2 program, for example access to certain locations was restricted by the presence of sub-surface services or specific site conditions. Deviations from the Stage 2 program were identified during regular progress updates, and the final scope of work completed at the Site (including both initial and additional Stage 2 ESAs) is summarised in *Tables 1a* and *1b* of *Annex B* respectively. Well abandonment at the site (subsequent to initial Stage 2 ESA) was outlined in ERM's abandonment letter (0207419L04, dated 30 August 2013).

Table 1 (of Letter 0207419L05, dated 19 March 2014) is presented in *Annex Q* which documents deviations from the SAQP scope of works and provides commentary regarding the scope of works completed. The scope of works completed (including any deviations due to site conditions) was agreed with Origin and is documented *Table 1b* of *Annex B.*

3.5.1 *Field and Laboratory QA/QC*

The suitability of soil, sediment, surface water and groundwater data has been assessed based on acceptable limits for field and laboratory QA/QC samples outlined in relevant guidelines made or approved under the *Contaminated Land Management Act (1997).* These guidelines include the NEPC (April 2013) *National Environment Protection (Assessment of Site Contamination) Measure 1999, NEPC, Canberra,* hereafter referred to as ASC NEPM (2013). In the event that acceptable limits are not met by laboratory analyses, the field observations of the samples have been reviewed and if no obvious source for the non-conformance was identified, such as an error in sampling, preservation of sample(s) or heterogeneity of sample(s), liaison with the laboratories has been undertaken in an effort to identify the issue that had given rise to the non-conformance.

3.5.2 *Assessment Criteria*

Individual soil, sediment and groundwater and surface water data, along with the maximum, minimum, mean, standard deviation and 95% Upper Confidence Limit (UCL) of the mean concentration (as required) were compared to the relevant screening values. Exceedences of the screening values have not necessarily been considered to indicate a risk to human health and/or the environment or the requirement for remediation. If individual or 95% UCL concentrations exceeded the screening values, the concentrations were considered potentially significant. As such, further consideration was given to the extent of the impact, the potential for receptors to be exposed and regulatory compliance.

The adopted screening values were primarily sourced from guidelines made or approved under the *Contaminated Land Management (CLM) Act (1997)* which includes the ASC NEPM (2013) and where alternative sources have been utilised appropriate justification has been provided. The most conservative HSLs (assuming sand based geology) were applied to the Site. Given that there were no exceedences suggesting a risk that required further assessment, proceeding to Tier 2 risk assessment and development of site-specific screening values was not considered warranted as per the ASC NEPM (2013).

As identified in the *Section 2.9*, any release of contaminants from the Site could affect the following ecological and human receptors:

- terrestrial ecological receptors within the open space areas both on and surrounding the Site, particularly to the north and west;
- onsite employees, including intrusive workers labouring within shallow trenches/excavations;
- recreational users of the Myuna Bay Sports and Recreation Centre and Lake Macquarie, including Myuna Bay and Bonnels Bay and their tributaries;
- freshwater aquatic organisms within the Muddy Creek wetland and tributaries of Lake Macquarie (as presented in *Figure 2* of *Annex A*);
- Marine aquatic organisms within the estuarine environment of Lake Macquarie, Bonnells Bay, Lake Eraring and Whiteheads Lagoon.

A CSM is the qualitative description of plausible mechanisms by which receptors may be exposed to Site contamination. For exposure to the identified receptors to be considered possible, a mechanism ('pathway') must exist by which contamination from a given source can reach a given receptor. A complete 'source-pathway-receptor' exposure mechanism is referred to as a 'SPR linkage'.

The CSM developed and refined for this Site is summarised in graphical form in *Annex C*. Also included within *Annex C* are associated conceptual cross-sections summarising geological and hydrogeological conditions and relevant sources/pathways/receptors. The conceptual hydrogeological model for the site is discussed further in *Section 5.4*.

The screening values adopted for the Site were selected to provide a screening level assessment of potential risks that may be associated with the SPR linkages that have been identified for this Site. The specific assessment levels adopted are summarized in *Table 1* of *Annex C* and presented alongside the analytical data in the summary tables presented in *Tables 4a-w* of *Annex B*.

The approach to the screening of the data gathered in this assessment was to initially adopt conservative assessment values. Any exceedences of these values were then evaluated on a case by case basis, in light of the specific characteristics of the individual sample and the area of the Site from which the sample was collected.

Soil Assessment Criteria

The Site is used primarily for commercial/industrial activities with areas of open grassland, open bushland and dense bushland outside the designated operational areas.

The ASC NEPM (2013) Ecological Investigation Levels (EILs) and Ecological Screening Levels (ESLs) for commercial/industrial Sites are appropriate for the assessment of risks to ecological receptors within operational areas of the Site (Areas EB to EF, EH and EI). Due to the presence of bushland areas within the Site and immediate surroundings, the EILs and ESLs for open space have also been included in the assessment (Areas EA, EG, EJ and EK). The significance of any exceedences of the EILs/ESLs has been evaluated on a case by case basis.

The ASC NEPM (2013) also provides EILs for aged and fresh contamination for the metal constituents Ni, Cr III, Cu, Zn and Pb. For the purposes of EIL derivation, a constituent incorporated in soil for at least two years was considered to be aged. Given that the Site has been operational since the 1980s and no significant individual release events of these metals have been recorded, any identified impacts are likely to primarily represent aged contamination. The EILs for aged contamination have been adopted.

The ASC NEPM (2013) and CRC CARE (2011) *Health screening levels for petroleum hydrocarbons in soil and groundwater* provide Health Screening Levels (HSLs) for soil and groundwater impacts located at depths from 0 to 4+ m bgl in soil types ranging from sand to clay and Health Investigation Levels (HILs) for shallow soil impacts. The screening levels for sandy soils and shallow impacts have been adopted across the Site, as a conservative approach. The significance of any exceedences of the HILs/HSLs have been evaluated on a case by case basis, with reference to the use of the area of identified potential concern.

HILs/HSLs for the protection of commercial workers and workers undertaking intrusive works have been adopted across the Site. HILs/HSLs for the protection of users of offsite open space have also been adopted in AECs EA and EJ, to evaluate risks to recreational areas located in close proximity to the Site.

As the nearest residential area to the Site is Dora Creek, which is located approximately 480 m from the boundary of Area EJ, the residential HILs/HSLs are considered to be very conservative for the assessment of Site impacts. These values have however been adopted in AEC EJ as a screening level assessment of potential risks to the residents of Dora Creek. The screening values adopted for each AEC are summarised within *Annex C*.

Groundwater and Surface Water Assessment Criteria

The ANZECC and ARMCANZ (2000) *Australia and New Zealand Guidelines for Fresh and Marine Water Quality*, hereafter referred to as ANZECC (2000), provides trigger values for the protection of both marine and freshwater environment.

The groundwater beneath the Site is not considered to be an ecological receptor of concern in itself, but the trigger values for the protection of 95% of marine species have been adopted across the Site to evaluate potential risks associated with the discharge of groundwater into the marine environment of Lake Macquarie.

The ANZECC (2000) trigger values for the protection of 95% of marine species (99% for mercury) have also been adopted in the evaluation of surface water samples collected from within Whiteheads Lagoon, Crooked Creek, the Return Water Dam and Lake Macquarie.

The trigger value for the protection of 99% of species has been adopted for mercury, to account for the potential for bioaccumulation of this metal. The ANZECC (2000) trigger values for the protection of 99% of freshwater species have also been adopted for the assessment of groundwater and surface water collected within Areas EB to EF, EH, EI and EJ, to evaluate potential risks associated with discharge into the freshwater environment of the Muddy Lake wetland.

Groundwater is not extracted for potable use in the area downgradient of the Site (*Section 2.7*). The brackish to saline condition of the groundwater beneath the Site is also likely to reduce the opportunity for its potable or domestic use in the future. The National Health and Medical Research Council (NHMRC) (2011) *Australian Drinking Water Guidelines*, hereafter referred to as the NHMRC (2011) ADWG, have however been adopted to evaluate the requirement to report groundwater contamination across the Site, in accordance with the NSW EPA (2015) *Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997*.

In accordance with the NEPM (2013) recreational Groundwater Investigation Levels (GILs), the NHMRC (2008) Guidelines for Managing Risk in Recreational Waters 2008 (GMRRW) recreational screening values were adopted in this assessment to evaluate potential risks to recreational users of Mannering Bay, Whiteheads Lagoon and Lake Macquarie in accordance with the NEPM ASC (2013). The human health (recreational) screening values have been adopted by applying a multiplication factor of 10 to the ADWG, as recommended in the GMRRW. It is noted that the GMRRW also includes a pH range of 6.5 to 8.5 and a dissolved oxygen criteria of >80%. A wider pH range of 5-9 is acceptable for water with a very low buffering capacity.

Sediment Assessment Criteria

The sediment quality data was assessed in relation to the ANZECC (2000) Interim Sediment Quality Guidelines (ISQGs). The ANZECC (2000) ISQGs do not include an assessment criterion for Total Recoverable Hydrocarbons (TRH). The criterion provided for TRH in the *National Assessment Guidelines for Dredging* (Commonwealth of Australia, 2009) has therefore been adopted.

Assessment Criteria for Selenium

ANZECC and ARMCANZ (2000) provides a low reliability marine trigger value for selenium, which has been adopted as the ecological screening value for surface water and groundwater in this assessment.

In the absence of ANZECC and ARMCANZ (2000) screening values for selenium in sediment, the British Columbia Ministry of Environment (BCME) (2001) *Ambient Water Quality Guideline* marine sediment screening value for selenium of 2 mg/kg has been adopted in this assessment. This value is designed to be protective of selenium bioaccumulation through the food chain and direct selenium toxicity. The BCME (2001) screening value for sediment was developed based on the potential for partitioning with water rather than directly based on toxicity of sediment benthic biota. Specifically, this screening value for sediment was based on the BCME (2001) marine water quality guideline of 2 μg/L at which partitioning with water would not exceed aquatic toxicity levels. Given that the adopted ANZECC (2000) marine water screening value is 5 μg/L, the BCME sediment guideline would be considered to be protective of Australian aquatic species.

It is noted that these screening values are not regulatory criteria in British Columbia and have no regulatory standing in NSW and hence these values have been adopted to provide a high level evaluation of potential ecological risk and have not been used to assess the duty to report requirements under the CLM Act (1997).

Further to the above, it is considered to be reasonable to adopt the BCME (2001) screening values in the absence of Australian guidance as the range of sensitivity of Australian aquatic species is not anticipated to vary from that of Canadian (or other international) species. This approach is endorsed within the ANZECC (2000) guidance, which states that:

- *"In general, the Australian species tested were within the range of sensitivities of the overseas species to the toxicants tested, although some Australian species were slightly more sensitive to some chemicals. This should not be interpreted to mean that toxicity to Australian and New Zealand species could be accurately predicted from overseas data on all chemicals but it gives some initial confidence that it is reasonable to derive trigger values from overseas data" (ANZECC, 2000; Section 8.3, page 48)" and;*

- *"Due to the lack of any large-scale comparison, the relative sensitivity of Australian and overseas aquatic species remains unclear, and likewise for New Zealand species. It must therefore be assumed for the current review of guidelines that there is no different in sensitivity." (ANZECC, 2000; Section 8.3, page 48).*

Assessment Criteria for Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA) (Soil)

No authoritative screening values have been published within Australia for assessing chronic risks to human health from either PFOS or PFOA in soils. As such, a literature review and web-based research were conducted to identify conservative screening values for these COPCs.

Values of 6 mg/kg and 16 mg/kg were adopted for PFOS and PFOA in soil respectively, based on US EPA Region 4 guidance *Emerging Contaminants Fact Sheet -PFOS and PFOA, May 2012* (US EPA, 2012) for residential land-use settings. Whilst these criteria are acknowledged to be designed for application to a more sensitive land-use, they are considered appropriate to inform requirements for more detailed, or site-specific, risk characterisation.

A review of international guidance by CRC Care (July 2014) *Technical Report No. 32 - Development of guidance for contaminants of emerging concern* provides a review of available international guidance including the above referenced values from the USEPA Region 4 guidance in relation to PFOS and PFOA in soils. As stated above, given that these criteria are designed for a higher sensitivity residential land-use, application of these criteria at the Site under an industrial landuse setting is considered to be appropriately conservative.

It is noted that these screening values have no regulatory standing in NSW and hence these values have been adopted to provide a high level evaluation of potential human health risk and have not been used to assess the duty to report requirements under the CLM Act (1997).

Assessment Criteria for Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA) (Groundwater)

No authoritative guidelines have been derived in NSW (or other Australian jurisdictions) for PFOS or PFOA in groundwater, protective of human health or the environment. Whilst groundwater is not used for potable supply, in the absence of a more appropriate guideline, health screening values of 0.2 μg/L and 0.4 μg/L for PFOS and PFOA respectively in groundwater have been adopted. These values are proposed by US EPA Office of Water Provisional Health Advisory (2009) and reflect reasonable, health based hazard concentrations above which action should be taken to reduce exposure to contaminants in drinking water (USEPA, 2014).

Whilst groundwater beneath the Site is not considered to be an ecological receptor in itself, ecological impacts may be associated with the discharge of groundwater into the adjacent receiving waters of Myuna Bay, Whiteheads Lagoon, Muddy Lake and Lake Macquarie. In the absence of a local guideline, an ecological screening value of 7.2 μg/L has been adopted for PFOS. This value was recommended by (RIVM, 2010) as the Maximum Acceptable Concentration (MAC) for marine ecosystems.

It is noted that these screening values have no regulatory standing in NSW and hence these values have been adopted to provide a high level evaluation of potential ecological risk and have not been used to assess the duty to report requirements under the CLM Act (1997).

It is considered to be reasonable to adopt these screening values for PFOS and PFOA in the absence of Australian guidance as the range of sensitivity of Australian aquatic species is not anticipated to vary significantly from that of US (or other international) species. As discussed above in relation to selenium, this approach to adoption of international screening values where an Australian value is not available is endorsed within the ANZECC (2000) guidance.

Other Additional Guidelines

Where no Australian endorsed assessment levels are available reference has been made to the following National Institute of Public Health and the Environment (RIVM) documents:

- RIVM (2001) *Technical Evaluation of the Intervention Values for Soil/Sediment and Groundwater: Human and Ecotoxicological Risk Assessment and Derivation of Risk Limits for Soil, Aquatic Sediments and Groundwater*; and
- RIVM (2001) *Ecotoxicological serious risk concentrations for soil, sediment and (ground)water; updated proposals for first series of compounds.*

It is noted that these screening values have no regulatory standing in NSW and hence exceedences of these screening values have been evaluated on a case by case basis.

3.5.3 *Appropriateness of Laboratory Limit of Reporting*

Comparison of the laboratory LOR to the screening values was undertaken to confirm that the screening values were less than the laboratory LOR. Any exceptions to this have been appropriately noted and justified.

3.6 STEP 6: SPECIFY LIMITS ON DECISION ERRORS

The acceptable limits on decision errors applied during the review of the results were based on the Data Quality Indicators (DQIs) of Precision, Accuracy, Representativeness, Comparability and Completeness (PARCC) in accordance with the ASC NEPM (2013), *Schedule B(3) - Guidelines on Laboratory Analysis*.

The potential for significant decision errors were minimised by:

- completing a robust QA/QC assessment of the data, requiring that 95% of data satisfy the DQIs and therefore placing a limit on the decision error of 5%;
- assessing whether appropriate sampling and analytical density has been achieved for the purposes of providing a baseline of soil, sediment and groundwater conditions at the point of transaction; and
- ensuring that the assessment criteria set were appropriate for the evaluation of a continuing usage of the Site that is consistent with current usage (i.e. industrial for the power station Site or open space for non-operational areas/buffer land).

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

The DQOs have been developed based on a review of existing data, discussions with NSW Treasury, Delta Electricity /GSP / Eraring Energy) and Origin. If data gathered during the assessment indicated that the objectives of the assessment programme were not being met, the sampling design (including sampling pattern, type of samples and analytes) was adjusted using feedback from project stakeholders.

4 *SAMPLING METHODOLOGY*

The methodology used to complete the scope of works outlined in *Section 1.3* is summarised in the following sections. This methodology is consistent with that proposed in the SAQP (ERM Reference: *0207419RP01 SAQP Final Rev02, 2013*), and is in general accordance with NSW Environmental Protection Authority (EPA) (1995) *Sampling Design Guidelines* and with *Sections 4* to *8* of *AS 4482.1-2005*.

Soil and groundwater wastes on Site were managed in accordance with the EMP developed for the Site (ERM Reference: *0207419RP02_EMP Final 150713*). All wastes were managed on-site with the permission of site personnel. Purge water was deposited in the CWS and soil cuttings from well installations were disposed in the southern asbestos land fill as agreed and directed by Eraring site personnel. Analytical data for soil and water samples were reviewed as they were received, to enable an assessment of suitability for disposal on site. This data is presented within *Annex B* and has been consolidated for all Stage 2 sampling works.

4.1 *RATIONALE*

Based on a review of the available information, the most appropriate sampling design was considered to be a combination of systematic (grid based) and judgemental (targeted) sampling. It is noted that intrusive investigations were limited to areas where access (due to infrastructure) and Site activities enabled investigations to occur without unacceptable health and safety risks to personnel and/or unacceptable disruption to Site operations.

The sampling plan was discussed and agreed by Site management, Origin and their consultant prior to the commencement of works. The Additional Stage 2 ESA works completed were agreed through various iterations of the proposed additional scope with amendments agreed during site inspections and subsequent to a 'hold point' review of locations, once Sub-Surface Clearance (SSC) had been completed. Origin approval of the Additional Stage 2 ESA locations was received on 1st December 2014 (refer to *Annex Q*). Where it was not practicable to undertake intrusive works due to health and safety, and/or operational constraints, downgradient sampling was used to assess the level of migration of constituents from these areas whilst minimising the potential risks. The progress of works, completion (or, in a small number of instances, abandonment) of sampling locations and any other deviations from the proposed work scope was communicated to the relevant stakeholders via the provision of regular weekly reports throughout the fieldwork programme. The sampling locations and sampling approach adopted are summarised in Tables *1a* and *1b* of *Annex B*.

In general, when the sampling approach deviated from the SAQP (including number of locations and number of samples), this was either due to an amendment or abandonment as a result of site conditions. Well abandonment at the site was also outlined in ERM's abandonment letter (0207419L04, dated 30 August 2013). The proposed SAQP is reconciled against the Stage 2 ESA works as noted in *Annex Q*. Deviations associated with the Additional Stage 2 ESA fieldworks are tracked within *Table 1b* of *Annex B* and were preliminarily agreed with Origin prior to the commencement of intrusive works with final confirmation received once SSC activities were complete (refer to *Annex Q*).

A tiered systematic sampling approach was undertaken with different sampling densities to be adopted relative to the contamination risk and logistical constraints in different areas of the Site. ERM divided the Sites into four general areas with sampling approaches adopted as outlined in *Table 4.1*.

Table 4.1 Proposed Systematic Sampling Approach

Area	Approach
Accessible operational areas	Boreholes advanced on an approximate 50 x 50 m grid in areas not covered by targeted sampling (see below).
Inaccessible operational areas	Boreholes advanced around perimeter where possible and in areas not covered by targeted sampling (see below).
Non-operational areas	Visual inspection and additional soil bores / monitoring wells focused primarily on assessing background conditions and identifying potential for migration both on and off-Site (including Lake Macquarie and Wangi Wangi Colliery
Waterways	Targeted sampling only (see below)

4.1.1 *Systematic Sampling Locations*

Boreholes were advanced on an approximately square grid pattern (50 x 50 m) across the accessible operational area (Area EI) excluding hazardous operational areas, as presented on *Figure 3.7* of *Annex A*, in order to establish an adequate baseline assessment of soil and groundwater conditions where one does not currently exist. Within Areas EI, it is noted that existing investigation locations were present associated with Underground Petroleum Storage System (UPSS) infrastructure. The systematic sampling design at EI was completed cognisant of these existing locations as well as ensuring a suitable coverage exists across the area. Based on a visual assessment of the final locations, the baseline established was considered to be sufficient for AEC EI. As part of the Additional Stage 2 ESA, a further 13 soil boreholes and 3 groundwater monitoring wells (16 locations in total) were advanced within Areas EB and EI.

The location of these boreholes were selected to "infill" potential data gaps in association with the CWS and ensure that a mutually agreed level of spatial coverage was achieved around the operational area, but also to target certain site features as discussed in *Section 4.1.2*. These locations included downgradient groundwater monitoring wells within the south eastern portion of AEC EI in order to assess potential groundwater impacts migrating from the operational area of the power station.

4.1.2 *Targeted Sampling Locations*

Additional targeted sampling locations were advanced in or adjacent to areas of potential concern identified during the Preliminary ESA and Site visits. Justification for additional targeted sampling locations is provided in *Tables 1a* and *1b* of *Annex B.*

During the Additional Stage 2 ESA, targeted sampling locations were advanced as outlined below:

- General Waste Landfill Areas (EA) - three groundwater monitoring wells were installed to target the eastern and western extent of the general waste landfills;
- Operational Area (EB and EI) - a total of thirteen soil boreholes and three groundwater monitoring wells were advanced targeting the CWS and associated drainage in and surrounding the operational area. Of those thirteen soil bores, two were advanced in close proximity to the transformers on the western side, one north of the maintenance workshop on the eastern side of the operational area, three targeting the metals impacts previously detected at EI_SB77 with the remainder targeting the CWS;
- Attemperation Reservoir (EJ) - one groundwater monitoring well was installed to target the potential occurrence of low pH and high metals concentrations down-gradient of the Attemperation Reservoir;
- Fire Training Area (EJ) - one soil bore and four groundwater monitoring wells were advanced around the current fire training facility to target potential fire accelerant and retardant usage; and
- EJ_MW02 (EJ) - a total of four soil bores were advanced in close proximity to EJ_MW02 where detections of PFOS within the shallow soils were recorded during the previous Stage 2 ESA.

4.1.3 *Sediment and Surface Water Sampling*

Aquatic sediment and surface water sampling was undertaken to target potential contamination from cooling discharges or other potential instances of the migration of constituents from the Site. The aquatic sampling included sampling in two zones of 'putative effect' including:

- within Whiteheads Lagoon, downgradient from the southern boundary of the Site, including within Crooked Creek (one of the potential transmission pathways) and Myuna Bay (a potential depositional zone; receptor); and
- within Lake Macquarie in an area beyond the high energy of the outlet canal (potential depositional zone), including allocation of "unaffected" control Sites further away. The outlet canal is also noted to be a potential pathway for overflow discharges via the Glory Hole and Boomerang Pond.

Aquatic sediments and surface waters were also collected from physiographically similar 'reference' locations within Bonnells Bay for comparative purposes.

Sediment and surface water sampling was undertaken from the bed of the Return Water Dam, located south and perceived downgradient of the CCPMF. These locations were intended to assess potential impact associated with operation of the stormwater and contaminated water drainage system and also to assess potential for downgradient migration of constituents from the CCPMF.

A review of the topography of the Site indicates that Lake Eraring falls within a separate sub-catchment to the vast majority of the Power Station infrastructure and lands (with the exception of a portion of the attemperation reservoir). Therefore any potential impacts within Lake Eraring maybe from either onsite or offsite sources.

Sediment samples were collected from the base of four drainage channels on Eraring land to the north of Wangi Road which drain to Lake Eraring, to allow for assessment of potential impacts to Lake Eraring from the Site, with a lower chance of confounding effects associated with external sources.

4.1.4 *Potential Acid Sulfate Soil Conditions*

In-situ surface water monitoring of field parameters, including pH and redox potential was attempted at a total of ten locations in the vicinity of the Attemperation Reservoir and Borrow Pit including four downgradient locations as presented on *Figure 3.4* of *Annex A*. These locations were typically characterised as shallow, ephemeral creeks and ponds, and photographs taken during inspection of these sampling points are presented in *Annex G*. It is noted that no surface water was present at six of the proposed sampling locations, hence surface water samples could not be collected and this was documented (refer to *Table 3.b* of *Annex B*).

Where surface water was present, monitoring was undertaken using a hand held water quality meter, with results recorded after the probes were submerged at the monitoring points, and the readings had stabilised.

Field parameters (including pH and redox potential) were also measured for groundwater in all monitoring wells prior to sample collection. A low-flow pump and flow through cell was used to submerge the probes, and field parameters were recorded regularly. These measurements were used to assess for the potential presence of acid sulfate soil conditions, as well as facilitating representative sampling, and are presented in *Tables 3a* and *3b* of *Annex B*.

4.1.5 *Existing Groundwater Monitoring Wells*

All existing groundwater monitoring wells were assessed for their integrity, via a visual inspection of the condition, and suitability before sampling. The suitability of existing monitoring wells were based on the following steps, with monitoring well locations presented in *Figures 3.1* to *3.8* of *Annex A:*

- ground truthing of each groundwater monitoring well with Site observations;
- bore logs were reviewed to confirm that the wells were appropriately constructed and screened within the groundwater bearing strata; and
- the groundwater monitoring wells were be gauged to confirm the total depth of the well against the bore logs and the depth of groundwater.

A comparison of groundwater level to screened depth for each existing well is provided in *Annex P*, and indicates that the existing monitoring wells are considered suitable for use for the Stage 2 ESA. All existing groundwater monitoring wells were purged and sampled in accordance with the protocol detailed in *Section 4.4.2*.

4.2 *SITE INSPECTION*

Stage 2 ESA

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 (Cable Locator). Both Cable Avoidance Tool (CAT) and Ground Penetrating Radar (GPR) surveys, coupled with Dial Before You Dig (DBYD) Plans and Site engineering drawings were utilised to identify underground services and utilities.

Additional Stage 2 ESA

Site inspections were undertaken by ERM, GSP, Origin and AECOM (as Origin's consultant) during planning of the Additional Stage 2 ESA. During these inspections, each proposed drilling location was inspected and tentative locations agreed (pending SSC activities) based on location of site infrastructure. Subsequent site inspections were conducted after the SSC was completed (noted to be the 'hold point' review) with final locations and deviations agreed by all parties.

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 *Figures 3.1 to 3.8* of *Annex A* and listed by AEC (Area EA - Area EK) in *Tables 1a* and *1b* of *Annex B*. Where practicable, all boreholes were advanced to an initial depth of 1.5 metres m bgl using hand augering and Non Destructive Digging (NDD) techniques in accordance with ERM's SSC procedures. Where locations were within the 'critical zone' of known or unknown subsurface infrastructure, hand augering and NDD was completed to depths of 2.4 m bgl (where achievable). Drilling and soil sampling of subsurface material beyond 1.5 m bgl, was primarily undertaken using a Geoprobe® drilling rig with a continuous push tube sampler. Alternative methods of borehole advancement included solid stem mechanical augering, and air rotary methods where bedrock was encountered or subsurface material could not be penetrated using push tube methods. During the Additional Stage 2 ESA, sonic (continuous coring) methods were utilised to obtain relatively undisturbed samples of the soil and bedrock within the operational area (AECs EB and EI).

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.

Soil properties were logged by an appropriately trained and experienced field scientist in general accordance with *Australian Standard AS 1726-1993*. 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.

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 E*. Where practicable, soil samples were collected from the surface and at 0.5 m intervals to 2 m bgl and at 1 m depth intervals thereafter, or from each lithological unit based on field observations. Where sample intervals deviated from the sampling plan these were documented accordingly.

These samples were collected for field screening purposes where the soil sample was logged (noting visual and olfactory signs of contamination) and also screened using a PID). For PID screening, soil samples were placed in a zip lock bag, sealed and assessed for the presence of ionisable volatile compounds. Where the presence of volatiles or other impact was suspected, additional samples were collected.

Where possible, up to two representative soil samples were collected for laboratory analysis and submitted for COPCs. Due to the lithology encountered at some locations (sandstone / bedrock) and therefore drilling techniques used to advance locations within various AECs (solid flight augering etc), representative soil samples for laboratory analysis could not be always be obtained during the previous Stage 2 ESA as per the SAQP. Continuous coring methods (using a sonic rig) adopted during the subsequent Additional Stage 2 ESA enabled relatively undisturbed soil samples to be collected where bedrock was encountered. This drilling method also enabled visual inspection, PID and olfactory assessment of the recovered cores.

Soil samples were labelled using the nomenclature presented in *Table 4.2* (below). Frequency of field QA/QC samples collected during the assessment works are summarised in *Annex F*.

Table 4.2 Sample Naming Protocol

Sample	Identification
Surficial sample taken from SS01 within AEC EA	EA_SS01
Sample taken from shallow hand auger soil bore or deeper soil bore, SB01 at depth of 0.5 m bgl, within AEC EA	EA_SB01-0.5
Sample taken from depth of 5 m bgl from a soil bore to be installed as Monitoring Well MW07, within AEC EA	EA_MW07-5.0
Sediment samples taken from SS01 within AEC EG at a depth of 0.25 m bgl	EG_SS01_0.25
Surface water samples taken from SS01 within AEC EG	EG_SS01
Sediment reference (control) samples taken from SC01 or CS01 within AEC EG at a depth of 0.25 m bgl	EG_SC01_0.25 or EG_CS01_0.25
Surface water reference (control) samples taken from SC01 or CS01 within AEC EG	EG_SC01 or EG_CS01
Trip Spike	T/Spike
Trip Blank	T/Blank
Field Duplicate	D01-1608132
Rinsate Blank	R01-160813

Representative 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 D*.

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. Where PFOS and PFOA analysis was required, the teflon insert within the jar lid was removed (in accordance with laboratory instructions). 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 ASC NEPM (2013) and the ERM (2012) *Assessment of Asbestos Impacted Areas SOP*. If potential Asbestos Containing Material (ACM) was identified, representative fragments were collected from the AEC and placed in snap lock bags. These samples were submitted to the primary laboratory for analysis, to confirm the presence or absence of asbestos.

Where asbestos was not observed at the surface or during the investigation works, discrete 500 ml samples of soil were collected in snap lock bags. These samples were submitted to the laboratory for asbestos identification and (where identified) quantification (%w/w analysis) in accordance with the WA DOH (2009) guidelines.

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 not scheduled to be converted to monitoring wells were backfilled using drilling arisings and the surface covering reinstated.

4.3.4 *Specific Procedure for Land Fill Area Investigations*

Due to the dense bushland and rough terrain occupying suspected areas of buried waste, as presented within *Figure 3.1* of *Annex A*, a geophysical survey was not considered a viable approach to define the extent of each area.

A land fill area reconnaissance was therefore conducted to obtain information on the nature and extent of each land fill area. This reconnaissance included a Site walkover and inspection, review of all available Site plans (as presented in *Annex K*) and an interview with Eraring Power Station Environmental Manager, Neil Williams. Following completion of land fill area reconnaissance, the extent of the northern and southern asbestos land fill areas were surveyed where practicable, using existing fence lines and a review of Site plans. Intrusive investigations were undertaken by advancing a series of soil bores around the perimeter of each area in an attempt to delineate the extent of buried waste as presented on *Figure 3.1* of *Annex A*. Additional drilling locations were completed east and west of the general waste landfill during the Additional Stage 2 ESA in-order to achieve further delineation of the area.

4.4 GROUNDWATER INVESTIGATION

4.4.1 Monitoring Well Construction

Selected boreholes were converted to groundwater monitoring wells in accordance with ERMs SOPs. The groundwater monitoring well locations are presented in *Figures 3.1 to 3.8* of *Annex A*. The following methodology was implemented to install 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 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, lockable 'envirocaps'.

Following monitoring well installation, each well was developed using a submersible 12V 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 D*.

4.4.2 *Groundwater Purging and Sampling Protocol*

Groundwater purging and the sampling of newly installed monitoring wells generally occurred at least one week following monitoring well installation and development, to allow subsurface conditions to stabilise. Both new and existing monitoring wells were 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), all 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 micro purge pump with a single use, disposable bladder dedicated tubing or using a peristaltic pump with dedicated tubing. Both types of pump were operated under low flow conditions until sufficient water has 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 in *Table 4.3* below.

Table 4.3 ***Water quality parameter stabilisation criteria***

Parameter	Stabilisation criteria
pH	± 0.1 pH units
Electric Conductivity (EC)	± 3% (µS/cm or mS/cm)
Temperature	± 0.5°C
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. Greater weight was therefore 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;
- samples to be analysed for metals filtered through disposable 0.45 µm filters and placed in 125 mL plastic bottles preserved with nitric acid; and
- samples to be analysed for PFOS/PFOA placed into 125 mL plastic (Teflon free) unpreserved bottles.

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. Primary samples were shipped under chain of custody documentation to the analytical laboratory.

4.4.3 *Waste Material Generated During Groundwater Development/Purging*

Waste water from development of groundwater monitoring wells was collected and stored in appropriately labelled dedicated drums within the designated staging area. The water was disposed on-site through the contaminated water treatment system, via contaminated water pits and interceptors with the approval of Site Management.

4.5 *SURVEYING*

All investigation locations were digitally located by field staff with a handheld Global Positioning System (GPS) unit. Additionally, all groundwater monitoring wells were surveyed by a registered surveyor (Aurecon and Monteath and Powys) to AHD for elevation and MGA coordinates for location. 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. Survey data is presented in *Annex M*.

4.6 *SEDIMENT INVESTIGATION*

Sediment samples were collected in Whitehead Lagoon, Lake Macquarie, Crooked Creek, the bed of the Return Water Dam, and drainage lines from non-operational areas of the Site into Lake Eraring. Where it was not possible to obtain a sediment sample (due to absence of sediment at the sample location, the location was either abandoned or moved slightly to allow a sample to be collected. Final sampling locations are shown in *Figures 3.1* to *3.3* of *Annex A*.

Sediment samples were collected in general accordance with the methodologies outlined in Commonwealth Scientific and Industrial Research Organisation (CSIRO) (2005) *Handbook for Sediment Quality Assessment* by direct push coring utilising polycarbonate sampling tubes. Sample handling, labelling and decontamination procedures were aligned with those adopted for soil sampling and those outlined in CSIRO (2005).

Divers advanced a polycarbonate sampling tube into the sediment up to a maximum depth of 1 m, placed a stopper on the end of the tube, and returned the sample to the surface for processing.

The sediment samples were extruded from the polycarbonate sampling tubes. Where possible, four sediment samples were collected from each location at 0.25 m intervals to a maximum depth of 1 m below natural surface (i.e. sampling at 0-0.25 m, 0.26-0.5 m, 0.51-0.75 m and 0.76-1 m). In the event that sediment was less than 1 m in thickness, samples were collected at 0.25 m intervals until refusal was encountered.

The cores were measured and colour, grain size, odour, and presence of debris, organic matter, or shells noted. Sediment samples were transferred to laboratory supplied glass jars for chemical analysis and 500 mL snap lock bags for grain size analysis. Care was taken to minimise head space in the sample jars to reduce the potential for loss of volatile COPCs. The samples were stored on ice and transported under chain of custody to the analytical laboratory. The polycarbonate sampling tubes and work surface were decontaminated between sampling locations.

4.7 *SURFACE WATER INVESTIGATION*

Surface water samples were collected in Whitehead Lagoon, Lake Macquarie, Crooked Creek, and the Return Water Dam at the same locations as the sediment samples.

Water samples were collected approximately 1 m below the water surface using a dip sampler and placed in laboratory prepared sample containers. Water samples were collected prior to the collection of sediment samples, to avoid increased turbidity which may occur following sediment sampling.

Sample containers were sealed and immediately placed in a cooler on ice to reduce potential for degradation of COPCs. The samples were then transported under chain of custody conditions to the analytical laboratory, and analysed for a combination of COPCs.

A calibrated water quality meter was used to analyse a sub-sample of the surface water collected at each location for field parameters including pH, conductivity, redox potential, temperature and dissolved oxygen. Observations of the general condition of the surface water and its surrounds were also recorded during sampling. Field parameters observed at surface water sampling locations are presented in *Table 3b* of *Annex B*.

4.8 *VISUAL INSPECTION OF NON-OPERATIONAL LOTS*

Visual inspections of non-operational areas outside of the main power station lands were completed by an experienced Environmental Scientist within lands which formed part of the transaction but which were not subject to a lease. The purpose of these inspections was to assess the potential for contamination to be present that was not previously identified during the Preliminary ESA. Visual inspections of leased areas (non-operational lots) owned by Origin were undertaken by Origin (refer to *Annex L*).

The visual inspections were carried out by ERM on 16 and 17 September 2013 and comprised a walkover of each lot, to identify indicators of significant contamination. Inspections were generally restricted to walking along existing tracks and paths through densely vegetated areas. This methodology was considered appropriate as the majority of dumped waste and other potentially contaminated materials observed were found either on, or in close proximity to existing roads, tracks or paths.

A photo log of the inspections of the non-operational areas is presented in *Annex G*.

For the purpose of the assessment, indicators of significant contamination were considered to be the presence of dead or stressed vegetation dead or stressed animals, unexplained bare patches, chemical substances, empty, part-filled or filled cans or drums that do or may have contained hazardous substances, stained soil, unusual odours, discoloured water in drains or natural water courses or excavations or by the presence of fly-tipped waste.

4.9 *LABORATORY ANALYSIS*

The laboratories used for the investigations are NATA accredited for the analytical methods required. The primary laboratory used for soil and groundwater analysis was ALS Environmental Pty Ltd (ALS). Inter-laboratory duplicate samples were couriered under chain of custody documentation to a secondary laboratory, Envirolab Services Pty Ltd (Envirolab). The analytical methods used by each laboratory are provided in the laboratory certificates in *Annex H*.

Soil, sediment, groundwater and surface water samples were analysed for the following COPCs:

- metals and metalloids (arsenic (As), mercury (Hg), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), Nickel (Ni), Zinc (Zn) and Selenium (Se));
- Total Recoverable Hydrocarbons (TRH);
- Benzene, Toluene, Ethyl benzene and Xylene (BTEX);
- Polycyclic Aromatic Hydrocarbons (PAHs) and Phenols; and
- Asbestos (presence / absence - soil only).

Additional contaminants of concern were analysed on a sub-section of the soil, sediment, groundwater and surface water samples collected. These contaminants included:

- Polychlorinated Biphenyls (PCBs) – related to transformer operation;
- Volatile Organic Compounds (VOCs) - to target solvent use in maintenance of plant; and
- Perfluorooctane Sulfonate (PFOS), Perfluorooctanoic Acid (PFOA) - to target AFFF use.

Selected soil and sediment samples were also analysed for the following to allow for adoption of appropriate screening values:

- Total Organic Carbon (TOC);
- Particle Size Distribution (PSD); and
- pH and Cation Exchange Capacity (CEC).

4.10 *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 5.5* of this report. Where available, low level analysis was conducted during the Additional Stage 2 ESA in order to meet the adopted screening values for certain VOCs, PAHs and metals.

5 RESULTS AND DISCUSSION

5.1 SITE GEOLOGY OBSERVATIONS

A generalised description of the lithology encountered at the Site is presented in *Table 5.1*. Detailed descriptions of the Site geology as observed during the investigation are presented on the borehole logs in *Annex D*.

It is noted that subsurface soil conditions were largely comprised of natural clayey sand/sandy clay or sandy gravelly clay as depicted in the cross sections provided within *Annex C* and the borehole logs presented in *Annex D*. Underlying these natural soils, weathered conglomerate and sandstone was encountered within the majority of the Site with the exception of areas north of the Operational Area where siltstone/sandstone was encountered. Within the Operational Area, filling or reworked natural material (across the western portion was encountered. This fill / reworked natural material generally overlaid bedrock. The presence of natural soils within the Operational Area were considered to be limited and were generally not encountered during the intrusive works. Stylised cross-sections showing geological conditions encountered across north-south and east-west transects of the site are presented in *Annex C*.

Table 5.1 ***Generalised Field Lithology Descriptions***

Lithological Unit	Description	Depth[1] (m bgl)
Hard-standing (present for some operational locations)	Asphalt and concrete, typically in good condition with no staining.	0 - 0.15
Fill	Road base, Gravelly sand, orange brown, moist, loose, containing cobbles, no odour or staining.	0 – 0.4
Clayey Sand	Light brown, moist, loose, coarse grained, containing gravel/ weathered conglomerate.	0.4 – 0.6
Sandy gravelly clay	Brown, moist, moderate plasticity, medium soft. Often becoming grey with depth.	0.6 – 6.3
Conglomerate/sandstone	Weathered rock[2] with clay, grey/brown clay, non-plastic, rounded rocks with well sorted medium grained sand.	6.3 – 24.5+

1. Given the variation in topography across the Site, depths and lithologies may vary.
2. Weathered sandstone/siltstone was identified north and northeast of the operational area

5.2 GROUNDWATER FIELD OBSERVATIONS

Existing groundwater monitoring wells on-site were gauged on 15 and 16 July 2013, prior to sample collection between 16 and 25 July 2013. Newly installed monitoring wells were generally gauged and sampled at least one week after well installation and development to allow subsurface conditions to stabilise.

Groundwater gauging and sampling was completed during the initial Stage 2 ESA between 29 July 2013 and 23 September 2013 and the subsequent additional Stage 2 ESA between 17 November and 4 December 2014. Rainfall recorded during these investigation periods has been outlined below;

- 29 July 2013 and 23 September 2013 a total of 39.8 mm was recorded with the largest rainfall events occurring on 8 August and 17 September 2013; and
- 17 November and 4 December 2014 a total of 41.4 mm was recorded with the largest rainfall events occurring on 25 November and 2 December 2014.

Recharge to groundwater from rainfall is expected to be relatively low given the expected limited permeability of the sandy clay soils encountered at the site. If a conservatively high groundwater recharge rate of 10% is considered, the 39.8mm of rainfall recorded between August 8 and September 17 2013 (or 41.4mm between 25th November and 2nd December 2014) would translate to approximately 4 mm of groundwater recharge over these periods. Given the relatively high hydraulic gradients observed at the site (varying between 0.02 and 0.03 with SWL variations from 36.59 m AHD in EJ_MW07 to 5.16 m AHD in EA_MW21 in a down-gradient direction and 26.34 m AHD in EA_MW01 to 0.36 m AHD in EJ_MW09 in a downgradient direction) this amount of rainfall would have had an insignificant effect on groundwater levels and the interpretation of groundwater flow direction. Similarly, ERM considers that groundwater recharge in the order of 4mm would have had an insignificant mixing effect between saline ash dam seepage and low salinity recharge from rainwater infiltration.

Groundwater gauging data is presented in *Tables 2a* and *2b* of *Annex B*. Groundwater was encountered at depths ranging from 0.49 m below top of casing (m btoc) (EJ_MW02) to 16.9 m btoc (EJ_MW41) during 2013 sampling and 0.36 m btoc (EI_MW15) and 17.63 m btoc (EJ_MW41) during 2014 sampling. Shallower groundwater where the water strike was found within 7 m of top of casing was generally found within fill, disturbed material (i.e. reworked natural material) and unconsolidated sediments consisting mainly of sandy gravelly clay or sand associated with estuarine sediments adjacent to Myuna Bay.

Deeper groundwater where the water strike was encountered between approximately 10 and 15 m bgl, was generally present within weathered to unweathered conglomerate and sandstone. Within the conglomerate and sandstone, occasional coal seams were present which also contained groundwater.

Groundwater levels indicate that there may be some localised groundwater mounding at the Site, such as south of the Attemperation Reservoir, north west of Myuna Bay, north of Whiteheads Lagoon, at the CCPMF, north of the transformers and along the Coal Haul Road.

Localised groundwater flow systems were assessed by dividing the Site into sub-catchments and evaluating the groundwater level gauging data within the context of the sub-catchment boundaries. Groundwater flow directions as informed by gauging data within the sub-catchments are discussed further in the conceptual hydrogeological model (*Section 5.4*).

Groundwater purged during sampling at all monitoring wells was observed to be generally clear to cloudy with some grey/brown or slight orange colouring. Hydrogen sulfide or sulfidic odours were observed at EA_MW04 (2013), EF_MW03 (2013), EJ_MW36 (2013), EJ_MW37 (2013), EF_MW06 (2013), EJ_MW14 (2013), EJ_MW22 (2013), EA_MW22 (2014), EB_MW06 (2014), EJ_MW33 (2013 and 2014) and EJ_MW39 (2014). No observable sheens were noted during 2013 sampling however a hydrocarbon sheen was observed at EE_MW10 (2014). Slight hydrocarbon odours were observed at EC_MW09 (2013), EE_MW07 (2014) and EE_MW10 (2014) with hydrocarbon odours observed at EE_MW01 (2014). The majority of wells exhibited moderate levels of recharge with drawdown of less than 0.6 m throughout the 30-40 minute purging and sampling process.

Groundwater salinity, measured as electrical conductivity, was highly varied across the site ranging from 31 µS/cm (EJ_MW29) to 120 500 µS/cm (EA_X_MW03) for 2013 sampling and 145 µS/cm (EJ_MW31) to 28 937 µS/cm (ED_X_EPSMW12) for 2014 sampling. Groundwater pH measured across the site was varied but predominantly exhibited slightly acidic conditions within the majority of groundwater monitoring wells with some isolated monitoring wells exhibiting low pH in areas down-gradient of the Attemperation Reservoir, the CCPMF and the southern portion of the site. Further discussions of pH variation across the site is presented in *Section 5.6*.

Actual or potential Non-Aqueous Phase Liquid (NAPL) was not identified in any monitoring wells during the gauging and sampling process undertaken by ERM in both the 2013 and 2014 sampling events.

It is noted that due to the nature of this assessment, only one round of groundwater sampling was initially undertaken (2013 sampling event). Given the Additional Stage 2 ESA works (which included resampling of selected monitoring wells, as agreed with Origin), some temporal variation in groundwater data has been observed This variation is noted in subsequent discussions.

A review of groundwater monitoring well installation details has been undertaken and a table of gauged groundwater water levels compared to top of screen elevation has been included as *Tables P1* and *P2* in *Annex P*. Whilst it is noted that some monitoring well screens were slightly below the observed SWL, this was considered acceptable in the context of the project objectives (to establish a baseline ESA) and the likely hydraulic connection with overlying strata. It is further acknowledged that across the Site, there was an absence of direct field indicators of gross petroleum hydrocarbon contamination (such as measured LNAPL). Indirect indicators of the potential presence of (petrol or diesel) LNAPL put forward in Australian Guidance (CRC Care, 2013) were also not observed. These indicators include:

- PID measurements in soil and/or drill cuttings above 500 ppm;
- groundwater benzene concentrations above 3 mg/L;
- groundwater BTEX concentrations above 20 mg/L (for petrol sources);
- TPH/TRH (petrol source, C6 - C14 or TRH C6 - C16) above 30 mg/L; and
- TPH/TRH (diesel source, C10 - C14 or TRH >C10 - C16) above 5 mg/L.

The absence of indirect indicators of LNAPL indicates that, even where monitoring well screens were found to be below the SWL (where the ingress of LNAPL into the monitoring well would not be facilitated), the presence of LNAPL in these monitoring well locations is considered unlikely.

Where the static water level was not within the screened interval, comment has been made as to the suitability of the wells for the investigation. It is noted that all monitoring wells were considered suitable for assessing groundwater at the Site.

5.3 *SEDIMENT AND SURFACE WATER INVESTIGATION FIELD OBSERVATIONS*

The majority of sediments sampled from Lake Macquarie, Whiteheads Lagoon and Crooked Creek were wet grey-brown silts with minor gravels and fragments of shells in near shore locations, with larger shell fragments in offshore locations. Samples in Whiteheads Lagoon and Crooked Creek were siltier with an organic/sulfurous odour.

The water depth to sediment in Lake Macquarie was between 0.5 m to approximately 6.0 m. Depth to sediment in Whiteheads Lagoon and Crooked Creek was shallower, ranging between 0.3 m and approximately 2 m from the water surface. The proposed locations for sediment samples EG_SX01 to EG_SX03 were abandoned due to the absence of sediment within the outlet canal due to the high velocity of water. Samples of accumulated sediment near the edge of the canal were collected where a viable amount was available for collection, namely in the vicinity of proposed locations EG_SX01 and EG_SX02.

The surface water samples within Lake Macquarie were generally very clear with no distinct odour. Samples within Whiteheads Lagoon and Crooked Creek were more turbid and brown with no distinct odour.

Sediments from the Return Water Dam were wet grey and brown silts. The depth to sediment in which the four samples were taken was between 0.3 m to 0.5 m. Sediment was sampled at the edge of the dam and not at the original proposed locations due to safety concerns.

5.4 *CONCEPTUAL HYDROGEOLOGICAL MODEL*

5.4.1 *Aquifers*

With consideration of the regional geological map (Geological Survey of New South Wales, 2003) and the investigation observations summarised in *Section 5.1* through to *Section 5.2*, two broadly defined aquifer systems are considered to be present in the investigation area as described below:

Shallow Unconsolidated Aquifer System

The first aquifer system is present within fill/reworked material, residual material (i.e. completely weathered sedimentary bedrock) and in alluvial sediments in near shore locations. This system presents an unconfined shallow aquifer within unconsolidated material. While indications are that the shallow aquifer system is not continuous across high lying areas of the Site (where fill and alluvial sediments are absent and the layer of residual material is thin), groundwater level gauging indicates that the shallow aquifer system covers the majority of the lower lying areas of the Site (refer to the conceptual cross sections presented in *Annex C* which indicate the groundwater table within the shallow unconsolidated aquifer system).

Due to the relatively high silt and clay content seen in the unconsolidated material, groundwater yields from this system would be expected to be low. While hydraulic testing was not undertaken as part of the investigation, groundwater yields for the alluvial sediments in the region are reportedly typically less than 1 litre per second (GHD, 2013). In the broader region, groundwater in the alluvial sediments have further been reported to be moderately acidic to slightly alkaline, and brackish to saline with electrical conductivity in excess of 10 000 µS/cm reported (GHD, 2013).

Deeper Sedimentary Bedrock Aquifer System

Deeper groundwater is present within the sedimentary bedrock, hosted within weathered and/or fractured conglomerate/sandstone and coal seams where present. Potentiometric groundwater levels measured for monitoring wells screened in the sedimentary bedrock aquifer system are presented in the conceptual cross sections in *Annex C*. In the absence of significant fracturing, the system would be expected to have relatively low hydraulic conductivity and yields.

Groundwater monitoring associated with the Mandalong Mine operations indicates that groundwater in the Munmorah Conglomerate is generally saline and that the groundwater exhibits considerable variability in pH (GHD, 2012; as cited in GHD 2013).

5.4.2 *Interconnectivity*

Some degree of hydraulic connectivity would be expected between the shallow unconsolidated aquifer system and the deeper lying aquifer system. Gauging data indicates that the hydraulic gradient is generally downwards.

A high degree of interconnectivity is expected between surface water features and the shallow unconsolidated aquifer system. Key hydraulic interactions are considered to include recharge from the CCPMF to the shallow unconsolidated aquifer system (see conceptual cross section A-B in *Annex C*), inflows from shallow groundwater into Crooked Creek (see conceptual cross section C-D in *Annex C*) and potential recharge from the settling basin and oil retention weir to the shallow unconsolidated aquifer system which would discharge to Muddy Lake according to the assessment of sub-catchments and groundwater gauging data (see conceptual cross section E-F and G-H in *Annex C*).

5.4.3 *Groundwater Flow Regime*

The broader hydrogeological regime and localised groundwater flow systems were assessed by dividing the Site into sub-catchments and evaluating the groundwater level gauging data within the context of the sub-catchment boundaries.

The sub-catchment overlay presented in *Figure 5.1* was developed using the following methodology:

- The National 1 second stream-enforced Digital Elevation Model (DEM) was extracted for the study extent (Source: Geoscience Australia (2011)).
- Hydrological analysis was undertaken using the Hydrology Spatial Analysis tools available within ArcGIS v10.1 to define sub-catchment areas.

- Analysis of the resulting sub-catchments with aerial imagery, particularly within the site was undertaken to adjust for known surface-water drainage systems and modifications to surface flow.

Figure 5.1 illustrates that the main operational areas of the Site fall into three sub-catchments, while the coal haul road located further to the north falls into a fourth sub-catchment located to the north of the Site. Groundwater flow direction arrows presented on *Figure 5.1* are based on the groundwater level gauging data and the inferred groundwater directions which align strongly with groundwater flow directions that would be expected from the topographical slope within the sub-catchment areas for both aquifer systems. While groundwater flow direction arrows for the fourth sub-catchment located to the north of the Site aren't presented on *Figure 5.1*, the assessment indicates that there is a groundwater flow divide to the north of the CCPMF with the groundwater flow direction along the Coal Haul Road to the north (based on limited gauging data).

Groundwater level gauging data for the three sub-catchments located in the main operational area are presented in *Figures 5.2* through to *Figure 5.4*. Note that the most recent set of groundwater level data gauging from 2014 was used to interpolate groundwater level contours in the western (*Figure 5.2*) and southern (*Figure 5.4*) sub-catchments. As a relatively limited subset of monitoring wells were gauged during 2014 for the eastern sub-catchment (presented in *Figure 5.3*), the 2013 gauging data set was used to interpolate groundwater levels for this sub-catchment as this represented a more complete data set.

As can be seen in the above mentioned figures, the evaluation of sub-catchments and groundwater gauging data within those sub-catchments elucidate localised groundwater flow dynamics within the broader site-wide hydrogeological regime. The evaluation indicates that groundwater flow from the coal storage area and the power station is towards the south south west, with groundwater in this sub-catchment ultimately draining towards Muddy Lake (which then drains into Lake Macquarie). In the sub-catchment within which the CCPMF is located (*Figure 5.3*), groundwater flow is to the south towards Myuna Bay from the CCPMF while groundwater in the south western section of this sub-catchment likely flows towards Whiteheads Lagoon. In the southern most sub-catchment indications are that to the south of the Attemperation Reservoir groundwater flows south south east towards Lake Eraring (see *Figure 5.4*).

5.5 *AREAS OF ENVIRONMENTAL CONCERN (AEC) SUMMARY*

For the purpose of this assessment, the Site has been divided into 12 separate AECs, defined as AECs EA – EL. The following sections provide a summary of investigation findings by AEC.

5.5.1 *Area EA – Coal Combustion Product Management Facility (CCPMF and Surrounds)*

Background

The CCPMF occupies an area of approximately 150 ha and is located in the eastern portion of the Site (refer to *Figures 3.1* and *3.2* of *Annex A*).

Potentially contaminating activities located within this AEC are primarily associated with inputs to and migration from the CCPMF, including ash slurry, water and fines from the dirty water collection/treatment system, mine water from the adjacent Awaba Mine and overflows from the oil retention lagoon as presented *Annex O*. The eastern portion of the current CCPMF was also previously used as an ash dam for the nearby former Wangi Power Station, although it is noted that the surface of the former Wangi Ash Dam was significantly lower than that of the current CCPMF.

In addition to the issues associated with the CCPMF, potential areas of concern also located within this AEC relate to the disposal of waste materials, including;

- Asbestos Landfill Areas (Northern and Southern) – inactive and capped.
- Filter Bag Disposal Area - remains active and is located on top of the Southern Asbestos Landfill area.
- General Waste Landfill Area – inactive and capped, located on the western edge of the CCPMF.

Historic investigations have demonstrated that seepage from the CCPMF is saline and contains heavy metals. In particular, selenium, copper, lead, zinc and arsenic concentrations in excess of ANZECC (2000) freshwater trigger values and/or NHMRC (2011) ADWG values have been detected in groundwater collected from monitoring wells located up, down and cross hydraulic gradient of the CCPMF. Selenium has also been reported in surface water collected from the CCPMF toe drain and return water canal, although concentrations were noted to have decreased between 2006 and 2013 (ERM, 2013a).

Through discussions with Site personnel it is understood that truck washout pit waste material is distributed around the CCPMF within rehabilitation areas. The waste sludge material is initially scraped out of the truck washout pits on an as-needed basis and is then stockpiled adjacent to the truck washout pits on an area of hardstand. The material remains on the area of hardstand until growth of grass and weeds is observed at which point it is transported to the rehabilitation areas surrounding the CCPMF. ERM understands that no samples are collected from this material prior to placement within the CCPMF.

AEC Methodology and Investigation Field Observations

Sampling was conducted in the EA AEC to target potential impacts to soil and groundwater from CCPMF leachate and runoff and to assess the extent of the general waste and asbestos landfills on the southern and western boundary of the CCPMF. The approximate extents of the Wangi Ash Dam and landfill areas are presented in *Figures 3.1* and *3.2* of *Annex A*.

A total of 15 soil investigation bores and 13 groundwater monitoring wells were installed within this AEC between 9 August 2013 and 1 October 2013. Soil bores and monitoring wells were distributed on the downhydraulic gradient side of the CCPMF to supplement the existing well network, including adjacent to the Return Water Dam, southeast of the Return Water Dam and to the south of Crooked Creek.

As part of the Additional Stage 2 ESA works, a further two groundwater monitoring wells (EA_MW22 and EA_MW23) were installed across the down-gradient edge of the CCPMF to assess potential migration in groundwater and provide additional coverage in this area. Three groundwater monitoring wells (EA_MW24, EA_MW25 and EA-MW26) were also installed to delineate the eastern and western boundaries of the general waste landfill (located at the southwestern corner of the CCPMF).

Perimeter groundwater monitoring wells (Area EJ) within this area were distributed to provide up hydraulic gradient background conditions on the western side of the CCPMF, down and cross hydraulic gradient conditions on the southern and south-eastern side of the CCPMF.

Ten existing groundwater monitoring wells located within this AEC were also inspected; nine of these were located down hydraulic gradient and one up hydraulic gradient on the northern side of the CCPMF. An assessment of the suitability of existing monitoring wells onsite is provided in *Annex P*. Seven of the ten existing wells were sampled (during the initial Stage 2 ESA) with a further two existing wells sampled during the Additional Stage 2 ESA. The remaining well was noted to be dry once sampling had commenced, and did not re-charge throughout the entirety of the project.

The soil bore and groundwater monitoring locations within this AEC are presented on *Figures 3.1* and *3.2* of *Annex A*. Relevant borehole logs advanced by ERM and available existing borehole logs ERM are presented within *Annex B*.

Ground Penetrating Radar (GPR) investigations were attempted to delineate the extent of each of the three distinct areas of historic waste disposal land fill. Dense bushland, consisting of established trees and exotic plant growth, occupied the landfill areas which restricted access with a GPR.

The three distinct areas of historic waste disposal were therefore broadly delineated using the following methodology;

- detailed Site inspections with Eraring Power Station personnel;
- a review of all available Site plans;
- surveying the fenced boundaries (Asbestos Landfill Areas); and
- advancement of soil bores.

The results of the detailed Site inspection and Asbestos Landfill survey are presented in *Annex K*. A visual survey of the General Waste Landfill Area was not completed due to an inability to visually define the extent. The extent of the General Waste Landfill Area was therefore defined through the advancement of soil bores at accessible locations around the anticipated perimeter of the area. During a site meeting held between ERM, Origin and AECOM on 13 June 2014, it was apparent that additional access trails had been created within the General Waste Landfill Area subsequent to the completion of the initial investigations. It was agreed that three additional monitoring wells were to be placed in this area in an attempt to further delineate the extent of the General Waste Landfill area.

The soil bores installed within this AEC are presented on *Figure 3.1* and included;

- Northern Asbestos Landfill - EA_SB09, EA_SB11, EA_SB16, EA_SB17, EA_SB18 and EA_MW04.
- Southern Asbestos Landfill - EA_SB08, EA_SB15 and EA_MW07.
- General Waste Landfill Area - EA_SB13, EA_SB14, EA_SB19, EA_SB20, EA_MW06, EA_MW24, EA_MW25 and EA_MW26.

Surficial waste was identified within the areas defined by the abovementioned soil bores, and consisted of construction and demolition materials segregated into areas of timber, concrete and general waste. Although one potential ACM fragment was observed approximately 10 m south of the ACM landfill area (of which laboratory analysis confirmed contained asbestos fibres), no ACM was visually observed on the surface within the waste areas. It is noted that inspections were not conducted on a grid basis in accordance with Western Australian (WA) Department of Health (DOH) Guidance for the Assessment, Remediation and Management of Asbestos-Contaminated Sites due to the presence of dense vegetation within each landfill area. No field indicators of contamination, such as staining, odours or stressed vegetation were noted. No staining or odours were detected at any depth through the sampled soil profile with the exception of EA_MW25 which reported a slight organic odour between 0.4 and 0.5 m bgl.

Measured concentrations of ionisable volatile compounds via headspace analysis were noted not to exceed 7.4 ppm (isobutylene equivalent) in any sample collected from this AEC.

A summary of the field observations from the drilling works are presented within *Table 5.2*

Table 5.2 *Field Observations Summary*

Borehole ID	Depth (m bgl)	Visual or Olfactory Evidence	PID Range (ppm)
EA_SB08	3	None	0.0 to 0.1
EA_SB09	3	None	0.0 to 0.3
EA_SB11	2.7	None	0.0 to 0.1
EA_SB13	3	None	0.0 to 0.1
EA_SB14	0.85	None	0.0
EA_SB15	2	None	0.0 to 0.1
EA_SB16	1.8	None	0.3 to 0.8
EA_SB17	1.8	None	0.3 to 0.4
EA_SB18	1.4	None	0.2 to 0.4
EA_SB19	0.5	None	0.2 to 0.3
EA_SB20	1	None	0.1 to 0.4
EA_SB21	1	None	0.3 to 0.5
EA_SB22	0.4	None	0.1 to 0.3
EA_SB23	0.2	None	0.2
EA_SB24	0.4	None	0.2 to 0.4.
EA_MW01	8	None	N/A
EA_MW02	8.8	None	0.0 to 0.4
EA_MW03	10	None	0.0 to 0.2
EA_MW04	4	None	0.0 to 0.3
EA_MW05	9	None	0.0 to 0.4
EA_MW06	13.5	None	0.0 to 0.2
EA_MW07	4	None	N/A
EA_MW16	7.5	None	0.0 to 0.2
EA_MW17	15.5	None	0.0
EA_MW18	13	None	0.0 to 0.1
EA_MW19	14	None	0.0 to 0.2
EA_MW20	7	None	0.0 to 0.2
EA_MW21	14	None	0.0 to 0.4
EA_MW22	4	None	0.1 to 7.4
EA_MW23	7	None	0.1 to 1.8
EA_MW24	16	None	0.1 to 7.1
EA_MW25	8.5	Slight organic odour (0.4 – 0.5 m bgl)	0.2 to 1.7

Groundwater parameter readings collected during the groundwater sampling works are presented in *Table 3a* of *Annex B*. Groundwater pH readings during the 2013 sampling event ranged from 2.71 (at EA_X_MW05) to 7.87 (at EA_MW04), with pH values <4 reported in two monitoring wells located to the south of the CCPMF.

Sulfidic odours were also detected at locations EA_MW04 (western side of the CCPMF) and EA_X_D10 (south of the CCPMF). Groundwater pH readings during the 2014 sampling event ranged from 2.82 (at EA_X_MW05) to 6.39 (at EA_MW26), with pH values <4 reported in EA_X_MW05 and EA_MW01 which are both down-gradient of the CCPMF.

These results are consistent with published acid sulfate soil information (www.asris.csiro/mapping/viewer.htm, accessed on 24 May 2013) which indicated that there was a high probability of encountering acid sulfate soils immediately to the south of the Site. Based on a review of aerial photography, these areas had been cleared of vegetation, and exposed soils suggested that earthworks had previously been undertaken in these areas. It is noted that these activities may have allowed oxidation of potential acid sulfate soil, to create actual acid sulfate soil conditions in these areas.

Soil Analytical Results

The soil analytical results are compared to the adopted human health and ecological screening values as presented in *Table 4b of Annex B*. Exceedences of the adopted screening values are also graphically presented in *Figures 6.1 and 6.2 of Annex A*.

Measured concentrations of TRH, BTEX, PAHs, phenols, VOCs and PCBs were either reported at or near the corresponding LOR, and thus, below the adopted screening values within all soil samples collected from within this AEC.

Potential asbestos containing material was observed at the surface in one soil bore (EA_SB08) collected from this AEC. It is noted that this bore was located outside the asbestos landfill area. It was identified as one fragment of fibre cement sheeting, 75 mm × 55 mm × 6 mm. The fragment was observed to be in good condition, with no free fibres or fibre bundles reported by the laboratory. Laboratory analysis of this sample indicated that asbestos fibres were present in this fragment, in the form of chrysotile, amosite and crocidolite within a bonded (fibre cement sheeting) matrix. All soil samples analysed for asbestos within this AEC returned negative results for the presence of asbestos fibres. Potential ACMs were not observed during the Additional Stage 2 ESA works or walkovers conducted by ERM in conjunction with Origin (and AECOM).

Concentrations of arsenic, cadmium, chromium, lead, mercury, selenium and zinc were reported below the adopted human health and ecological screening values in all samples analysed. Concentrations of nickel were reported above the adopted EILs in a number of samples and copper was also reported above the adopted EIL in one sample.

Groundwater Analytical Results

Groundwater quality field parameters are presented in *Table 3a* of *Annex B* and groundwater analytical results compared to the adopted screening values are presented in *Table 4a of Annex B*. Exceedences of the adopted screening values are also graphically presented in *Figures 6.3 and 6.4 of Annex A*.

A number of laboratory LOR non-conformances were identified within this AEC, however these are not considered to affect the outcomes of the investigation (refer to *Section 5.5* for further discussion).

Measured concentrations of TRH, BTEX, VOCs, PAHs, phenols and PCBs in groundwater were reported below the laboratory LOR in all samples analysed, with the exception of samples collected from monitoring wells, EA_MW06, EA_MW07 and EA_MW25.

The concentration of benzo(a)pyrene (BaP) in groundwater collected from EA_MW25 exceeded the adopted drinking water screening value (0.089 µg/L compared to a screening value of 0.01 µg/L) with carcinogenic PAHs (as BaP Toxicity Equivalence Quotient (TEQ)) also reported above the adopted recreational exposure screening value (0.117 µg/L compared to a screening value of 0.1 µg/L). Polycyclic Aromatic Hydrocarbon (PAH) compounds (BaP and indeno(1,2,3-c,dpyrene) in EA_MW25 exceeded the adopted ecological (marine) guideline. Whilst ANZECC (2000) does not provide a marine quality guideline for BaP and indeno(1,2,3-c,dpyrene), RIVM (2001) provides a Serious Risk Concentration (SRC) for the protection of aquatic species in groundwater of 0.72 µg/L and 0.036 µg/L respectively.

Detectable concentrations of TRH, phenols and PAH were reported in groundwater samples collected from monitoring wells EA_MW06 and EA_MW07 , however the reported concentrations did not exceed the adopted human health or ecological screening values.

Human health screening values were not identified for phenol, however the US EPA (2009[1]) has published a human health water criterion for phenol of 10 000 µg/L. Although this value has no regulatory standing in Australia, it indicates that the maximum phenol concentration detected in EA_MW06 is unlikely to represent a significant risk to human receptors.

[1] US EPA (2009) *Human Health Criteria – Phenol*, Current criteria for phenol, Fact sheet EPA 822-F-009-001, May 2009

Arsenic, copper, lead, nickel, selenium and zinc were detected at concentrations in excess of the adopted human health and/or ecological screening values in groundwater samples collected from across this AEC.

Waste Delineation Results

The results of the detailed site inspection and asbestos landfill survey are presented in *Annex K*. The findings of the buried waste investigation were consistent with anecdotal evidence provided by Eraring Power Station personnel. No field indicators of contamination, such as staining, odours, stressed vegetation or ACM were noted in the observed soil profile at the locations sampled nor on the Site surface, outside the landfill areas identified by Eraring Power Station personnel.

Based on the results of the investigation, the following spatial estimates were made:

- Northern Asbestos Landfill occupies an area of approximately 14,265 m^2 ;
- Southern Asbestos Landfill occupies an area of approximately 7,177 m^2; and
- General Waste Landfill occupies an area of approximately 25,481 m^2.

Based on site engineering drawings (*Annex K*) and information provided by Site personnel, the Northern and Southern Asbestos Landfills were engineered and filled via a series of trenches and the abovementioned estimates do not take into account unexcavated material between trenches. These estimates are therefore are considered conservative approximations.

The absence of a fence around the General Waste Landfill Area meant that it was difficult to visually define its spatial extent. Therefore the extent of the General Waste Landfill Area was defined through the advancement of soil bores around the estimated perimeter and as such, is considered a conservative approximation. Based on the results of the Additional Stage 2 ESA, it is noted that the General Waste Landfill Area is unlikely to extend west beyond the access road (as anecdotally suggested).

Discussion

Nickel and copper were the only metal contaminants detected in soil at concentrations above the adopted screening values. The 95% UCL calculated for both nickel and copper in AEC EA were found to comply with the screening values (refer to *Annex J*) and none of the nickel or copper concentrations measured were more than double the ecological screening values with the exception of sample EA_MW25_3.5 (26 mg/kg compared to a screening values of 10 mg/kg).

It is noted that this sample was obtained from 3.5 m bgl which is beyond 2 m bgl for which the EILs apply (ie outside the primary root and habitation zone of the majority of species). This suggests that these exceedences are unlikely to represent a significant risk to the terrestrial environment.

Asbestos fibres were detected in one sample of fibre cement sheeting (EA_SB08_ACM) collected from within this AEC. Asbestos fibres were not detected in any of the soil samples, and no other ACM fragments were recorded for this AEC. Based on the observations made during the site works, an issue of the capping at the landfills or the presence of a separate source of ACM was not apparent. Based on the field observations, the results of the sampling and the usage and access at the historical landfill areas, the risk to human health is considered to be minimal.

A number of groundwater monitoring wells reported metal concentrations greater than the adopted ecological and human health screening values. Metal concentrations in excess of the NHMRC (2011) ADWG values were also reported in a number of wells. The metals of concern included arsenic, copper, lead, nickel, selenium and zinc.

While salinity levels inferred from electrical conductivity measurements showed significant variation across the monitoring well network with a number of readings indicating brackish to saline conditions, salinity levels were generally higher in monitoring wells located down-gradient of the CCPMF compared to up-gradient monitoring wells. Electrical conductivity results from the monitoring wells installed as part of the Additional Stage 2 ESA indicated similar trends with downgradient locations reporting saline conditions (12 860 µS/cm at EA_MW22). It is noted that monitoring wells EA_MW23 (to the east) and EJ_MW50 (to the west) show a proportional order of magnitude decrease in salinity (as indicated by EC measurements) which were 2289 µS/cm and 2718 µS/cm respectively. These locations provide a broader lateral delineation of the saline groundwater conditions exhibited downgradient of the CCPMF. Resampling of EA_X_MW05 and EA_X_MW06 reported consistent EC results (for both 2013 and 2014 sampling events) confirming saline conditions directly down-gradient of the CCPFM (*Table 3a* of *Annex B*). Existing monitoring well EA_X_MW03 reporting very high EC results (120,500 µS/cm) however significantly elevated impacts were not apparent with down-gradient monitoring wells such as EA_MW03 and EJ_MW52. Based on the EC exhibited in down-gradient wells from the CCPMF, any elevated salinity is likely to be diluted or significantly lower than the salinity of the lake.

As the groundwater in this area is brackish to saline and there are no groundwater extraction wells located in the vicinity of the Site, the groundwater is not a human health or ecological receptor in itself.

The screening values were therefore adopted to evaluate potential risks associated with the discharge of groundwater into Lake Macquarie, where it may affect recreational users or aquatic organisms. Metal impacts within Lake Macquarie and its tributaries are discussed further in *Section 5.5.7*.

Elevated metals concentrations were detected in wells up gradient of AEC EA, such as EJ_MW07 (zinc), EJ_MW06 (copper and zinc). Cross gradient wells also demonstrated elevated metal concentrations, including EA_MW05 (copper and zinc). It is therefore considered that elevated metals concentrations from up-gradient areas may also be contributing to the metals concentrations observed in groundwater samples collected from AEC EA.

It is noted however that nickel, zinc and selenium results were generally higher than background levels in the monitoring wells located downgradient of the CCPMF. It is likely that the ongoing operation of the CCPMF contributes to these results, although no clear distribution of metal concentrations in groundwater was evident between the various downgradient wells. Detections of selenium in groundwater were limited to monitoring wells EA_X_GM1/D2 and EA_X_MW03. Potential acid sulfate soil conditions in the area downgradient of the CCPMF (near EJ_MW52) could also have contributed to the mobilisation of metals in groundwater. Discussions of metals and metalloid concentrations across the broader site is presented in *Section 5.6* of this report.

The data within Area EA and surrounding areas indicates that pH levels below 4.5 were highly localised directly down-gradient of the CCPMF with the two monitoring wells (EA_X_D26 and EA_X_D29) located down-gradient from the monitoring well with a measured pH of 2.7 (EA_X_MW05) reporting pH levels of 5.6 (as measured in 2013). Groundwater pH data collected during the 2014 sampling event confirmed low pH groundwater at EA_MW01 (3.86) which is adjacent to the ash dam and at EA_X_MW05 (2.82) which is down-gradient of the ash dam. Measured pH values less than 5 were identified within a number of monitoring wells including those adjacent to, downgradient and up gradient of the CCPMF and adjacent to the Return Water Dam. It is also noted that a review of pH in down-gradient monitoring well locations from the CCPMF identified higher pH values in groundwater with the exception of EJ_MW52 which reported a pH of 3.39. It is noted this location is within the Myuna Bay Sport and Recreation Facility and adjacent to Crooked Creek and within 80 m of Myuna Bay itself. This location is suspected to be affected by (actual) acid sulfate soils, hence the low pH (refer to *Figure 6.6* of *Annex A*). Further discussion of pH measurements across the Site is presented in *Section 5.6*.

A qualitative comparison of low pH and concentrations of metals in groundwater was undertaken for monitoring wells within AEC EA. A broader site wide discussion is also presented in *Section 5.6*. Elevated metals in groundwater appear to be primarily due to the presence of up-gradient sources (such as the CCPMF or Return Water Dam) with the pH being a secondary driver of elevated metals. This is supported by elevated concentrations at monitoring wells EA_MW02 and EA_MW16 adjacent to the Return Water Dam, and EA_X_GM1_D2 adjacent to the CCPMF. Conversely, monitoring well EJ_MW52, which reported a low pH (3.39), primarily due to the presence of actual acid sulfate soils, reported low concentrations of metals. As discussed previously, these lower metals concentrations are likely due to the distance from the metals source, with the low pH not manifesting elevated metals in this case.

5.5.2 *Area EB – Transformer Area*

Background

The Transformer Area houses the main generator transformers for the Site and is located immediately to the west of the boiler and turbine units and adjacent to the cooling water inlet canal (refer to *Figure 3.7* of *Annex A*). This AEC is within an operational area of the Site and is largely covered in hard-standing. A small grassed area is present at the southern end of this AEC.

Sampling locations in this area primarily targeted transformer operation. Whilst the phase-out and disposal of equipment containing PCBs was undertaken at the Site during the late 1990s, twelve operational transformers still use oil containing low concentrations of PCBs and oil containing PCBs was used extensively prior to implementation of this program.

In addition to operation of the transformers, AEC EB also contains four 25 000 L ASTs and two decommissioned ASTs of similar size, used for the storage of transformer oil. The location of these ASTs is presented in *Figure 3.7* of *Annex A*.

There are historic reports of leakages occurring from the transformers and in 2011 a failure of the 2B Generator and an associated fire resulted in the release of transformer oil to the environment. The use of firefighting foam containing PFOS also represents a potential contaminant source for this area (ERM, 2013a).

There have been no soil or groundwater investigations completed within AEC EB prior to the current assessment.

AEC Methodology and Investigation Field Observations

Sampling was conducted in this AEC to target potential contamination of soil and groundwater from transformer operation, transformer oil storage and leak and fire associated with the 2B Generator. Soil bores and monitoring wells were distributed around the perimeter of inaccessible areas, and in accessible locations not restricted by the presence of above and below ground infrastructure. Sampling locations in close proximity to this area include those installed primarily to target contamination potentially associated with the contaminated water pits and lines located in the workshop areas (Area EE) on the western side of the boiler and turbine units.

It is noted that a number of locations were abandoned within this AEC during the Initial Stage 2 ESA due to the presence of above and below ground infrastructure. During subsequent onsite meetings between ERM, Origin and AECOM, additional soil boreholes were agreed to be advanced within AEC EB. The four additional locations were advanced during the Additional Stage 2 ESA works to target the transformers and CWS on the western side of the operational area. This drilling was undertaken utilising a sonic continuous core drilling methodology. Based on a spatial review of the current locations, the sampling density is considered sufficient for the purposes of this investigation.

The location of the CWS relative to currently completed investigation locations is presented in *Figure 3.7* of *Annex A*. Organic odours were detected at some of the sampling locations, however these were considered to be associated with the presence of organic matter in the clay soils and were not considered to be indicative of a likely soil impact.

Measured concentrations of ionisable volatile compounds via headspace analysis were not recorded above 7.8 ppm (isobutylene equivalent) in any of the samples collected from this AEC. Field indicators of potential impact are summarised in *Table 5.3* (below). Coal pieces were recorded amongst the reworked clay at a number of locations.

Site inspections and a review of as built drawings provided by Eraring Power Station confirmed the locations and depth of contaminated water pits and drainage lines. As a result, groundwater monitoring wells and soil bores were advanced surrounding these structures to a minimum depth of the invert of the CWS (which is nominally 3 - 4 m bgl) to assess any potential contaminant releases from the base of the pits/lines.

Although it was difficult to distinguish between fill and natural material within this AEC, discussions with Eraring Power Station personnel suggest that the western side of the boiler and turbine units has been infilled with up to 10 m of reworked clay/sand/gravel fill material.

Table 5.3 *Field Observations Summary*

Borehole ID	Depth (m bgl)	Visual or Olfactory Evidence	PID Range (ppm)
EB_SB09	3	None	0.1 to 2.3
EB_SB11	3	None	0.4 to 5.8
EB_SB12	3	None	1.4 to 4.6
EB_SB13	3	Coal pieces (gravels) from 2.7-2.85 m bgl	0.1 to 4.8
EB_SB18	3	None	0.0 to 0.2
EB_SB19	3.9	Dark black staining on surface of clay from 1.8-2.2 m bgl due to coal inclusions at 1.6 m bgl.	0.0 to 0.5
EB_SB23	3.9	None	0.1 to 5.3
EB_SB25	4	None	0.7 to 2.7
EB_SB26	4.3	Slight organic (natural) odour at 3.8 m bgl	1.6 to 3.5
EB_SB27	4.5	None	0.6 to 2.7
EB_SB28	4	None	0.3 to 3.3
EB_MW01	10	Organic (natural) odour at 6.8 m bgl	0.5 to 4.3
EB_MW02	5	None	0.0 to 0.2
EB_MW04	4.6	None	0.0 to 1.5
EB_MW05	6.2	Coal inclusions at 2 m bgl	0.0 to 4.3
EB_SB20/ EB_MW06	7	None	0.0 to 1.8
EB_MW07	4.6	Coal layer from 7.8-10 m bgl	0.1-0.4
EB_MW08	10	None	0.1-0.3
EB_MW10	10	None	0.0-4.7

Groundwater parameter readings collected during the 2013 and 2014 groundwater sampling events are presented in *Table 3a* of *Annex B*. A hydrogen sulfide odour was identified at EB_MW06 in 2014 (but not in 2013) and an organic odour was identified at EB_MW07 in 2014 (but not in 2013).

Soil Analytical Results

The soil analytical results are compared to the adopted human health and ecological screening values as presented in *Table 4d of Annex B*. Exceedences of the adopted screening values are also graphically presented in *Figures 6.1 and 6.2 of Annex A*.

Concentrations of TRH, BTEX, PAHs, phenols, VOCs and PCBs in soils were reported below the LOR or the adopted screening level (where available) for all samples analysed, with the exception of sample EB_MW07_7.8.

The concentrations of TRH (C_{10} - C_{16}) and copper measured in the sample collected at EB_MW07 at 7.8 m bgl, marginally exceeded the screening values adopted for the assessment of ecological risks within a commercial/industrial area. PAHs were also detected in this sample but the measured concentrations of TRH, PAH and copper did not however exceed the adopted human health screening values.

These impacts are likely to be attributable to a coal layer recorded at this location. Given the magnitude and depth of the observed impacts, the potential risk to ecological receptors is not considered significant.

Concentrations of PFOS and PFOA in soil were not detected in any of the samples analysed from within the AEC EB.

Potential ACM was not observed in any of the sampling locations advanced across this AEC, and all samples analysed for asbestos within this AEC returned negative results. The limitations of assessing for the presence of asbestos in soils using vertical boring methods are, however, acknowledged. Concentrations of arsenic, cadmium, chromium, lead, mercury, nickel, and zinc were reported below the adopted human health and ecological screening values in all samples analysed.

Groundwater Analytical Results

Groundwater quality parameters are presented in *Table 3a* of *Annex B* and groundwater analytical results compared to the adopted Site screening values (including freshwater and marine ecosystem specific values) are presented in *Table 4c of Annex B*. Exceedences of the adopted screening values are also graphically presented in *Figures 6.3 and 6.4 of Annex A*.

A number of laboratory LOR non-conformances were identified within this AEC, however these are not considered to affect the outcomes of the investigation (refer to *Section 5.5* for further discussion).

Measured concentrations of TRH, BTEX, VOCs, PAHs, phenols and PCBs in groundwater samples were reported either below the laboratory LOR or below the adopted human health and ecological screening values in all samples analysed from within this AEC with the exception of EB_MW01. .

The measured concentration of B(a)P in the groundwater sample collected from EB_MW01 exceeded the adopted drinking water screening value (0.082 µg/L compared to a screening value of 0.01 µg/L) with carcinogenic PAHs (as BaP Toxicity Equivalence Quotient (TEQ)) also reported marginally above the adopted recreational exposure screening value (0.111 µg/L compared to a screening value of 0.1 µg/L). Indeno(1,2,3-c,dpyrene) in EB_MW01 was also reported at a concentration marginally above the adopted ecological (marine) screening value. Whilst ANZECC (2000) does not provide a marine quality screening value for BaP and indeno(1,2,3-c,dpyrene), RIVM (2001) provides a Serious Risk Concentration (SRC) for the protection of aquatic species in groundwater of 0.72 µg/L and 0.036 µg/L respectively.

The analytical concentration of PFOA in EB_MW06 was reported as 0.04 µg/L in 2013, which was marginally above the laboratory LOR but below the adopted screening values for human health receptors. EB_MW06 was resampled during the Additional Stage 2 ESA and reported a result below the laboratory LOR (<0.02 µg/L).

Concentrations of cadmium, copper, nickel, selenium and zinc were reported at concentrations exceeding the adopted ecological screening values in several samples analysed from within this AEC. Concentrations of nickel and selenium were also detected at concentrations exceeding the NHMRC (2011) ADWG value, but were found to comply with the adopted human health (recreation).

Discussion

Although initially selected sample locations were abandoned due to accessibility issues, additional soil boreholes were advanced to target the transformer and CWS, hence the sampling density completed for AEC EB was deemed to provide a suitable level of spatial coverage across the area.

Copper and TRH were detected in soils at EB_MW07 at a depth of 7.8 m bgl. This is outside the primary root and habitation zone of the majority of species and is therefore of limited concern with respect to ecological risk (ASC NEPM, 2013). TRH and copper were not identified in the soil sample collected from a depth of 2.5 m bgl at this sampling location.

No authoritative guidelines have been derived in NSW (or other Australian jurisdictions) for PFOS or PFOA in groundwater, protective of human health or the environment. Whilst groundwater is not used for potable supply, in the absence of a more appropriate guideline, health screening values of 0.2 µg/L and 0.4 µg/L for PFOS and PFOA respectively in groundwater have been adopted. These values are proposed by US EPA Office of Water Provisional Health Advisory (2009) and reflect reasonable, health based hazard concentrations above which action should be taken to reduce exposure to contaminants in drinking water (USEPA, 2014).

Concentrations of PFOS and PFOA were below these screening values in the groundwater samples analysed for this AEC and are therefore considered unlikely to represent a risk to offsite recreational users of Lake Macquarie and its tributaries. Ecological screening values were not identified for PFOA however a value of 7.2 µg/L (from RIVM MAC for marine ecosystems) was adopted for PFOS. All concentrations were below this screening value for protection of marine ecosystems. It is further noted that the concentration of PFOA in EB_MW06 during the 2014 sampling event was below the laboratory LOR (0.02 µg/L) compared to the detection of 0.04 µg/L reported in 2013. These results indicate that a broader PFOS/PFOA issue is unlikely to be present within AEC EB, based on the sampling conducted. PFC impacts within the operational area are more broadly discussed in *Section 5.3.9*.

Concentrations of cadmium, copper, nickel, selenium and zinc in groundwater were found to exceed the ecological screening values at a number of locations although there was no clear trend in metals concentrations across the AEC. Concentrations of nickel and selenium exceeding the NHMRC (2011) ADWG values were also reported at several locations.

As the groundwater in this area is brackish to saline and there are no groundwater extraction wells located in the vicinity of the Site, the groundwater is not a human health or ecological receptor in itself. The screening values were therefore adopted to evaluate potential risks associated with the potential discharge of groundwater to Muddy Lake (a freshwater ecosystem) which drains into Lake Macquarie (a marine ecosystem), where it may affect recreational users or aquatic organisms. Metal impacts within Lake Macquarie and its tributaries are discussed further in *Section 5.5.7.*

On the basis of a review of concentrations reported for up-gradient monitoring wells in AEC EH and (cross) up-gradient wells such as EJ_MW27 and EJ_MW28, background conditions are considered likely to contribute significantly to these metal results.

For PAH impacts at EB_MW01, given the minor exceedences of the recreational and ecological (marine) guidelines for BaP TEQ and indeno (1,2,3-c,d) pyrene respectively and the likely dilution over distance prior to the groundwater reaching a potential receptor, these minor exceedences are not considered to represent a significant risk to human health or the environment.

5.5.3 *Area EC – Fuel Oil Installation, Fuel Pipelines and ASTs*

Background

AEC EC covers two potential contamination sources. The first, the Fuel Oil Installation comprises four 1,200,000 L steel ASTs installed in the early 1980s, and used for the storage of diesel and fuel oil (refer to *Figure 3.1* of *Annex A*). The second is the associated pipe networks and smaller ASTs (refer to *Figure 3.7* of *Annex A*). The four large ASTs supply fuel oil via an above ground 300 mm (estimated) diameter pipeline to the Gas Turbine, the bulldozer refuelling station, and various smaller ASTs across the Site.

Historic soil and groundwater investigations have not been undertaken within the AEC EC. The volume of fuel being stored and transferred across the Site represents a potential source of contamination. In addition, leaks from the aboveground pipes have been reported and a maintenance program was undertaken in 2010/2011 (ERM, 2013a). The precise location of these leaks was not identified however it is understood that the leaks were within the compound rather than along the pipeline connecting the AST's to the operational area.

Sampling was conducted in this area to target potential contamination of soil and groundwater associated with loss of fuel and oil. Monitoring wells were distributed around the perimeter of inaccessible areas. The grid sampling locations within Area EI can also be utilised to assess potential impacts associated with the fuel and oil pipeline and ASTs. Where possible, bores were targeted toward potential source areas / areas of visible staining. ERM considers that the network of soil bores and monitoring wells advanced within this AEC was sufficient to adequately target the identified potential sources.

AEC Methodology and Investigation Field Observations

No field indicators of contamination, such as staining, odours or stressed vegetation were noted on the ground surface within AEC EC. Hydrocarbon odours were reported at two sampling locations located adjacent to ASTs within the main operational area (outside of the Fuel Oil Installation Area), including at 3.0 m bgl and from 0.7 to 1.1 m bgl within EC_MW09 and EC_MW15, respectively. No staining or odours were identified by ERM at any depth through the sampled soil profile within or surrounding the Fuel Oil Installation area or the fuel/oil pipeline. Hydrocarbon odours were reported at 3.0 m bgl and from 0.7 to 1.1m bgl within EC_MW09 and EC_MW15, respectively. Maximum concentrations of ionisable volatile compounds via headspace analysis were noted to be 13.2 ppm at 3.0 m bgl within EC_MW09 and 68.3 ppm at 1.1 m bgl within EC_MW15 (isobutylene equivalent).

Sixteen soil investigation bores were advanced in this AEC to assess the nature and extent of potential soil contamination, with the intention of converting each of these into groundwater monitoring wells. Eight of these were located to provide coverage of the area of the four large ASTs; EC_MW01 to EC_MW08. A further eight were located along the pipeline route to target potential contamination from fuel and oil from leaking from the pipeline.

Due to sub-surface services present on Site, it was deemed unsafe to advance EC_MW05, EC_MW07 and EC_MW16 using mechanical drilling. These boreholes were therefore terminated when refusal was encountered with the hand auger. Whilst a monitoring well could not be directly located at the proposed EC_MW05 location, a borehole, EJ_SB43, was converted into a monitoring well as it was in a similar location, downgradient of the fuel oil installation. Similarly EJ_SB42 was converted into a monitoring well when it became apparent that EC_MW07 could not be advanced due to sub surface infrastructure. EC_MW16 was abandoned. The wells that were installed are considered to adequately to assess groundwater conditions in this area.

Competent bedrock (comprising sandstone and conglomerate) was encountered at a depth of less than 0.5 m bgl at a number of locations in this AEC. As such, the ability to collect soil samples from these locations was limited as it became necessary to utilise rotary air hammer drilling techniques in order to advance these holes. As the matrix being drilled was competent bedrock this is not considered to constitute a significant data gap.

Groundwater was gauged at depths of between 1 and 14 m bgl in this AEC and the groundwater was fresh to brackish with a slightly acidic pH of 5.26 (minimum) in 2013 and 4.1 in 2014.

A summary of the field observations from the drilling works are presented within *Table 5.4*

Table 5.4 *Field Observations Summary*

Borehole ID	Depth (m bgl)	Visual or Olfactory Evidence of Impact	PID Range (ppm)
EC_MW01	6.5	None	0.1 to 2.6
EC_MW02	12.2	None	0.2 to 0.5
EC_MW03	10	None	0.1 to 1.8
EC_MW04	26.5	None	N/A
EC_MW06	5	None	0.0 to 0.3
EC_MW08	12	None	0.0 to 0.5
EC_MW09	5	Hydrocarbon odour at 3.0 m bgl	0.0 to 13.2
EC_MW10	5	None	0.0 to 0.3
EC_MW11	15	None	0.1
EC_MW12	12.5	None	0.1 to 4.3
EC_MW13	2.7	None	1.3
EC_MW14	8	None	0.4
EC_MW15	3	Hydrocarbon odour from 0.7 m bgl	0.1 to 68.3

Groundwater parameter readings collected during the 2013 and 2014 groundwater sampling events are presented in *Table 3a* of *Annex B*. No odours were detected during groundwater sampling at AEC EC with the exception of a slight hydrocarbon odour identified at monitoring well EC_MW09 in 2013.

Soil Analytical Results

Soil analytical results are compared to the adopted Site screening values in *Table 4f* of *Annex B*. Exceedences of the adopted screening values are also presented in *Figures 6.1 to 6.2* of *Annex A*.

Concentrations of phenols, PAHs, PCBs, BTEX and VOCs were not detected above the LOR in soil samples collected by ERM from any location within the AEC EC.

Various metals were detected in soils at concentrations above the LOR however there were no exceedences of the adopted screening values.

Measurable concentrations of TRH were detected in the soil sample collected from EC_MW09 at 3.0 m bgl. Of the fractions detected, only TRH(C10-C16) exceeded the ASC NEPM (2013) ESLs for commercial/industrial land use (although it is noted that the ESLs are designed for contamination in soil up to 2 m bgl given the likely depth of plant root uptake). Field screening also detected a hydrocarbon odour at 3 m bgl within EC_MW09.

Measurable concentrations of TRH were also detected above the LOR in EC_MW15 at 1.1 m bgl, however these concentrations did not exceed the adopted human health or ecological screening values.

Groundwater Analytical Results

Groundwater quality field parameters are presented in *Table 3a* of *Annex B* and groundwater analytical results compared to the adopted Site screening values (including freshwater and marine ecosystem specific values) are presented in *Table 4e of Annex B*. Exceedences of the adopted screening values are also graphically presented in *Figures 6.3 and 6.4 of Annex A*.

A number of laboratory LOR non-conformances were identified within this AEC, however these are not considered to affect the outcomes of the investigation (refer to *Section 5.5* for further discussion). The LOR achieved for BaP was greater than the NHMRC (2011) ADWG value for 2013 sampling (the potential implications of this LOR non-conformance are discussed further in *Section 5.5*). Samples obtained for PAHs during the 2014 sampling event were analysed for super ultra-trace PAHs (with a laboratory LOR for BaP of 0.005 µg/L.

Concentrations of BTEX, VOCs, and phenols above the LOR were not detected in groundwater samples collected from within AEC EC. Concentrations of TRH were detected in EC_MW09 above the LOR but below the adopted human health screening values. Concentrations of PFOS and PFOA were below the laboratory LOR with the exception of EC_MW09 which reported PFOS at 0.15 µg/L. All PFOS results were below the adopted screening values for human health and the environment.

PAH compounds were detected in EC_MW09 and EC_MW12 during the 2013 sampling event. Concentrations of BaP exceeded the NHMRC(2011) ADWG screening value (0.01 µg/L) in the samples collected from EC_MW12 (during 2013) reported as 0.07 µg/L and EC_MW09 during 2014 reported as 0.064 µg/L. The measured concentrations did not however exceed the screening values adopted to evaluate potential risks to recreational users of Lake Macquarie (noting Muddy Lake is directly down-gradient which then discharges to Lake Macquarie). All results were below the adopted ecological (marine) screening values with the exception of indeno (1,2,3-c,d)pyrene in EC_MW09 which marginally adopted screening value (0.04 µg/L compared to 0.036 µg/L).

Concentrations of PAH compounds were detected in excess of the NHMRC (2011) ADWG value for BaP in EC_MW09 and EC_MW12 however the concentrations did not exceed the adopted recreational screening values. Naphthalene and Indeno (1,2,3-c,d)pyrene were reported in the groundwater sample collected from EC_MW09 at a concentration marginally above the ecological (freshwater and marine) screening levels respectively. Measured concentrations of metals in groundwater marginally exceeded the ecological screening values and NHMRC (2011) ADWG values in a number of wells across this AEC.

As the groundwater in this area is brackish to saline and there are no groundwater extraction wells located in the vicinity of the Site, the groundwater is not considered a human health or ecological receptor in itself. The screening values were therefore adopted to evaluate potential risks associated with the potential discharge of groundwater into Muddy Lake (a freshwater ecosystem) which drains into Lake Macquarie (a marine ecosystem), where it may affect recreational users or aquatic organisms. Metal impacts within Lake Macquarie and its tributaries are discussed further in *Section 5.5.7*. Groundwater results from nearby wells in nonoperational areas (EJ_MW13-15) also demonstrate that background conditions at the Site are likely to contribute to these metal results. Given the minor nature of the exceedence of the ecological screening value for naphthalene and indeno (1,2,3-c,d) pyrene and the likely dilution over distance prior to the groundwater reaching a potential receptor, this minor exceedence was not considered to represent a significant risk to the environment.

5.5.4 *Area ED – Operational and Decommissioned USTs*

Background

A total of six active and decommissioned USTs are reported to be present on Site (refer to *Figure 3.7* of *Annex A*). All six USTs are understood to be approximately 30 years old and of single steel wall construction. Three decommissioned USTs are located in the vicinity of the Stores Building and are reported to have contained leaded and unleaded petrol and diesel. A decommissioned UST that was formerly used for the storage of lubrication oil is also located in the vicinity of Unit 1 Turbine House. Site personnel reported that two of the USTs remain in use and have been integrity tested; the main turbine refuse oil UST located in the vicinity of Unit 1 Turbine House and the garage refuse oil storage UST located near the Vehicle and Mobile Plant Workshop. Documentation relevant to the decommissioning works could not be reviewed during this assessment.

Soil and groundwater investigations have been completed within this AEC to facilitate compliance with relevant UPSS legislation.

An investigation of the soil and groundwater conditions in the area surrounding the USTs located to the west of the Stores building (Geo-Logix, 2011c) identified petroleum hydrocarbons in shallow soil in the immediate vicinity of the dispensers and in groundwater immediately downgradient of the USTs. Petroleum hydrocarbons were not however detected in groundwater wells installed to the south of the Stores Building to assess the potential for TRH impact to a man-made canal. Petroleum hydrocarbons were also not detected in four shallow soil vapour wells installed to evaluate potential vapour intrusion risks within the office space overlying the Stores Building.

Investigation of soil and groundwater conditions in the areas surrounding the UPSS in the Unit 1 Turbine House area (Geo-Logix, 2011b) and Vehicle and Mobile Plant Workshop (Geo-Logix, 2011a) did not identify TRH or PAH in soil in groundwater.

Geo-Logix (2011a) also recommended that regular groundwater monitoring and sampling of soil vapour wells be undertaken to "ensure conditions are not worsening over time". It is understood that this sampling had not been undertaken at the time of this assessment.

Investigation Methodology and Field Observations

Soil samples were not collected from within this AEC and no groundwater monitoring wells were installed. Reference to soil results from boreholes advanced within EI (surrounding ED) has been made within the discussions section below. The investigation within this AEC was limited to the sampling of the existing monitoring well network, installed to fulfil the requirements of the UPSS Regulation 2008 (now 2014).

A total of twelve existing monitoring wells were sampled during the 2013 sampling event with the locations presented in *Figure 3.7* of *Annex A*. Soil and groundwater data collected from within AECs EI and EE has also been used to assess the groundwater conditions in AEC ED. These included EI_SB56, EI_SB70, EB_SB12, EI_SB68, EI_SB71, EI_MW06, EE_SB11, EE_SB22, EE_SB23, EI_SB96 and EI_SB95, some of which are located either directly down-gradient or cross-gradient. Groundwater monitoring well ED_X_EPSMW12 was resampled during the 2014 sampling event.

Of the twelve monitoring wells sampled, only one well (ED_X_EPSMW5) was recorded as having a detectable hydrocarbon odour and monitoring well ED_X_EPS2 was reported as exhibiting a sulfurous odour. No other field indicators of potential contamination were noted.

Groundwater within this AEC was fresh to saline and reported a moderate to slightly acid pH. Field parameters are presented in *Table 3a* of *Annex B*.

Groundwater Analytical Results

Groundwater quality field parameters are presented in *Table 3a* of *Annex B* and groundwater analytical results are compared to the adopted Site screening values (including freshwater and marine ecosystem specific values) presented in *Table 4g* of *Annex B*. Exceedences of the adopted screening values are also presented in *Figures 6.3 and 6.4* of *Annex A*.

Several LOR non-conformances were identified, however these were not considered to affect the outcomes of this investigation (refer to *Section 5.5* for further discussion).

Measured concentrations of phenols in groundwater were below the LOR in all samples. Concentrations of TRH and VOCs were below the LOR in all groundwater samples with the exception of those collected from ED_X_EPSMW5 and ED_X_EPSMW6, however none of these concentrations were above the adopted human health screening values. Concentrations of PAHs were below the LOR in all samples with the exception of an exceedence of the ANZECC (2000) (freshwater and marine) trigger value for naphthalene in ED_X_EPSMW5.

Concentrations of cadmium, copper, lead, nickel, selenium and zinc were found to exceed the ecological screening level in several samples. Concentrations of arsenic and nickel were also found to exceed the NHMRC (2011) ADWG values in two samples.

Discussion

Previous soil investigations completed by Geologix identified shallow soil impacts with AEC ED in the immediate vicinity of the dispensers. Soil sample results from soil bores advanced as part of AEC EI (surrounding AEC ED) did not identify concentrations of TRH or BTEX compounds above the laboratory LOR. Based on these results, extensive soil impacts within area ED were considered unlikely to be present.

A review of the suitability of existing monitoring wells installed by Geo-Logix (2011), to confirm that the wells were appropriately constructed and screened within the groundwater bearing strata is presented within *Annex P*. All existing monitoring wells appear to be screened across the same geological unit, and thus single water bearing zone for each specific area of the site, as presented in *Annex P*. This is further supported by consistent SWL measured by Geo-Logix and ERM over two separate gauging rounds.

The concentration of naphthalene measured in ED_X_EPSMW5 exceeded the ANZECC (2000) (freshwater and marine) trigger value. Naphthalene was not however identified in the groundwater monitoring wells located (cross) downgradient of this sampling location (e.g. EI_MW06 and ED_X_EPSMW12) during the 2013 sampling event. Additional sampling of ED_X_EPSMW12 during the 2014 sampling event reported concentrations of PAHs below the laboratory LOR. It is also noted that field observations and soil analytical results in downgradient soil bores EI_SB57, EI_SB58 and EI_SB69 did not indicate the presence of broader PAH or hydrocarbon impacts. The naphthalene concentrations detected in groundwater from the monitoring well installed within this AEC are not considered to be indicative of significant impacts nor are they considered to represent a significant risk to recreational users or aquatic receptors within Muddy Lake or Lake Macquarie and its tributaries, based on the distance to these receptors and the likely attenuation that would occur across this distance.

Measured concentrations of various metals in groundwater marginally exceeded the adopted ecological screening values and NHMRC (2011) ADWG values in a number of wells across this AEC. As the groundwater in this area is brackish to saline and there are no groundwater extraction wells located in the vicinity of the Site, the groundwater is not a human health or ecological receptor in itself.

The screening values were therefore adopted to evaluate potential risks associated with the potential discharge of groundwater into Muddy Lake (a freshwater ecosystem) which drains into Lake Macquarie (a marine ecosystem), where it may affect recreational users or aquatic organisms. Metal impacts within Lake Macquarie and its tributaries are discussed in *Section 5.5.7*.

Groundwater results from nearby wells in nonoperational areas (EJ_MW05 and EJ_MW15) also demonstrate that background conditions at the Site are likely to contribute to these elevated metal results.

5.5.5 *Area EE - Workshops*

Background

Maintenance workshops are located throughout the Site (refer to *Figure 3.7* of *Annex A*), with two main workshops situated to the east of the boiler and turbine units and in close proximity to the black start gas turbine. Other workshops are located adjacent to the northeast and northwest corner of the turbine building.

In their current configuration and use, the maintenance workshops appear to be managed well and have little potential to cause significant soil and/or groundwater contamination. Parts washing facilities were observed and all appeared to be in good order and are regularly serviced by third party contractors. Historically, potentially contaminating activities that took place within the workshops included the storage and use of oils, fuels and lubricants. Trichloroethylene (TCE) and other solvents were also stored and used for degreasing and parts washing.

AEC Methodology and Investigation Field Observations

Sampling was conducted to target potential contamination of soil and groundwater from the use of solvents in parts washing, and use of lubricants and oils in general maintenance and repairs. Soil bores and monitoring wells were distributed in accessible locations not restricted by the presence of below ground infrastructure, to target four main workshop areas. In addition, the grid sampling locations within Area EI can be used to evaluate the potential for migration of impacts from the maintenance workshops.

Nine soil investigation bores were advanced in this area to assess the nature and extent of potential soil contamination, with a further eight groundwater monitoring wells installed. Due to the proximity of sub-surface services on Site it became necessary to abandon six soil bore locations and one monitoring well location. Whilst a monitoring well could not be directly located at the proposed EE_MW04 location, there were five monitoring wells installed in this area. In addition two soil bores were advanced in this area.

This was therefore considered to adequately assess subsurface conditions in this area, for the purposes of this investigation. It is acknowledged, however, that due to the reduction of sampling locations, the potential size of hot spot which may remain undetected would be slightly increased.

Based on the hydrogeological regime (as discussed in *Section 5.4*, it is noted that groundwater monitoring wells were located downgradient and adjacent to each investigated workshop. Monitoring wells EE_MW08, EB_MW07 and EB_MW04 were noted to be down-gradient of the northern workshop. Monitoring wells EE_MW03, EE_MW06 and EE_MW05 were noted to be down-gradient of the eastern workshop. These locations are presented in *Figure 3.7* of *Annex A*.

Field observations made during the soil investigation works are summarised in *Table 5.5* (below). No field indicators of contamination, such as staining, odours or stressed vegetation on the ground surface were noted. Excluding samples EE_SB16 and EE_MW07, no staining or 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 12.0 ppm (isobutylene equivalent). A sweet odour was noted at EE_SB16 and measured concentrations of ionisable volatile compounds were noted at 12.0 ppm (isobutylene equivalent). Similar concentrations of ionisable volatile compounds were detected at EE_MW07. There were slight odours associated with these PID readings, however the nature of these odours were not discernible.

Table 5.5 *Field Observations Summary*

Borehole ID	Depth (m bgl)	Visual or Olfactory Evidence	PID Range (ppm)
EE_SB11	3	None	0.0 to 0.2
EE_SB12	3	None	0.0 to 0.2
EE_SB13	3	None	0.0 to 0.1
EE_SB15	3.9	None	0.0 to 0.3
EE_SB16	1.5	Slight sweet odour from 0.23m bgl.	3.0 to 12.0
EE_SB17	0.95	None	0.1 to 0.2
EE_SB18	0.7	None	0.1 to 0.2
EE_SB22	3.9	None	0.2 to 0.8
EE_SB23	1.9	None	0.0 to 0.2
EE_MW01	3	None	0.1 to 1.2
EE_MW02	4	None	0.0 to 0.6
EE_MW03	3	None	0.0 to 0.2
EE_MW05	9	None	0.1 to 3.9
EE_MW06	7	None	0.0 to 1.6
EE_MW07	4	Slight odour (1-2.4m)	0.3 to 12.0
EE_MW08	5.1	None	0.0 to 0.7
EE_MW10	5	None	0.1 to 0.8

Groundwater within this AEC was fresh to saline and reported a moderate to slightly acidic pH with the exception of EE_MW02 which reported a pH of 10.65. No obvious source for the elevated pH was noted nearby this monitoring well. Field parameters are presented in *Table 3a* of *Annex B*. No odours during the 2013 groundwater sampling event were detected however hydrocarbon odours were noted in EE_MW01 (at the eastern workshop) and EE_MW07 and EE_MW10 during the 2014 sampling event. Monitoring well EE_MW10 was observed to have a sheen during sampling.

Soil Analytical Results

The soil analytical results are compared to the adopted human health and ecological screening values as presented in *Table 4h of Annex B*. Exceedences of the adopted screening values are also graphically presented in *Figures 6.1 and 6.2 of Annex A*.

Soil analytical concentrations of TRH, BTEX, phenols, VOCs and PCBs were reported below the corresponding LOR in all of the samples analysed, with the exception of one sampled collected from EE_SB15 at a depth of 0.05 m bgl which reported concentrations of heavy end TRH (>C15-C40) above the LOR. VOCs in soil were not identified at EE_SB16 where a sweet odour was identified during drilling works.

These concentrations did not however exceed the screening values adopted for the assessment of risks to commercial, intrusive workers and ecological receptors in commercial/industrial areas. It is noted that vapour intrusion screening values for the TRH (>C15-40) fraction are not available, as these fractions are non-volatile.

Benzo(a)pyrene was reported at a concentration equal to the adopted commercial/industrial ecological screening values within a single sample (EE_SB12_0.3). The total PAH concentrations measured at this location did not however exceed the screening values adopted for the assessment of risks to commercial/industrial receptors.

Potential asbestos containing material was not observed in any of the locations advanced across this AEC, and all samples analysed for asbestos within this AEC returned negative for the presence of asbestos. The limitations of assessing for the presence of asbestos using vertical boring sampling methods are, however, acknowledged.

Measured concentrations of zinc in the soil sample collected at 0.05 m bgl in EE_SB15 exceeded the AEC specific EIL for commercial/industrial areas (aged) however not the screening values adopted for the assessment of risks to commercial/industrial workers.

Groundwater Analytical Results

Groundwater quality field parameters are presented in *Table 3a* of *Annex B*. The groundwater within AEC demonstrated slightly acidic and brackish conditions.

The groundwater analytical results compared to the adopted Site screening values (including freshwater and marine ecosystem specific values) are presented in *Table 4h of Annex B*. Exceedences of the adopted screening values are also graphically presented in *Figures 6.3 and 6.4 of Annex A*.

Several LOR non-conformances were identified within this AEC, however these are not considered to affect the outcomes of the investigation (refer to *Section 5.5* for further discussion). The LOR achieved for vinyl chloride was greater than the adopted screening values for drinking water and recreational exposure during the 2013 sampling event.

Solvents, including TCE had previously been used in this work area and the anaerobic reductive dechlorination of TCE can result in the release of vinyl chloride into groundwater. As such, further assessment conducted during the 2014 sampling round adopted an ultra-trace (lower LOR) analytical technique for the additional samples collected within AEC EE (see *Section 5.5*).

TRH, BTEX, VOCs and phenols were not detected at concentrations above the laboratory LOR in groundwater collected from within this AEC with the exception of:

- TRH C6-C10 and C6-C10 less BTEX (F1) in EE_MW08 (2013);
- Benzene in EE_MW07 and EE_MW08 (2014);
- Ethylbenzene in EE_MW08 (2014);
- Xylene in EE_MW08 and EE_MW10 (2014);
- Chloroform and trichloroethene in EE_MW01 (2014);
- Cis-1,2-dichloroethene (DCE) in EE_MW01 and EE_MW07 (2014) and EE_MW08 (2013 and 2014);
- Trans-1,2-dichloroethene (DCE) in EE_MW08 (2014); and
- Vinyl chloride in EE_MW07 and EE_MW08 (2014).

All compounds as detected above were below the adopted human health and ecological screening values with the exception of vinyl chloride which exceeded the NHMRC (2011) ADWG but not the adopted recreational screening values or ecological trigger value.

Benzo(a)pyrene was identified in EE_MW06 in both 2013 and 2014 sampling events at concentrations in excess of the NHMRC (2011) ADWG but not the adopted recreational screening values or ecological trigger value.

Cadmium, copper, lead, nickel, selenium and Zinc were reported at concentrations above the ecological screening values in a number of groundwater samples collected from across this AEC. Selenium and arsenic concentrations also exceeded the NHMRC (2011) ADWGs however the detected concentrations were below the adopted recreational screening values.

Discussion

A review of the suitability of existing monitoring wells installed by Geo-Logix (2011), to confirm that the wells were appropriately constructed and screened within the groundwater bearing strata is presented within *Annex P*. All existing monitoring wells appear to be screened across the same geological unit, and thus single water bearing zone for each specific area of the site, as presented in *Annex P*. It is noted that three existing monitoring wells (ED_X_EPSMW1, ED_X_EPSMW2 and ED_X_EPSMW3) reported standing water levels above the screened interval but within the gravel pack. However, based on the dissolved phase concentrations of TRH reported in these monitoring wells and other indirect indicators (such as concentrations of benzene, TRH and PID screening values), NAPL is considered unlikely to be present.

A slight sweet odour was detected in soil at EE_SB16 (at 0.3 m bgl) and the presence of PAHs in soil was confirmed in the analytical results. The sample was also analysed for VOCs with all compounds reported below the laboratory LOR. Although only one sample was analysed from this location, field screening (performed to borehole completion at a depth of 1.5 m bgl) did not identify potential further contamination. Borehole EE_SB16 was terminated at a shallow depth due to uncertainty in the location of the nearby stormwater system identified at a depth of approximately 1.5 - 2.0 m bgl. Review of field observations and soil analysis (including VOCs) at surrounding locations EE_MW07, EE_SB15, EE_SB22 and EI_SB88 did not indicate the presence of sweet odours or potential VOC impacts in soils. In the absence of elevated PID screening results (and VOC results below the laboratory LOR), the slight sweet odours were not considered to be representative of a significant VOC release or issue at the northern workshop.

The measured concentrations of benzo(a)pyrene at EE_SB16 and EE_SB_12 (at a depth of 0.3 m bgl) was equal to the adopted ESL for commercial/industrial areas (coarse grained soils). The sum of carcinogenic PAH's (as BaP TEQ) at this location did not however exceed the human health screening values.

Measured concentrations of zinc in soil at EE_SB15 (0.05 m bgl) exceeded the AEC specific calculated EILs. However, the 95% UCL calculated for zinc in AEC EE was found to comply with the screening values (refer to *Annex J*). This suggests that this exceedence is unlikely to represent a significant risk to the terrestrial environment.

Within the eastern workshop, PAH compounds were detected in the groundwater samples collected from EE_MW06 during both the 2013 and 2014 sampling events. EE_MW06 is located cross and down-gradient from the eastern workshop.

BaP was reported at concentrations of 0.031 µg/L (2013) and 0.011 µg/L (2013) which were both marginally above the NHRMC (2011) ADWG (of 0.01 µg/L) but did not exceed the adopted recreational screening values. Minor detections of naphthalene were also noted in EE_MW02 (up-gradient of the workshop) however all other groundwater samples collected from monitoring wells within this area including EE_MW03 (inferred down-gradient, and EE_MW01 (inferred up-gradient) reported results for PAHs below the laboratory LOR. There are four other monitoring wells located in close proximity to EE_MW06 and BaP was not detected in groundwater samples collected from these sampling locations. Hence, the benzo(a)pyrene identified in EE_MW06 is not considered to be indicative of significant concentrations of PAH compounds migrating offsite or into surface water where it may pose a direct potential human health risk. It is further noted that groundwater within the operational area is unlikely to be used for drinking water purposes now or in the future hence the minor exceedence of the drinking water screening value is not considered to pose a risk to human health via the ingestion pathway.

Detections of chloroform and trihalomethanes were observed in EE_MW01 however concentrations reported were significantly below the adopted human health and ecological guidelines. A slight hydrocarbon odour was also noted during sampling of EE_MW01 in 2014. Concentrations of TRH, BTEX and PAHs were however reported below the laboratory LOR or below the adopted screening values for EE_MW01. Surrounding monitoring wells adjacent to the eastern workshop also returned results below the laboratory LOR for chloroform and trihalomethane compounds. Concentrations of chloroform and trihalomethanes were also detected in EI_MW10 (110 m south west and cross gradient) with levels significantly below the adopted screening values. Given the low level of these compounds and the general intermittent occurrence across the operational area, the risk to human health or the environment posed by these minor detections is not considered to be significant.

Measured concentrations of arsenic in EE_MW02 and selenium in EE_MW07 and EE_MW10 equalled or exceeded the NHMRC (2011) ADWGs but not the adopted recreational screening values. These exceedences were also marginal, at less than 250% of the NHMRC (2011) ADWG values and in the absence of groundwater extraction bores in the vicinity of the Site are considered unlikely to represent a significant health risk. In addition, groundwater monitoring wells down-gradient of these locations reported selenium at significantly lower concentrations and generally below the adopted ecological screening values.

Measured concentrations of metals in groundwater exceeded the adopted ecological screening values in the majority of the wells sampled in the vicinity of the workshops. These screening values were adopted to evaluate potential risks associated with the potential discharge of groundwater into Muddy Lake (a freshwater ecosystem) which drains into Lake Macquarie (a marine ecosystem), where it may affect aquatic organisms. Metal impacts within Lake Macquarie and its tributaries are discussed in *Section 5.5.7*.

Groundwater wells which recorded elevated levels of metals are located both cross gradient and down-gradient of the workshops and similar results have been noted in up-gradient wells outside of the operational areas of the power station (e.g. EH monitoring wells and EJ_MW27 and EJ_MW28). On this basis, these results are unlikely to be associated with workshop activities. Background conditions at the Site are also likely to contribute to the measured metal concentrations.

At the northern workshop, light fraction TRH and BTEX compounds were identified within groundwater samples collected from monitoring wells EE_MW07 and EE_MW08 with Cis-1,2-dichloroethene (DCE) detected in groundwater monitoring wells EE_MW07 and EE_MW08. Vinyl chloride (noted to be a degradation product of TCE) was detected in EE_MW07 and EE_MW08 (0.8 µg/L and 1.8 µg/L respectively) above the adopted NHMRC (2011) ADWG screening value (of 0.3 µg/L). It is noted that both EE_MW07 and EE_MW08 are directly adjacent to the northern workshop on the inferred down-gradient edge. Monitoring well EE_MW10, up-gradient of the workshop and reported concentrations of VOCs below the laboratory LOR with monitoring well EB_MW07 down-gradient of the workshop also reporting concentrations below the laboratory LOR. The occurrence of minor detections of VOC at EE_MW07 is consistent with the field observations of a sweet odour in soil at EE_SB16.

In terms of identifying potential Dense Non Aqueous Phase Liquid (DNAPL), the suitability of the well construction for screening of TCE, DCE and vinyl chloride (such as screened interval) has been reviewed and relevant comments have been included in the as *Annex P* of this report. The well screen interval is considered appropriate based on the objectives of the scope of works although it is acknowledged that a confining layer at the base of the screening interval was not present. However, assuming connection with deeper water bearing zones, it is noted that soil concentrations were below the laboratory LOR for chlorinated solvents and groundwater concentrations of chlorinated solvents in Area EE were orders of magnitude below that which would indicate the likely presence of DNAPL contamination. The occurrence of VOC compounds noted was consistent with the historical use and storage of solvents and hydrocarbon compounds within the workshop.

It is acknowledged that down-gradient delineation of VOC impacts in groundwater is limited to EB_MW07, with site constraints limiting the installation of additional locations. Concentrations of VOCs in soil samples and observations in soil bores south west of the workshop (such as EB_SB23, EI_SB85 and EI_SB96) did not indicated the presence of VOC impacts down-gradient of the workshop. Given the various lines of evidence gathered from downgradient drilling locations and the magnitude of VOC detections from the targeted monitoring wells installed, the potential risk posed to human health or the environment is not considered to be significant. Furthermore, based on the additional sampling completed from the monitoring wells installed, a significant broader VOC issue is not considered likely to be present associated with the workshop areas.

5.5.6 *Area EF - Former (Northern) Gas Turbine Location*

Background

The Former (Northern) Gas Turbine area, located in the north of the Site (refer to *Figure 3.1* of *Annex A*), is the historic location of four gas turbines. These turbines were operated using a combination of distillate and fuel oil, with the fuel supplied from two 1.5 ML ASTs, located immediately adjacent.

It is understood that these ASTs are no longer in use. This AEC also includes four transformers (decommissioned or removed from this AEC) including one space for a former transformer that is understood to have been removed due to leakage. Oil water separators and an oil containment dam are also located within this AEC.

The surface of this AEC is primarily covered by a concrete hardstand, with areas of maintained grassed cover. The AEC is predominantly cleared of vegetation but the surrounding area is occupied by relatively dense bushland. Historic soil and groundwater investigations have not been undertaken within the AEC and limited information was identified with respect to former operations (ERM, 2013a).

AEC Methodology and Investigation Field Observations

Sampling was conducted to target potential contamination of soil and groundwater from transformer operations and the potential losses of fuel and transformer oil. Soil bores and monitoring wells were distributed in accessible locations not restricted by the presence of below ground infrastructure, to target former infrastructure, turbine buildings and the retention pond.

A total of nine groundwater monitoring wells were advanced within this AEC from 16 July 2013 through until 19 July 2013. The specific targeted locations are detailed in *Table 1a* of *Annex B* and graphically presented in *Figure 3.1* of *Annex A*. Borehole logs are presented in *Annex D*.

No field indicators of contamination, such as staining, odours or stressed vegetation were noted, with the exception of a sweet odour observed from 0.4 - 1.2m bgl within EF_MW08. Measured concentrations of ionisable volatile compounds via headspace analysis were noted not to exceed 2.2 ppm (isobutylene equivalent) in any soil samples collected from this AEC.

A summary of the field observations from the drilling works are presented within *Table 5.6*.

Table 5.6 ***Field Observations Summary***

Borehole ID	Depth (m bgl)	Visual or Olfactory Evidence	PID Range (ppm)
EF_MW01	9	None	0.0 to 0.1
EF_MW02	9	None	0.0 to 0.1
EF_MW03	11	None	0.0 to 0.1
EF_MW04	9	None	0.0 to 0.2
EF_MW05	9	None	0.0 to 0.3
EF_MW06	9	None	0.0 to 0.1
EF_MW07	9	None	0.0 to 0.2
EF_MW08	5.8	Sweet odour observed from 0.4 - 1.2m bgl	0.2 to 2.2
EF_MW09	7	None	0.0

Groundwater within this AEC was fresh to brackish and reported a moderate to slightly acidic pH. Field parameters are presented in *Table 3a* of *Annex B*. A slight hydrogen sulfide or sulfur odour was detected at EF_MW03 and EF_MW06. No other odours or visual observations of contamination were made during the 2013 or 2014 groundwater sampling events.

Soil Analytical Results

The soil analytical results are compared to the adopted human health and ecological screening values as presented in *Table 4k of Annex B*. Exceedences of the adopted screening values are also graphically presented in *Figures 6.1 and 6.2 of Annex A*.

A sweet odour was observed within the soil profile of EF_MW08 at a depth of 0.4 m bgl - 1.2m bgl, however this was not reflected in the analytical results, with concentrations of TRH, BTEX, VOCs, PAHs, phenols and PCBs reported below the laboratory LOR in samples collected at 0.7 m bgl and 1.2 m bgl.

With the exception of the abovementioned location, EF_MW08, no visual or olfactory indications of volatile compounds were noted in AEC EF. TRH, BTEX, VOCs, PAHs, phenols and PCBs were all reported below the laboratory LOR in soil samples analysed from within this AEC.

Analytical concentrations of metals in soil were either reported at or near the corresponding laboratory LOR in all samples analysed within this AEC.

All samples analysed for asbestos within this AEC returned negative results. The limitations of assessing for the presence of asbestos using vertical boring sampling methods are, however, acknowledged. No ACMs were observed within AEC EF during the site walkover or fieldworks.

Groundwater Analytical Results

Groundwater quality field parameters are presented in *Table 3a* of *Annex B* and groundwater analytical results compared to the adopted Site screening values (including freshwater and marine ecosystem specific values) are presented in *Table 4j of Annex B*. Exceedences of the adopted screening values are also graphically presented in *Figures 6.3 and 6.4 of Annex A*.

A number of laboratory LOR non-conformances were identified within this AEC, however these are not considered to affect the outcomes of the investigation (refer to *Section 5.5* for further discussion).

Analytical concentrations of TRH, BTEX, VOCs, PAHs, phenols and PCBs in groundwater were reported at or near the corresponding laboratory LOR in all samples analysed, with the exception of EF_MW08 and EF_MW09 which reported minor concentrations of TRH compounds during the 2013 sampling. Subsequent sampling of monitoring well EF_MW08 during 2014 reported TRH compounds below the laboratory LOR.

Copper, nickel and zinc were detected at concentrations greater than the laboratory LOR in a number of monitoring wells across the AEC, with copper, nickel and zinc exceeding the adopted ecological screening values and nickel detected above the NHMRC (2011) ADWG value.

Discussion

It is noted that a sweet odour was reported at EF_MW08 with one sample being collected at 1.2 m bgl and analysed for VOCs. This sample was chosen at this depth based on the presence of the highest PID screening value. Furthermore, odours were not reported within the drilled profile beyond 1.2 m bgl and viable deeper samples could not be collected due to the geological conditions and the use of solid flight augers. Given the absence of VOCs within the sample analysed, the presence of a sweet odour at EF_MW08_1.2 is not considered to represent a broader contamination issue. This is further supported by the absence of organic contamination in groundwater at this location (including volatile fraction TRH).

Groundwater monitoring well EF_MW01, EF_MW04 and EF_MW08 were sampled during the 2014 event to assess TRH and VOC compounds within groundwater. All results were reported below the laboratory LOR indicating the absence of significant hydrocarbon or VOC impacts in this area.

Measured concentrations of metals in groundwater marginally exceeded the ecological screening values and NHMRC (2011) ADWG values in a number of wells across this AEC. The metal concentrations measured in these wells are however generally consistent with those identified in up gradient wells (e.g. EJ_MW05) and are therefore considered likely to be reflective of background conditions.

Zinc was detected in all of the groundwater monitoring wells at concentrations in excess of the adopted ecological screening values. Similar results were also recorded in up gradient wells (e.g. EJ_MW05). On this basis, these results are also considered likely to reflect background conditions and are not attributed to the former operation of the northern gas turbine area.

The ecological screening values were adopted to evaluate potential risks associated with the potential discharge of groundwater into Muddy Lake (a freshwater ecosystem) which drains into Lake Macquarie (a marine ecosystem), where it may affect aquatic organisms. Metal impacts within Lake Macquarie and its tributaries are discussed in *Section 5.5.7.*

5.5.7 *Area EG - Whiteheads Lagoon, Return Water Dam, Crooked Creek, Drainage Channels & Lake Macquarie Sediments & Surface Water*

Background

The potential exists for the sediments and surface waters of Lake Macquarie and its tributaries to have been impacted by the historic operations of the Power Station.

Historic groundwater and surface water monitoring indicates that seepage from the CCPMF is saline and contains elevated concentrations of heavy metals and selenium. It is understood that prior to 1991, CCPMF seepage was discharged directly into the surface water features Crooked Creek and Whiteheads Lagoon. Emergency overflow can still be potentially discharged to Crooked Creek (from the Return Water Dam (refer to *Annex O*). The potential also exists for groundwater discharges to affect conditions within offsite surface water bodies.

AEC Methodology and Investigation Field Observations

Aquatic sampling was undertaken to target potential contamination from cooling discharges or other potential instances of offsite migration of contaminants from the Site in two aquatic zones, including:

- within Whiteheads Lagoon down-gradient from the southern boundary of the Site, including within Crooked Creek (one of the potential transmission pathways) and Myuna Bay (a potential depositional zone); and within Lake Macquarie, an area beyond the high energy of the outlet canal (potential depositional zone), including allocation of "unaffected" control sites further away.

Sediments and surface waters were also collected from physiographically similar 'reference' locations within Bonnells Bay for comparative purposes.

The investigation locations were comprised of areas close to (creek), near (lagoon) and far from (bay) discharge points. Sediment sampling was also undertaken from the bed of the Return Water Dam, located south and perceived down hydraulic gradient of the CCPMF.

A review of the topography of the Site indicates that Lake Eraring falls within a separate sub-catchment to the vast majority of the Power Station infrastructure and lands (with the exception of a portion of the attemperation reservoir). Therefore any potential impacts within Lake Eraring may be from either onsite or offsite sources.

Sediment samples were collected from the base of four drainage channels on Eraring land to the north of Wangi Road which drain to Lake Eraring, to allow for assessment of potential impacts to Lake Eraring from the Site, with a lower chance of confounding effects associated with external sources. These results are reported in *Section 5.5.10.*

A summary of the field observations from the sediment sampling are presented within *Table 5* of *Annex B*. Surface water field parameters are presented in *Table 3b* of *Annex B*. All surface water samples collected from recreational receptors in Whiteheads Lagoon and Lake Macquarie were within the prescribed pH range of 6.5 to 8.5 with the majority of these surface water samples reporting a Dissolved Oxygen (DO) concentration of greater than 80%. It is noted that DO concentrations ranged between 58.3% to 110.7% with an average concentration of 83%.

The surface water samples were filtered in the laboratory prior to metals analysis. ANZECC (2000) states that the major toxic effects of metals are associated with the dissolved fractions and that it is preferable to compare filtered surface water data against the trigger values.

Sediment Analytical Results

The sediments were analysed for grain size, phenols, TRH, BTEX, PAHs, PCBs and metals. The sediment analytical results were compared to the ANZECC (2000) ISQG-Low and ISQG-High values and the SRC_{eco} and the SRC_{human} (RIVM 2001). The sediment analytical results compared to the adopted screening values are presented in *Table 4l of Annex B*.

A number of laboratory LOR non-conformances were identified within this AEC, however these are not considered to affect the outcomes of the investigation (refer to *Section 5.5* for further discussion). Exceedences of the adopted screening values are also graphically presented in *Figures 6.3 and 6.4 of Annex A*.

Phenol, BTEX, and PCB concentrations were less than the LOR and the adopted screening values in all sediment samples analysed for these compounds. PAH concentrations marginally in excess of the LOR were identified in a large number of sediment samples but PAH concentrations in excess of the adopted screening values were not identified.

TRH concentrations marginally in excess of the LOR were identified in a large number of sediment samples however the measured concentrations did not exceed the ISQG-trigger value (550 mg/kg) provided in the Commonwealth of Australia (2009) *National Assessment Guidelines for Dredging*.

According to the ANZECC (2000) document, the ISQG values should be normalised to 1% TOC, to account for the reductions in bioavailability that can be associated with the presence of organic matter in sediment. Measured TOC values across the sampling area ranged between 0.1% and 7.9% TOC (*Table 4l* of *Annex B*); hence, across the majority of samples, the normalisation process would result in an increase in the ISQG values.

The TRH and PAH concentrations in the samples with measured TOC concentrations of <1% were sufficiently low that normalising the ISQG value to 1% did not result in an exceedence of the screening values. Arsenic, copper, and zinc concentrations exceeded the ISQG-Low values in nineteen, seven, and eight sediment samples respectively. The nickel concentration exceeded the ISQG-Low in two samples and the ISQG-High in one sample in Whiteheads Lagoon. There were no concentrations exceeding the SRC_{eco} or the SRC_{human} screening values.

In the absence of ANZECC and ARMCANZ (2000) screening values for selenium in sediment, the British Columbia Ministry of Environment (2001) *Ambient Water Quality Guideline* marine sediment screening value for selenium of 2 mg/kg has been adopted in this assessment. This value is designed to be protective of selenium bioaccumulation through the food chain and direct selenium toxicity. The measured selenium concentrations ranged from 0.1 to 42 mg/kg, with an average concentration of 2.4 mg/kg. The highest selenium concentrations of selenium were measured in samples collected from within Crooked Creek and the Return Water Dam.

Surface Water Analytical Results

The surface water samples collected from AEC EG were analysed for phenols, TRH, BTEX, PAHs, PCBs, and metals. The surface water analytical results were compared to the ANZECC (2000) trigger values for the protection of 95% of marine species and the NHMRC (2008) *Guidelines for Managing Risks in Recreational Waters*. The surface water analytical results compared to the adopted screening values are presented in *Table 4m* of *Annex B*.

A number of laboratory LOR non-conformances were identified within this AEC, however these are not considered to affect the outcomes of the investigation (refer to *Section 5.5* for further discussion). The concentrations of BTEX, TRH, PAH, and PCB constituents were less than the LOR in all surface water samples analysed. Phenols were detected in a small number of samples, but no phenol concentrations exceeded the guidelines.

Copper, lead, nickel, and zinc concentrations exceeded the ANZECC (2000) marine water trigger values in a small number of samples. There were no concentrations reported which exceeded the NHMRC (2008) *Guidelines for Managing Risks in Recreational Water*.

Discussion

<u>*Sediment*</u>

As noted in Simpson *et al.* (2005), the ISQG-Low represent concentrations below which the frequency of adverse biological effects is expected to be very low, while the ISQG-High represent concentrations above which adverse biological effects are expected to occur more frequently. If a detected concentration exceeds the relevant ISQG, it does not necessarily mean that adverse biological effects will occur, but rather that more detailed consideration of the results may be required.

The data collected for the key contaminants of concern for the aquatic sediments is broadly summarised in *Table 5.7*

Table 5.7 *Summary of sediment analytical results*

Area	Data	Concentration Ranges (mg/kg)							Sample IDs
		PAH	TRH C_{10}-C_{36}	As	Cu	Ni	Se	Zn	
Control (Bonnells Bay)	Min	<*LoR*	<*LoR*	3.6	2.1	<*LoR*	<*LoR*	5	EGCS01-04
	Max	0.6	68	25	128	13	2	231	
	>SL	0%	0%	33%	0%	0%	NA	0%	
Crooked Creek & Return Dam	Min	<*LoR*	3	1.1	<*LoR*	<*LoR*	0.4	1.3	EGSS9-10; EGSS18-20; EG23-26
	Max	0.2	188	27	27	16	42	47	
	>SL	0%	0%	33%	0%	0%	NA	0%	
Myuna Bay Near	Min	<*LoR*	<*LoR*	5	1.6	<*LoR*	<*LoR*	5.7	EGSS12-13 EGSS01-2
	Max	0.03	86	14	16	10	2	32	
	>SL	0%	0%	0%	0%	0%	NA	0%	
Myuna Bay Far	Min	<*LoR*	<*LoR*	3.02	<*LoR*	1.4	0.2	3	EGSS03-08; EGSS31-34
	Max	0.8	64	33	153	15	3	246	
	>SL	0%	0%	100%	60%	0%	NA	60%	
Whiteheads Lagoon (North)	Min	0.01	22	8	6	4	0.9	13.4	EGSC03-04; EGSS21-22; EGSS27-28
	Max	0.03	128	19	12	7	3	35	
	>SL	0%	0%	0%	0%	0%	NA	0%	
Whiteheads Lagoon (South)	Min	<*LoR*	<*LoR*	2.3	<*LoR*	<*LoR*	0.1	3	EGSS11; EGSS14-17; EGSS29-30
	Max	0.2	73	22	11	54	5	201	
	>SL	0%	0%	29%	0%	43%	NA	14%	

<LoR – less than laboratory Limit of Reporting
>SL – greater than the ANZECC (2000) ISQG-low screening values or the Commonwealth of Australia (2009) ISQG-trigger value for TRH

The ISQG-Low for arsenic is 20 mg/kg and the maximum arsenic concentration detected was 33 mg/kg. The highest concentrations exceedences were measured in the distant Myuna Bay samples and the arsenic results in the control samples (Bonnells Bay) were of the same order of magnitude as those measured in Crooked Creek and Whiteheads Lagoon. Similar spatial trends were noted for copper and zinc, with the highest analytical results and greatest concentrations of these metals measured in the Bonnells Bay and distant Myuna Bay samples.

These results suggest that it is unlikely that the elevated arsenic concentrations are linked to historical discharges to Crooked Creek or Whiteheads Lagoon. It is possible that urban and sewage inputs, in addition to outputs from power generation activities, have contributed to the widespread enrichment of sediments throughout this area with heavy metals (Kirby *et. al.*, 2001, Lake Macquarie City Council, 1995). Metal concentrations naturally present in regional soil and groundwater may also contribute to the observed metal impacts in sediment.

The maximum nickel concentration of 54 mg/kg measured at the southern end of Whiteheads Lagoon (in EG_SS15_0.5) only marginally exceeds the ISQG-High of 52 mg/kg. The other two samples collected at this location (at 0.25 m bgl and 0.75 m bgl) reported nickel concentrations in excess of the ISQG-low values. The other samples collected within Whiteheads Lagoon reporting nickel concentrations of a similar order of magnitude to the control locations. Given that elevated nickel concentrations have been identified in groundwater collected down-gradient of the CCPMF, these nickel impacts may be associated with the operation of the CCPMF and/ or the historical operation of the Wangi Ash Dam. These results do not however suggest that historical discharges to Whiteheads Lagoon have resulted in widespread nickel impacts.

As noted in the Preliminary ESA (ERM, 2013a), selenium concentrations in surficial sediments are expected to be related to fly ash from the power station, including the direct release of seepage from the CCPMF into Crooked Creek prior to 1991 (Nobbs *et al.* 1997, Kirby *et. al.*, 2001, Lake Macquarie City Council, 1995).

Selenium concentrations measured in sediment samples collected from the Return Water Dam (EG_SS23-26, 5 - 42 mg/kg) were significantly higher than those measured in the other sampling locations. Similarly, the selenium concentrations measured in the sediment samples collected from Crooked Creek (EG_SS09-10, 0.6 - 6.3 mg/kg; EG_SS18-20, 0.4 to 18 mg/kg) were generally higher than those measured in other sampling areas.

It is noted that Eraring Energy holds Environmental Protection Licenses (EPL) 1429, issued under Section 55 of the Protection of Environment Operations (POEO) Act. This licence to operate requires the monitoring of water discharges, ambient water quality in Lake Macquarie and water discharges from the CCPMF to the outlet canal. The EPL does not include a requirement to monitor groundwater conditions at the Site, however it is understood that Development Consent conditions for the CCPMF include a requirement for ongoing groundwater monitoring. It is noted that the licenced discharges under the POEO Act do not directly alter any of the requirements under the CLM Act (1997).

The Return Water Dam is part of the contaminated water management system at the Site. Emergency overflow from the CCPMF can also be discharged to Crooked Creek via a weir. As such, the return Water Dam and Crooked Creek receive discharges as a part of the licensed contaminated and waste water management system at the Site. On this basis, the Return Water Dam and Crooked Creek are considered likely to be impacted as a result of these licensed operations.

Moderately elevated selenium concentrations were also detected in a number of the sediment samples collected from the southern end of Whiteheads Lagoon (up to 5 mg/kg). Seepage impacts to Crooked Creek and to a lesser extent Whiteheads Lagoon, do not however appear to have translated into elevated selenium concentrations within Myuna Bay, with selenium concentrations measured in Myuna Bay sediment samples being of the same order of magnitude as those measured in the Control locations.

TRH and PAH constituents were detected in sediment samples collected from throughout the sampling area at concentrations below the adopted screening values. No clear trend was apparent between the different sampling areas, with the samples collected from Bonnells Bay and Myuna Bay reporting results of a similar order of magnitude to those collected from Whiteheads Lagoon and Crooked Creek. These results suggest that a range of activities may have contributed to the TRH and PAH impacts measured within the sediment, potentially including a range of current and historic urban and industrial inputs and recreational boating activities. It is noted that petroleum hydrocarbons and PAHs are common components of uncombusted petroleum products or incomplete combustion of fuel products in exhaust emissions from two stroke or four stroke outboard and inboard boat engines (van Dam, Camillieri and Turley, 1998). These historical urban and industrial inputs would be in addition to potential outputs from power generation activities. In either case, concentrations of both TRH and PAH constituents identified were below the adopted screening values.

Sediment samples were collected from the base of four drainage channels on Eraring land to the north of Wangi Road, which drain to Lake Eraring, to allow for assessment of potential impacts to Lake Eraring from the Site. Contaminants were reported at concentrations below the adopted screening values in these samples (*Section 5.5.10*), suggesting that the impact of the Site on Lake Eraring is unlikely to be significant.

Surface Water

Copper was reported at concentrations in excess of the adopted ecological screening level in a number of samples collected from Crooked Creek and the Return Water Dam. However, copper concentrations in surface water in Whiteheads Lagoon and Myuna Bay met the screening values, as did copper concentrations in sediment in Crooked Creek. Copper concentrations in surface water were however generally low, at <5 μg/L in all samples, relative to a screening level of 1.3 μg/L.

Zinc concentrations ranged from <5 to 254 μg/L, exceeding the screening level of 15 μg/L in a number of the surface water samples. A large number of zinc exceedences were recorded in Myuna Bay and the zinc concentrations in Myuna Bay were comparable to those at the reference locations in Bonnells Bay. This result is consistent with what was observed in the sediments and suggests that the zinc concentrations measured in Myuna Bay may be representative of conditions throughout the area.

The highest surface water zinc concentrations were recorded in Crooked Creek, immediately down-gradient of the CCPMF, which suggests that the operation of the CCPMF may contribute to these impacts. Elevated zinc concentrations have also been recorded in groundwater collected from down-gradient of the CCPMF (*Section 5.5.1*). Measured zinc concentrations in surface water from the lower reaches of Crooked Creek were however consistent with those in the broader study area.

Nickel exceeded the ecological screening level in one sample, EG_SS18, located in Crooked Creek but widespread nickel impacts to surface water were not identified.

No ANZECC (2000) marine water quality guideline is available for selenium but the ANZECC (2000) trigger value for the protection of 95% of freshwater species is 11 μg/L. The most elevated selenium results (up to 94 μg/L) were detected in the surface water samples collected from Crooked Creek and the Return Water Dam, with selenium reported at or near the LOR in the other sampling areas. This result is consistent with what was observed in the sediment results and suggests that selenium seepage impacts to Crooked Creek do not appear to have translated into elevated selenium concentrations within Myuna Bay.

Surface water impacts to the Return Water Dam and Crooked Creek would be expected, on the basis of licensed discharges from the CCPMF. The licence to operate held by the Site (EPL 1429) includes a requirement to monitor ambient water quality in Lake Macquarie and water discharges from the CCPMF. It is noted that the licenced discharges under the POEO Act do not directly alter any of the requirements under the CLM Act (1997).

55.8 *Area EH - Coal Storage Area*

Background

The coal storage area occupies an area of approximately 25 ha and is used for stockpiling of coal prior to transfer via conveyor to the boilers (refer to *Figure 3.1* and 3.7 of *Annex A*).

Potential contamination sources identified within this AEC include the refuelling of equipment (bulldozers) used to move coal, and contaminated stormwater runoff from this area which is captured in the 'Dirty Water' collection/treatment system (known as the 'Boomerang' and 'Sausage' retention ponds). These retention ponds are understood to be lined with reclaimed, natural clays of low permeability. The retention ponds are also cleaned out on a regular basis and the fines collected are deposited in the CCPMF.

There have been no historic soil or groundwater investigations undertaken within this AEC (ERM, 2013a).

AEC Methodology and Investigation Field Observations

Sampling was conducted in this AEC to target potential contamination of soil and groundwater associated with leaching of contaminants from stockpiled coal, contaminated water lines and retention ponds. A total of 10 groundwater monitoring wells were advanced within this AEC between 25 July 2013 and 19 August 2013.

Investigation locations were distributed around the perimeter and within the coal stockpile area including specific locations targeting leaching of contaminants from stockpiled coal, contaminated water lines and retention ponds. Specific targeted locations are detailed in *Table 1a* of *Annex B* and graphically presented in *Figure 3.1* of *Annex A*. Borehole logs are presented is *Annex D*. Site inspections and a review of as built drawings provided by Eraring Power Station confirmed the locations and depth of contaminated water drainage lines to the west of the coal stockpile area. As a result, groundwater monitoring wells in these locations were advanced to a minimum depth of 7.8 m bgl to assess a potential release from the base of the drainage lines.

No field indicators of contamination, such as staining, odours or stressed vegetation were noted, with the exception of a hydrocarbon odour and staining observed from 0.1-0.7 m bgl within EH_MW07, on the north western perimeter of AEC EH. Measured concentrations of ionisable volatile compounds via headspace analysis were noted not to exceed 6.4 ppm (isobutylene equivalent) in any soil samples collected from this AEC.

During the 2013 sampling event, it was noted that an insufficient volume of groundwater was available for collection from within EH_MW02 to facilitate the laboratory analysis of a full suite of compounds as specified in the SAQP. As such, laboratory analysis was completed for TRH and BTEX only. Subsequent analysis on EH_MW02 (conducted as part of the 2014 sampling event) was completed for perflurochemicals (including PFOS and PFOA).

groundwater within the operational area identified some concentrations above laboratory LOR however these concentrations were not observed in monitoring wells down-gradient of the operational area (and adjacent to receptors). The source of the PFCs at AEC EH is unconfirmed and no potential sources were observed during the investigations. A review of surface water interactions and sub-catchments within the site identified AEC EH as potentially receiving some surface flows from the fire training area and/or some surface water via the conveyor M1 silt trap (which drains to the "sausage pond" (refer to *Annex P*)), noted to be adjacent to EH_MW01. However, given the magnitude of concentrations and the location of EH_MW01 and the management of waste water within the sausage pond to the CCPMF, the risk to human health or the environment is not considered to be significant.

Subsequent resampling of monitoring well EH_MW10 during the Additional Stage 2 ESA reported a reduction in the concentration of PFOS with 0.17 μg/L measured (which is below the adopted drinking water criteria). Monitoring well EH_MW02 is located 240 m down-gradient (south) of EH_MW10 and is screened within the same aquifer (shallow) and reported PFCs below the laboratory LOR. During the Additional Stage 2 ESA, a number of surrounding monitoring wells (either down-gradient or cross-gradient) were also analysed for PFOS (including EB_MW04, EB_MW07 EH_MW08, EH_MW09, EC_MW11, EC_MW12 and EC_MW13). All these monitoring wells reported PFOS and PFOA below the laboratory LOR and below the adopted site screening value. Based on the isolated nature of the PFOS detection and the confirmed concentrations in both EH_MW10 and EH_MW01, the risk to human health and the environment is not considered to be significant. Furthermore, based on the data collected from the monitoring wells sampled, it is considered that the potential presence of a significant perfluorochemical issue in groundwater within AEC EH is unlikely.

5.5.9 *Area EI – Accessible Operational Area*

Background

AEC EI covers the operational area of the Power Station. Sampling was conducted within the operational area using a grid based sampling approach of accessible areas, excluding hazardous operational areas. Targeted locations were also installed to assess potential areas of concern, including the contaminated water drainage network (or CWS), workshop areas, storage sheds/containers, USTs, ASTs, fuel pipelines and AFFF storage. The ground surface of this AEC is comprised of a combination of compacted gravel overlying fill, vegetated (decorative garden) areas and concrete roads. The AEC is largely used for container storage, workshops and general support and administrative activities related to the primary operational areas of the power station.

AEC Methodology and Investigation Field Observations

During the initial Stage 2 ESA, a total of 80 soil bores were advanced within AEC EI. Fourteen of these soil bores were subsequently converted to monitoring wells to provide spatial coverage and to target potential areas of concern based on field observations and discussions with Eraring Power Station site personnel. During the Additional Stage 2 ESA a further twelve soil bores were advanced (as agreed with Origin and AECOM to target the CWS (and associated pits), down-gradient southeastern corner of the operational area and to delineate elevated metals impacts identified at EI_SB77 during the initial Stage 2 ESA).

Three of these soil bores were converted to groundwater monitoring wells to assess groundwater quality (in conjunction with the previously installed wells). The additional soil bore (and monitoring well) locations were agreed with Origin (and AECOM) prior to commencement of mechanical drilling. The scope completed as well as documented deviations and agreements of the changes is presented in *Table 1b* of *Annex B*. This table also presents (by location), the rationale and targeted site feature.

No field indicators of contamination, such as staining, odours or stressed vegetation were noted on the ground surface. Odours were detected at four locations within this AEC as summarised in the table below. No further staining or significant odours were detected throughout the soil profile within the operational area. A slight hydrocarbon odour was detected between 2.0 m bgl and 2.4 m bgl at EI_SB104. Other odours detected during drilling works included a sewage like odour at 1.2 m bgl at EI_SB41/MW05, an organic odour at 1.6 m bgl at EI_SB48/MW06 and a hydrogen sulfide odour at EI_SB71/MW12. Maximum concentrations of ionisable volatile compounds via headspace analysis were noted to be 36.1 ppm at EI_SB71 (isobutylene equivalent). This borehole was converted into a monitoring well, EI_MW12 and a H_2S odour was detected as this borehole was advanced.

Due to site hazards (high vehicle traffic areas) and the presence of underground services, it was necessary to initially abandon thirty locations within AEC EI (0207419L04 dated 30 August, 2013). Subsequent soil bores and monitoring wells were placed (in agreement with Origin and AECOM) to address any potential data gaps identified after the initial Stage 2 ESA including targeting the CWS (to depth) and the down-gradient edge of the operational area. The locations of the soil bores and monitoring wells are considered to adequately assess soil and groundwater conditions in this area.

Competent bedrock (comprising sandstone and conglomerate) was encountered at a depth of less than 0.5 m bgl at a number of locations in this AEC. As such, the ability to collect soil samples from these locations was limited during the initial Stage 2 ESA as it became necessary to utilise rotary air hammer drilling techniques. Subsequent drilling conducted as part of the Additional Stage 2 ESA utilised sonic drilling methodologies (audio frequency), whereby continuous core sampling was available for the boreholes completed (including advancing through the conglomerate encountered.

A summary of the field observations from the drilling works are presented within *Table 5.9.*

Table 5.9 ***Field Observations Summary***

Borehole ID	Depth (m bgl)	Visual or Olfactory Evidence	PID Range (ppm)
EI_SB01	0.6	None	0.1
EI_SB02	1	None	0.2 to 0.6
EI_SB03 / MW07	8.3	None	0.1 to 0.6
EI_SB04	0.75	None	0.5 to 6.7
EI_SB05 / MW08	9	None	0.1 to 0.8
EI_SB06	0.25	None	1.6
EI_SB08 / MW09	7.5	None	0.2 to 1.0
EI_SB09	0.3	None	0.5
EI_SB11	0.65	None	1.0
EI_SB12	0.4	None	0.2
EI_SB14	1.1	None	0.4 to 0.6
EI_SB15	1.3	None	0.1 to 0.2
EI_SB17	0.8	None	0.2 to 0.5
EI_SB18 / MW02	8	None	0.1 to 0.5
EI_SB20	1.2	None	0.3 to 0.9
EI_SB21	1	None	0.3 to 0.4
EI_SB23	0.9	None	0.4 to 1.1
EI_SB24	2.15	None	0.2 to 0.4
EI_SB26	0.5	None	0.7
EI_SB27 / MW03	6.5	None	0.1 to 0.7
EI_SB28	0.3	None	0.1
EI_SB29	0.75	None	0.1 to 0.3
EI_SB31 / MW04	8	None	0.1 to 0.8
EI_SB32	0.75	None	0.0 to 0.1
EI_SB33	0.25	None	0.4 to 0.6
EI_SB35	0.8	None	0.1 to 0.2
EI_SB36	1	None	0.5 to 0.6
EI_SB38	1	None	0.1
EI_SB39	0.5	None	0.5 to 0.7
EI_SB41 / MW05	8.1	Sewage like odour at 1.2 m bgl	0.1 to 0.9
EI_SB42	1.4	None	0.3 to 0.6
EI_SB43	0.65	None	0.8
EI_SB44	0.75	None	0.8 to 0.9
EI_SB45	1.3	None	0.2 to 1.0
EI_SB46	0.6	None	0.3 to 0.4
EI_SB47	1.3	None	0.3 to 0.4

Borehole ID	Depth (m bgl)	Visual or Olfactory Evidence	PID Range (ppm)
EI_SB48 / MW06	3.5	Organic odour at 1.6 m bgl	0.0 to 0.9
EI_SB49	1.7	None	0.7 to 0.8
EI_SB50	0.9	None	0.6
EI_SB51	0.5	None	0.8 to 0.9
EI_SB52	0.55	None	0.0 to 0.2
EI_SB53 / MW01	8	None	0.1 to 0.5
EI_SB54	0.6	None	Not Sampled
EI_SB55 / MW13	9	None	0.1 to 0.8
EI_SB56	0.77	None	0.7 to 0.8
EI_SB57	3	None	0.1 to 0.2
EI_SB58	3	None	0.1 to 0.8
EI_SB59 / MW10	5	None	0.0 to 0.4
EI_SB63	0.65	None	0.0 to 0.1
EI_SB64	0.8	None	0.0
EI_SB65	3	None	0.0 to 0.1
EI_SB66	1.5	None	0.0 to 1.1
EI_SB67	3	None	0.7
EI_SB68	3	None	0.1 to 1.0
EI_SB69	1	None	0.0 to 0.1
EI_SB70	3	None	0.0 to 0.2
EI_SB71 / MW12	7	H_2S odour at 6.0m bgl	0.1 to 36.1
EI_SB72	0.4	None	0.1
EI_SB73 / MW11	3	None	0.2 to 0.8
EI_SB74	0.7	None	0.1
EI_SB75	0.5	None	0.2
EI_SB76	0.5	None	0.4
EI_SB77	0.45	None	0.1
EI_SB78	0.55	None	0.0
EI_SB79	0.65	None	0.1
EI_SB80	0.2	None	0.1
EI_SB81	0.3	None	0.1 to 0.3
EI_SB82	0.3	None	0.0 to 0.1
EI_SB83	0.5	None	0.0
EI_SB84	1.3	None	0.0 to 0.1
EI_SB85	2.2	None	0.0 to 0.2
EI_SB86	0.7	None	0.0 to 0.1
EI_SB87	1.9	None	0.0 to 0.2
EI_SB88	0.33	None	0.1
EI_SB89	1.42	None	0.0 to 0.1
EI_SB90	3.9	None	0.0 to 0.1
EI_SB91	0.65	None	0.0 to 0.1
EI_SB92	1.35	None	0.0 to 0.2
EI_SB93	1.25	None	0.0 to 0.1
EI_SB94 / MW14	5	None	0.0 to 0.3
EI_SB95	4	None	0.5 to 3.9
EI_SB96	4	None	0.1 to 4.6
EI-SB97	4	None	0.0 to 1.5
EI-SB98	4	None	0.0 to 0.9
EI_SB99	4	None	1.3 to 2.2
EI-SB100	4	None	0.7 to 6.9
EI_SB101	4	None	0.4 to 1.7
EI_SB103	4	None	0.0 to 1.2
EI_SB104	4	None	0.0 to 6.0

Borehole ID	Depth (m bgl)	Visual or Olfactory Evidence	PID Range (ppm)
EI_MW15	6.7	Slight hydrocarbon odour noted from 2 to 2.4 m bgl	0.1 to 4.3
EI_MW16	5.9	None	0.6 to 1.9
EI_MW17	7	None	0.0 to 0.7

Soil Analytical Results

The soil analytical results are compared to the adopted human health and ecological screening values as presented in *Table 4q of Annex B*. Exceedences of the adopted screening values are also graphically presented in *Figures 6.1 and 6.2 of Annex A.*

Concentrations of BTEX, phenols, VOCs and PCBs were reported below the corresponding laboratory LOR for all soil samples analysed within this AEC. There were a number of detections of TRH above the LOR in soils, however there were no reported exceedences of the adopted screening values. Measured concentrations of benzo(a)pyrene were reported above the adopted ecological screening values for commercial/industrial areas, within five of the samples analysed across this AEC. All of these exceedences were detected in shallow soils between 0.1 and 0.3 m bgl.

Potential asbestos containing material was observed at the surface in one soil bore (EI_SB23) collected from this AEC. This was in the form of degraded fibre sheeting, (which would be categorised as asbestos fines). Laboratory analysis of this sample confirmed that asbestos fibres (chrysotile) were present in a degraded bonded (friable) state. All remaining soil samples analysed for asbestos within this AEC returned negative results for the presence of asbestos fibres.

Measured concentrations of nickel exceeded the AEC specific EILs for commercial/industrial areas (aged) at 38 locations while a further 12 locations exceeded the AEC specific EILs for zinc. In general these were marginal exceedences, at less than 250% of the adopted levels. A number of minor exceedences were also noted for arsenic and copper, marginally above the AEC specific EILs. One exception to this was EI_SB77 (at a depth of 0.15 m); at this location, measured concentrations of arsenic, copper, nickel and zinc significantly exceeded the adopted levels. Measured concentrations of lead also exceeded the human health screening level (HIL 'D'). Zinc was also reported at a concentration above the adopted EIL in the soil sample collected from EI_MW16 (and associated duplicate samples) at 0.2 m bgl during the Additional Stage 2 ESA. Nickel was also reported marginally above the EILs in a number of samples collected during the Additional Phase 2 ESA.

Concentrations of PFOS above the laboratory LOR were detected in the soil samples collected from EI_SB72 and EI_SB77 (both at 0.15 m bgl) however both concentrations were significantly below the adopted screening value for human health.

Groundwater Analytical Results

Groundwater quality field parameters are presented in *Table 3a* of *Annex B* and groundwater analytical results compared to the adopted site screening values (including freshwater and marine ecosystem specific values) are presented in *Table 4p of Annex B*. Exceedences of the adopted screening values are also graphically presented in *Figures 6.3 and 6.4 of Annex A*.

A number of laboratory LOR non-conformances were identified within this AEC, however these are not considered to affect the outcomes of the investigation (refer to *Section 5.5* for further discussion). The LOR achieved for vinyl chloride during the initial Stage 2 ESA was greater than the adopted screening values subsequent ultra-trace analysis conducted on samples collected during the Additional Stage 2 ESA. Tetrachlorethene was detected at two locations (EI_SB94/EI_MW14 and EI_MW16) from this AEC. Whilst the anaerobic reductive dechlorination of tetrachloroethene can result in the release of vinyl chloride into groundwater, concentrations of vinyl chloride from samples collected during the subsequent 2014 sampling event were below the laboratory LOR.

Concentrations of BTEX, phenols and PCBs were not detected above the laboratory LOR in groundwater samples analysed from within this AEC with the exception of EI_MW05 which reported a minor detection of phenols. Concentrations of TRH, PAHs and some VOCs (including tetrachloroethene, trichloroethene, chloroform and trihalomethanes), were detected above the laboratory LOR in a number groundwater samples collected from within this AEC. The measured concentrations were below the adopted human health and ecological screening values with the exception of EI_MW09 which reported BaP, benzo(g,h,i)perylene and BaP TEQ above the ecological (marine) or recreational guidelines. Subsequent re-analysis of EI_MW09 (during the 2014 sampling event) utilising super ultra-trace PAH laboratory methods report detections of these compounds however concentrations were below the adopted site value.

Arsenic, cadmium, copper, lead, nickel, selenium and zinc were detected at concentrations greater than the LOR in a number of wells across the AEC. Arsenic and nickel concentrations exceeded the NHMRC (2011) ADWG values in a number of individual wells. Measured concentrations of cadmium, copper, nickel and zinc exceeded the adopted ecological screening values in groundwater samples collected from across this AEC.

PFOS and PFOA were detected in a number of groundwater samples collected during the 2013 and 2014 sampling events. All concentrations of PFOS and PFOA were below the adopted human health or ecological criteria with the exception of EI_MW01 (2014), EI_MW02 (2013, 2014), EI_MW04 (2014) and EI_MW17 (2014) which reported concentrations of PFOS above the adopted drinking water criteria.

Discussion

The works completed within EI were deemed sufficient to meet the objectives of the Stage 2 ESA. In locations where bores could not be advanced due to infrastructure, then relocation was assessed with consideration for other existing sampling points and achieving spatial coverage.

Bores were relocated if they were in close proximity to an existing location, to prevent unnecessary 'doubling up' of effort. Given the contaminant concentrations detected in this area and the subsequent additional intrusive works undertaken as part of the Additional Stage 2 ESA, significant data gaps were not considered to be present. Advancement of soil bores beyond the previous termination depths (where shallow bedrock was encountered) was completed utilising sonic drilling methods to enable adequate inspection of the drilled profile below the documented depths of the CWS and to facilitate collection of relatively undisturbed soil samples. Field observations of potential contamination (including olfactory, PID, colouration and staining indicators) were not identified within the soil bores advanced to target the CWS. Corresponding soil samples further supported the absence of a leaking CWS. A slightly elevated PID measurement of 36.1 ppm v (isobutylene equivalent) was identified at EI_SB71 however corresponding TRH, BTEX and VOCs results were below the laboratory LOR.

Benzo(a)pyrene was detected in soils during the initial Stage 2 ESA within AEC EI at concentrations exceeding the ecological screening level adopted from the ASC NEPM (2013). The 95% UCL calculated for benzo(a)pyrene in AEC EI was, however, found to comply with the screening level (refer to *Annex J*). Additional analysis conducted within AEC EI during the subsequent Additional Stage 2 ESA did not identify BaP impacts within the soil bores completed. As this is an industrial area which is not of ecological significance, minor exceedences of the adopted ecological levels are not considered to be cause for concern.

Metals were detected in soils at a number of locations across this AEC during both the 2013 and 2014 sampling works, however in general, the concentrations detected were <250% of the EILs. The 95% UCL calculated for nickel in AEC EI for samples collected during both the Initial and additional Stage 2 ESAs were found to comply with the screening level (refer to *Annex J*).

The 95% UCL calculated with the initial Stage 2 ESA data for zinc in AEC EI (not including EI_SB77), was also found to comply with the screening level (refer to *Annex J*). As previously stated, AEC EI is generally covered with concrete hardstanding and as such metals impacts are not considered to represent a significant risk to the terrestrial environment. The one exception to this was EI_SB77 where more elevated concentrations of metals were detected including an unusually high detection of zinc (26,300 mg/kg), exceeding the EIL. The measured concentration of lead in this sample was also high, exceeding the HIL-D screening value for direct contact. Both these metals were identified within the sample collected from 0.15 m bgl. This area is used by contractors for placement of demountable site sheds which are unlikely to be the source of this impact.

The ground surface is compacted gravel overlying fill. Previous use for this land for storage of metal is considered to be a possible source of this impact. It is also noted that there was anecdotal evidence of a laboratory within one of the demountable buildings. Activities within this laboratory may also present a source for the elevated metals. Additional soil bores in the vicinity of this bore were completed as agreed with Origin and AECOM in order to delineate the potential metals hotspot at EI_SB77. Soils bores advanced included EI_MW16 (directly adjacent and 8 m south or down-gradient), EI_SB98 (15 m northwest or up-gradient), EI_SB97 (32 m west) and EI_SB99 (45 m southwest). All soil boreholes (including these additional locations) did not report metals concentrations elevated to this extent. It is therefore suggested that, as previously anticipated, this is a localised hotspot of which the source is no longer present. Furthermore, there does not appear to be any significant migration of elevated metals concentrations in any direction from this location. These exceedences are not therefore considered to be cause for significant concern under the current conditions at the Site.+

It is noted that significant exposure to these metals may occur in the event that the overlying compacted gravel was removed or excavation of the area was undertaken. In line with industry best practice, the potential future human health risks could be managed through the implementation of an Environmental Management Plan (EMP) (refer to *Section 5.8.2*).

PFOS was detected in shallow soil samples collected from within this AEC. Human health screening values were not identified for PFOS in soil, however the US EPA Region 4 (2009[2]) has published a residential soil guideline for PFOS of 6 mg/kg.

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[2] EPA Region 4. 2009. *Soil Screening Levels for Perfluorooctanoic Acid (PFOA) and Perfluorooctyl Sulfonate (PFOS)*, Memorandum.

Although this value has no regulatory standing in Australia, it indicates that the maximum PFOS concentration detected within this AEC is unlikely to represent a significant risk to commercial/industrial workers at the Site. Furthermore, no known sources of PFCs were identified or observed during the completion of EI_SB72 and EI_SB77 where PFOS was detected in soil.

Groundwater monitoring well (EI_MW16) was installed directly adjacent to (and down-gradient) of EI_SB77. Concentration of metals within this well (and others within AEC EI (inferred down or cross gradient to EI_SB77) were not significantly elevated and consistent with those measured in other groundwater wells located within this AEC. It is therefore likely that the metal impacts measured in the shallow soil sample collected from EI_SB77 are not significantly affecting groundwater.

Metals concentrations in excess of the ecological screening values and NHMRC (2011) ADWG values were detected in groundwater across this AEC, however in general, the concentrations were <250% of these screening values. These concentrations were in same order of magnitude as samples collected across the remainder of the Site, which indicated that these results are consistent with background conditions. One exception to this was at EI_MW10, where zinc concentrations were noted to be in excess of 100 times the adopted ecological (freshwater) screening value. This well was installed in close proximity to a workshop. Based on a review of aerial photography, this workshop appears to be clad with galvanized steel roofing, which could potentially be a source for these elevated concentrations. Reanalysis of EI_MW10 during the Additional Stage 2 ESA identified elevated zinc concentrations approximately six times the ecological screening value.

As the groundwater in this area is brackish to saline and there are no groundwater extraction wells located in the vicinity of the Site, the groundwater is not a human health or ecological receptor in itself. The screening values were therefore adopted to evaluate potential risks associated with the potential discharge of groundwater into Muddy Lake (a freshwater ecosystem) which drains into Lake Macquarie (a marine ecosystem), where it may affect recreational users or aquatic organisms. Metal impacts within Lake Macquarie and its tributaries are discussed in *Section 5.5.7*.

Whilst groundwater is not used for potable supply, in the absence of a more appropriate guideline, health screening values of 0.2 µg/L and 0.4 µg/L for PFOS and PFOA respectively in groundwater have been adopted. These values are proposed by US EPA Office of Water Provisional Health Advisory (2009) and reflect reasonable, health based hazard concentrations above which action should be taken to reduce exposure to contaminants in drinking water (USEPA, 2014).

Concentrations of PFOS in EI_MW02, EI_MW01, EI_MW04 and EI_MW17 exceeded this screening value with the concentration of PFOS being an order of magnitude higher at EI_MW02 (7 µg/L) compared to other locations in AEC EI (which ranged from 0.04 µg/L - 0.7 µg/L). Concentrations of PFOS and PFOA were also detected in groundwater at up-gradient locations within AEC EH (EH_MW01 and EH_MW10). A potential source of PFCs within the AEC EI (or AEC EH) was not observed or identified during investigations however based on the distribution of PFCs within operational area, a separate unconfirmed source may have been present within the northeastern portion of AEC EI.

A holistic review of the broader Eraring Power Station operational area also shows one isolated detection of PFOA on the western side of the power block (EB_MW06) and detections of PFOS on the eastern side of the power block in monitoring wells near workshops (EC_MW09 and EC_MW15). A review of concentrations shows a general decrease of PFOS and PFOA from north to south with EI_MW13 and EI_MW17 (both furthest down-gradient of the operational area) reporting concentrations significantly less than those detections up-gradient within the operational area and in AEC EH (EH_MW01). Further review of PFOS and PFOA data in groundwater monitoring wells down-gradient (south and south west) and cross gradient (west and east) of the operational area did not identify any concentrations of PFOS or PFOA above the laboratory LOR. Based on the limited distribution across AEC EI, the magnitude and general trend of PFOS and PFOA concentrations, there is currently no evidence of off-site migration of these constituents. Ecological screening values were not identified for PFOA however a value of 7.2 µg/L (from RIVM MAC for marine ecosystems) was adopted for PFOS. All concentrations were noted to be below this screening value for protection of marine ecosystems.

A detection of tetrachloroethene (PCE) in groundwater was reported from monitoring wells EI_MW14 and EI_MW16 however the concentrations reported were significantly below the adopted screening values for the protection of human health and the environment. Based on the conceptual hydrogeological model presented in *Section 5.4*, there are no groundwater monitoring wells located immediately down-gradient of EI_MW14. The most directly down-gradient monitoring well is EI_MW12 on the southern edge of the power block. It is noted that the measured concentrations of all VOCs in the groundwater sample collected from this monitoring well were below the laboratory LOR. The most directly down-gradient monitoring wells from EI_MW16 are EI_MW11 (100 m south), EE_MW02 (220 m South South West (SSW)), EE_MW06 (255 m SSW) and EE_MW05 (270 m SSW). These monitoring wells all reported concentrations below the laboratory LOR for VOCs.

It is acknowledged that minor detections of TCE and PCE were identified at EI_MW14 and EI_MW16, noting that EI_MW15, located in between these locations, reported results below the laboratory LOR for VOCs. Whilst it is noted that minor detections of VOCs in groundwater were encountered within the operational area adjacent to workshops, based on the distribution and magnitude of detections, a broader, significant VOC issue is unlikely to be present.

Degradation products (including vinyl chloride) were also below the laboratory LOR and screening values within these monitoring wells. Concentrations of PCE were not detected at any other monitoring well locations, including those noted to be down-gradient of EI_MW14 and EI_MW16 such as EI_MW12 or EI_MW11 or those from other AECs in the operational area. It is further noted that the density of wells in this AEC was considered sufficient in providing spatial coverage, and identifying potential issues of material concern. Given the magnitude and isolated nature of the detections of PCE within AEC EI, based on the monitoring wells sampled, the presence of minor detections of VOCs is not considered to represent a broader VOC issue within groundwater in this AEC.

Asbestos fibres were detected in one sample of degraded fibre cement sheeting (collected at EI_SB23_0.1) from within this AEC. Based on the condition of the material analysed, it was classified as friable material.

Asbestos fibres were not detected in any of the remaining soil samples, and no other ACM fragments were observed or recorded for this AEC. Given the presence of asphalt hardstanding at this location and surrounding area, the current risk to human health is considered low and hence further assessment is not considered warranted based on the ongoing use of this area as a car park. Addition of the location and nature of this detection to the Site asbestos register is however recommended to facilitate suitable control of intrusive works which may occur in this area.

5.5.10 *Area EJ – Non-Operational Areas*

Background

This AEC is located around the perimeter of the Site and includes non-operational areas, not previously identified as part of the above-mentioned AECs. A significant portion of this AEC was comprised of remnant bushland, particularly surrounding the CCPMF, and at the western and eastern site boundaries. Areas immediately surrounding the operational areas were typically either paved or cleared.

This AEC also included the Attemperation Reservoir, and the spillway. Two large areas of formerly disturbed terrain were also located on the southern part of the site, shown as two cleared areas adjacent to the spillway and Attemperation Reservoir. This AEC also comprised several unsealed, internal roadways.

Sampling locations in this AEC largely sought to address potential on and off-site migration of contamination as well as targeting specific non-operational areas of the site, including:

- Sewage Treatment Works (Refer to *Figure 3.1* of *Annex A)*, including sludge and retention ponds. Sewage from both internal and external sources is treated in this area. Previous investigations have indicated elevated metals concentrations associated with this work area, however a soil bund to the north was considered effective in limiting off-site migration of contaminants through surface run-off. EJ_MW17 to EJ_MW20 targeted this area;

- Former Fire Training Area (Refer to *Figure 3.5* of *Annex A)* - Locations EJ_MW40, EJ_MW42 and EJ_MW43 targeted were installed to assess potential contamination associated with the use of accelerants (hydrocarbons) and AFFF;

- Current Fire Training Area (Refer to *Figure 3.1* of *Annex A*) - Locations EJ_SB45, EJ_MW55, EJ_MW56, EJ_MW57 and EJ_MW58 were installed as part of the Additional Stage 2 ESA to assess potential contamination associated with the use of accelerants (hydrocarbons) and AFFF;

- Attemperation Reservoir (Refer to *Figure 3.5* of *Annex A)* - Five existing monitoring wells were located around the perimeter of the Attemperation reservoir. These were sampled to assess the potential for seepage and off-site migration of saline water. During the Additional Stage 2 ESA, EJ_MW54 was also advanced directly to the west to target potential groundwater impacts associated with the Attemperation reservoir;

- Drainage Lines into Lake Eraring (Refer to *Figure 3.2* to *3.4* of *Annex A)* - Sampling at EJ_MW11, EJ_MW29, EJ_MW31, EJ_MW32, EJ_MW38, EJ_MW47 and EJ_MW49 targeted drainage channels flowing to Lake Eraring to assist in characterising potential off-site migration of contaminants (given the positioning of these wells in relation to the site boundary). Four surficial soil samples were also collected from this area;

- Main Cooling Water Pumping Station (Refer to *Figure 3.5* of *Annex A)* - One sampling location (EJ_MW12) was advanced down gradient of the pumping station;

- Cooling Towers (Refer to *3.5* of *Annex A)* - Two sampling locations (EJ_MW27 and EJ_MW28) were advanced down gradient of the pumping station;

- Fuel Oil Installation (Refer to *Figure 3.5* of *Annex A)* - Comprised of four 1,200,000 L steel ASTs installed in the early 1980s, and used for the storage of diesel and fuel oil. These ASTs supply fuel oil to the Gas Turbine, the bulldozer refuelling station, and various smaller ASTs across the site. Three sampling locations (EJ_SB41, EJ_SB42 and EJ_SB43) were advanced targeting material storage and areas of disturbed terrain;

- Substation (transmission) (Refer to *Figure 3.1* of *Annex A)* - Three locations (EJ_MW24 to EJ_MW26) were advanced to target potential contamination associated with the substation;

- Truck Washout Pits (Refer to *Figure 3.1* of *Annex A)* - These were previously observed to be in poor condition, with build-up of oil and waste at the base of the pits. Sludge from the contaminated water treatment system had also been dried out and then stockpiled on unsealed hardstand adjacent to the truck wash bays. Seven locations (EJ_MW13 to EJ_MW16, and EJ_MW21 to EJ_MW23) were installed to assess potential impacts associated with these pits. It is noted that waste material associated with these pits is disposed of around the CCPMF in rehabilitation areas as discussed in *Section 5.3.1;*

- Acid Sulfate Soils (Refer to *Figure 3.4* of *Annex A*) - Monitoring wells EJ_MW40 and EJ_MW41 were located at the northern and southern borrow pits. These locations targeted areas of recent soil disturbance to assess whether (ASS) conditions were created during these works. Field measurements were also collected at surface water locations, near areas of recent soil disturbance to assess potential impacts associated with ASS conditions; and

- Inlet Canal (Refer to *Figure 3.6* of *Annex A)* - Sampling locations (EJ_MW34 to EJ_MW37) target any impact associated with the inlet canal and submarine pipe.

The remaining sampling locations were located around the site perimeter as follows:

- EJ_MW01 to EJ_MW03 and EJ_MW05 to EJ_MW07 were located along the inferred up gradient site boundary and up gradient of operational site features;

- EJ_MW08 andEJ_MW09 were located down gradient of the CCPMF area;

- EJ_MW10, EJ_MW30 and EJ_MW33 were located down gradient of the sub-catchment divide, east of the operational area;
- EJ_MW47 and EJ_MW49 were located far down gradient of the operational area;
- EJ-MW50 and EJ_MW51 were installed to provide additional coverage on the down gradient site boundary of the CCPMF to better understand the extent and nature of potential contamination migrating off-site; and
- EJ_MW52 and EJ_MW53 are located within the Myuna Bay Sport and Recreation Centre to assess impact to off-site groundwater between Site and receiving off-site receptors.

Consideration was also given to locations adjacent to the Muddy Lake wetland, located to the west of the Site. Locations EJ_MW01 and EJ_MW02 were located on the western site boundary to assess the potential risk to this receptor and to provide up-gradient, reference data points. During the Additional Stage 2 ESA, EJ_MW04 and EJ_MW39 were advanced and installed along the up-gradient boundary (as agreed with Origin and AECOM) to provide additional western reference data points.

Based on the soil results of EJ_MW02 during the initial Stage 2 ESA, four additional soil bores were advanced in close proximity to EJ_MW02 to a maximum depth of 1.5 m bgl to target PFOS impacts identified in shallow soils.

Whilst it is acknowledged that AEC EJ is a proportionally large area of the site, given the combination of targeted and systematic sampling locations conducted, the ability to identify significant impacts (which would in turn influence the outcome of this investigation), was considered acceptable.

AEC Methodology and Investigation Field Observations

A total of three soil bores and 41 monitoring wells were advanced within this AEC during the initial Stage 2 ESA. Five soil bores and thirteen monitoring wells were advanced within this AEC as part of the Additional Stage 2 ESA. Two groundwater monitoring wells were initially abandoned (EJ_MW04 and EJ_MW39) during the first round of intrusive works however were successfully installed during the Additional Stage 2 ESA.

The purpose of these locations was to characterise conditions at the site boundary, and assess for potential ingress of contaminants from off-site sources or assess the potential for contaminants to be migrating offsite.

Four surficial soil samples (EJ_SS01 to EJ_SS04) were also collected from drainage channels leading to Lake Eraring. These samples were originally intended to be collected using push tube methods. On inspection of these channels, they were found to be dry with overgrown vegetation and a hand auger was therefore used to collect the samples.

Fourteen surface water monitoring points were also attempted as part of this investigation. Four surface water samples were proposed to be paired with sediment sample EJ_SS01 - EJ_SS04. However these surface water samples were not collected as the creeks were dry at the time of investigation. Soil samples were collected at these locations in lieu of sediment samples. The remaining ten surface water samples were attempted across AEC EJ (identified as Point 1 to Point 10 in *Figure 3.4* of *Annex A*), of which four locations had water and were sampled. Surface water monitoring was undertaken using a YSI multi-parameter water quality meter. The probes were held approximately 30 cm below the surface until readings stabilised. Field observations made during the surface water monitoring are be summarised as follows;

- Sampling Point 1 – The creek was found to be dry, hence field parameters could not be collected. No visual evidence of impact was observed.
- Sampling Point 2 – Surface waters were found to be clear, with no odour.
- Sampling Point 3 - The creek was found to be dry, hence field parameters could not be collected. No visual evidence of impact was observed.
- Sampling Point 4 - Surface waters were found to be clear, with no odour.
- Sampling Point 5 - The creek was found to be dry, hence field parameters could not be collected. No visual evidence of impact was observed.
- Sampling Point 6 - Surface waters were found to be clear, with no odour.
- Sampling Point 7 - Surface waters were found to be clear, with no odour.
- Sampling Point 8 – The creek was found to be dry, hence field parameters could not be collected. No visual evidence of impact was detected.
- Sampling Point 9 - The creek was found to be dry, hence field parameters could not be collected. No visual evidence of impact was observed.
- Sampling Point 10 - The creek was found to be dry, hence field parameters could not be collected. No visual evidence of impact was observed.

Field measurements recorded at these sampling points are provided in *Table 3b* of *Annex B*. Field indicators of potential impact are summarised in *Table 5.10* (below).

Organic odours were recorded in soil samples collected at several locations, however these were associated with the presence of organic matter in clay soils and are considered unlikely to reflect potential impact. There was no significant correlation between organic odours detected and the analytical data recorded for this AEC.

Dark brown colouration was observed within shallow road base fill (clayey sand and gravel) at location EJ_MW22 at a depth from 0 m bgl to 0.35 m bgl. Water ingress was observed within the borehole (between 0.9 and 1.6 m bgl) during drilling and a sheen was present at 0.9 m bgl. Measured concentrations of ionisable volatile compounds via headspace analysis were not recorded above 6.3 ppm (isobutylene equivalent) in all samples collected from this AEC however, and TRH were not detected in soil or groundwater at this sampling location. It is possible that the sheen observed was related to the presence of iron bacteria, which are micro-organisms which obtain energy by oxidising soluble ferrous iron into insoluble ferric iron. The presence of iron bacteria may be associated with a sheen (which unlike a hydrocarbon sheen will fragment when broken rather than reforming) and a "rotten" odour in soils and groundwater which may be related to the hydrogen sulfide like odour noted at this location during sampling. No sheen or odour was noted during sampling of EJ_MW22 as part of the Additional Stage 2 ESA.

Groundwater conditions encountered during the groundwater sampling works are summarised in *Table 3a* of *Annex B*. Hydrogen sulfide odours were detected at several locations (EJ_MW14, EJ_MW22, EJ_MW33, EJ_MW36 and EJ_MW37). No other field indicators of potential impact were detected for groundwater sampled.

Field pH readings collected from surface monitoring locations ranged from 2.88 to 8.25, with acidic conditions identified in surface water samples collected to the north of the Attemperation Reservoir. Acidic conditions were also identified in groundwater in the vicinity of the Attemperation Reservoir, inlet canal and southern Site boundary. These results are consistent with published acid sulfate soil information (www.asris.csiro/mapping/viewer.htm, accessed on 24 May 2013) which indicated that there was a high probability of encountering acid sulfate soils immediately to the south and west of the Site. Based on a review of aerial photography, parts these areas had been cleared of vegetation, and exposed soils suggested that earthworks had previously been undertaken in these areas. It is noted that these activities may have allowed oxidation of potential acid sulfate soil conditions, to create actual acid sulfate soil conditions in these areas.

Elevated salinity (as estimated by EC) was exhibited within monitoring wells adjacent to the outlet canal (EJ_MW12, EJ_MW34, EJ_MW35, EJ_MW26 and EJ_MW37). The elevated EC within groundwater at these locations is considered to be a function of the cooling water (originally extracted as salt water from the lake).

Table 5.10 *Field Observations Summary*

Borehole ID	Depth (m bgl)	Visual or Olfactory Evidence of Impact	PID Range (ppm)
EJ_SB44	1.5	None	0.2 to 0.4
EJ_SB45	1.2	None	0.7 to 1.1
EJ_SB46	1.5	Organic sulfur odour at 1.5 m bgl	0.4 to 0.9
EJ_SB47	1.5	Organic odour at 1.3 m bgl	0.2 to 0.6
EJ_SB48	1.5	Organic odour at 0.8 m bgl	0.1 to 0.3
EJ_SB49	1.5	Organic odour at 1.3 m bgl	0.2 to 0.5
EJ_MW01	10	None	0.3 to 0.6
EJ_MW02	8	None	0.7 to 2.7
EJ_MW03	3	None	0.0 to 0.3
EJ_MW04	15	None	0.5 to 1.7
EJ_MW05	7.5	None	0.0 to 0.2
EJ_MW07	8	None	0.0 to 0.2
EJ_MW08	8	None	0.0 to 0.2
EJ_MW09	6.3	None	0.0 to 0.8
EJ_MW10	5	None	0.0 to 0.2
EJ_MW11	7.2	None	0.0 to 0.2
EJ_MW12	4.5	None	0.0 to 0.2
EJ_MW13	5.9	None	0.0 to 6.3
EJ_MW14	5.7	Hydrogen sulfide odours detected.	0.1 to 5.2
EJ_MW15	5.8	None	0.0 to 2.3
EJ_MW16	6	None	0.0 to 1.6
EJ_MW17	5.5	None	0.0
EJ_MW18	21	None	0.4 to 4.2
EJ_MW19	18	None	0.1
EJ_MW20	5.1	None	0.7 to 0.9
EJ_MW21	7	None	0.1 to 3.0
EJ_MW22	5.5	Staining from 0 to 0.35 m bgl. Sheen detected on groundwater inflow at 0.9 m bgl (2013). No sheen observed in 2014. Hydrogen sulfide odours detected.	0.0 to 0.1
EJ_MW23	7	None	0.0 to 0.2
EJ_MW24	7	None	0.1 to 0.5
EJ_MW25	7	None	0.1 to 0.6
EJ_MW26	6	None	0.0 to 0.6
EJ_MW27	7	None	0.0 to 2.2
EJ_MW28	9	None	0.1 to 3.4
EJ_MW29	4	None	0.0 to 0.5
EJ_MW30	6.9	None	0.0 to 0.2
EJ_MW31	3	None	0.1 to 0.3
EJ_MW32	4.5	None	0.0 to 0.2
EJ_MW33	4	Hydrogen sulfide odours detected.	0.1 to 0.3
EJ_MW35	3.9	None	0.1 to 0.7
EJ_MW36	4	Hydrogen sulfide odours detected.	0.0 to 0.3
EJ_MW37	3.9	Hydrogen sulfide odours detected.	0.1 to 0.4
EJ_MW38	3	None	0.1 to 0.2
EJ_MW39	11	None	0.0 to 2.2
EJ_MW40	6.5	None	0.2 to 0.5
EJ_MW41	21.5	None	0.0 to 0.7
EJ_MW42	5.5	None	0.4 to 0.7
EJ_MW43	12	None	0.1 to 1.5
EJ_SB43 / EJ_MW44	12	None	0.7 to 0.8
EJ_SB42 / EJ_MW45	12.5	None	0.6

Borehole ID	Depth (m bgl)	Visual or Olfactory Evidence of Impact	PID Range (ppm)
EJ_MW47	10.9	None	0.4 to 1.5
EJ_MW49	7.5	None	0.5 to 1.7
EJ_MW50	9.5	None	0.2 to 2.3
EJ_MW51	18	None	0.4 to 2.0
EJ_MW52	2.8	None	1.2 to 1.8
EJ_MW53	3.5	None	1.1 to 1.4
EJ_MW54	8	None	0.0 to 1.1
EJ_MW55	13	None	1.0 to 3.1
EJ_MW56	13.5	None	0.0 to 0.6
EJ_MW57	10	None	0.0 to 0.2
EJ_MW58	5	None	0.0 to 0.4

Soil Analytical Results

The soil analytical results are compared to the adopted human health and ecological screening values as presented in *Table 4t of Annex B*. Exceedences of the adopted screening values are also graphically presented in *Figures 6.1 and 6.2 of Annex A*.

Soil analytical concentrations of TRH, BTEX, PAHs, phenols, VOCs and PCBs were reported below the LOR or the corresponding screening level (where available) for all samples analysed.

Trace concentrations of PFOS, marginally above the LOR, were detected in sample EJ_MW02_0.25 but below the adopted human health screening value. Subsequent PFOS analysis from four soil boreholes advanced adjacent to this location reported results below the laboratory LOR (for samples at both 0.5 m bgl and 1.0 m bgl) within the exception of EJ_SB47_0.5. Concentrations of PFOS and PFOA was detected in soil bores advanced within the current fire training area. Detections of PFOS ranged between 0.0008 mg/kg EJ_SB45_0.2 to 0.0869 mg/kg (EJ_MW55_0.5). However all concentrations of both PFOS and PFOA were significantly below the adopted human health screening value for direct contact of 6 mg/kg, noting this is for a residential setting (USEPA Region 4, 1999 and USEPA 2014).

Concentrations of copper were detected in several soil samples exceeding the corresponding ecological screening values. Concentrations were found to comply with the adopted human health screening values in all instances. The calculated 95% UCLs for copper marginally exceeded the ecological screening values and one sample recorded concentrations >250% of the screening level.

Concentrations of nickel were detected in several soil samples exceeding the corresponding ecological screening values. Concentrations were found to comply with the adopted human health screening values in all instances. The calculated 95% UCLs for nickel (refer to *Annex J*) marginally exceeded the ecological screening values and one sample recorded concentrations >250% of the screening values.

Concentrations of zinc were detected in several soil samples exceeding the corresponding ecological screening values. Concentrations were found to comply with the adopted human health screening values in all instances. The calculated 95% UCL for zinc (refer to *Annex J*) complied with the ecological screening level but two samples recorded zinc concentrations at >250% of the ecological screening value.

Arsenic was recorded in one sample (EJ_MW28_0.25) at a concentration in excess of the corresponding ecological screening value. Comparatively high concentrations of copper, nickel and zinc were also detected at this location and foreign material was recorded in the borelog associated with this sample. This elevated concentration was <250% of the corresponding screening value and the UCL for arsenic (refer to *Annex J*) was below the adopted screening value.

Potential ACM was observed in the form of two fragments of fibre cement sheeting (i.e. in a bonded matrix) adjacent to the Borrow Pit in the Former Fire Training area (refer to *Figure 3.4*). These fragments were observed to be in a reasonable condition (bonded matrix) with approximate dimensions of 60 mm× 40 mm ×5 mm. These fragments were collected and submitted for analytical testing (sample ID EJ_FFTA_ACM_GRAB). Results of the analysis concluded that the fragments contained Chrysotile and Amosite asbestos fibres. Asbestos fibres were not detected in any of the other soil samples analysed from within this AEC.

Groundwater Analytical Results

Groundwater quality field parameters are presented in *Table 3a* of *Annex B* and groundwater analytical results compared to the adopted site screening values are presented in *Table 4r of Annex B*. Exceedences of the adopted screening values are also graphically presented in *Figures 6.3 and 6.4 of Annex A*.

A number of laboratory LOR non-conformances were identified within this AEC, however these are not considered to affect the outcomes of the investigation (refer to *Section 5.5* for further discussion).

With the exception of the aforementioned LOR exceedences, groundwater analytical concentrations of TRH, BTEX, VOCs, phenols, and PCBs were reported either below the laboratory LOR or below the adopted human health and ecological screening values (where available) in all groundwater samples analysed from within this AEC.

PFOS and PFOA were detected in a number of groundwater samples collected within AEC EJ. Monitoring wells EJ_MW20, EJ_MW55, EJ_MW56 and EJ_MW57 reported concentrations of PFOS in excess of the adopted human health drinking water screening values. PFOA was also reported at a concentration exceeding the adopted human health drinking water screening value in EJ_MW55, EJ_MW56 and EJ_MW57. Concentrations of PFOS in monitoring wells EJ_MW56 and EJ_MW57 also exceeded the adopted ecological screening value.

Elevated concentrations of several PAH compounds, including benzo(a)pyrene, exceeding the ecological and recreational screening values were recorded in the groundwater samples collected from monitoring well EJ_MW18. Concentrations of PAH compounds in the remaining samples were reported below the laboratory LOR in all instances. Concentrations of cadmium in groundwater, marginally above the laboratory LOR, were detected in several samples.

These concentrations were found to exceed the ecological screening values for freshwater, but complied with the marine ecological and human health screening values. The measured cadmium concentrations were of the same order of magnitude as those measured in groundwater collected from across the Site, hence they are unlikely to be attributable to the operation of the Site.

Mercury was detected in groundwater at two locations surrounding the Attemperation Reservoir at concentrations marginally exceeding the ecological screening values but these concentrations were found to comply with the adopted human health screening values. Concentrations of copper and zinc were also detected above the adopted ecological screening values in most of the samples analysed.

Concentrations of selenium in excess of the NHMRC (2011) ADWG value were detected on the southern Site boundary (EJ_MW 12 and EJ_MW30) and adjacent to the truck washout pit (EJ_MW13 and EJ_MW15).

Arsenic concentrations were detected at two locations (EJ_MW18 and EJ_MW44) exceeding the NHMRC (2011) ADWG value. Lead was also detected at three locations (EJ_MW08, EJ_MW12 and EJ_MW30) exceeding the drinking water guideline.

Nickel was recorded at concentrations exceeding the NHMRC (2011) ADWG and ANZECC (2000) freshwater trigger value in samples collected from across this AEC. Particularly elevated concentrations of nickel were recorded for EJ_MW13, EJ_MW14 and EJ_MW15, and these concentrations were typically associated with elevated concentrations of zinc, and in some instances cadmium.

Elevated levels of nickel recorded at EJ_MW30 were also associated with elevated concentrations of other heavy metals in this sample. Nickel was noted to exceed the human health recreational exposure guideline in the groundwater sample collected from EJ_MW51 with other heavy metals also reported at concentrations exceeding the adopted ecological screening values.

Sediment Results

Sediment samples were collected from the base of four drainage channels on Eraring land to the north of Wangi Road, which drain to Lake Eraring, to allow for assessment of potential impacts to Lake Eraring from the Site. Contaminants were reported at concentrations below the adopted screening values in these samples, suggesting that the impact of the Site on Lake Eraring is unlikely to be significant, relative to the impact of external sources.

Discussion

Contaminant constituents at the remaining locations along the west and north western boundaries (EJ_MW02, EJ_MW03 and EJ_MW05) were found to comply with the adopted criteria, except for exceedences of ecological screening values for one soil sample collected at EJ_MW03, and minor exceedences of ecological screening values for groundwater sampled at EJ_MW03 and EJ_MW05.

PFOS was detected in shallow soil samples collected from within this AEC. Human health screening values were not identified for PFOS in soil, however the US EPA Region 4 (2009[3]) has published a residential soil guideline for PFOS of 6 mg/kg. Although this value has no regulatory standing in Australia, it indicates that the maximum PFOS concentration detected within this AEC is unlikely to represent a significant risk to commercial/industrial workers at the Site. Based on the lateral and vertical delineation of PFOS impacts surrounding EJ_MW02, the risk to human health or the environment posed by PFOS concentrations in soil at this location is not considered significant. Furthermore, no known (or suspected unknown) source was identified within this area during the investigations.

Elevated concentrations of arsenic, copper, nickel and zinc (some more than 250% of the adopted screening level) exceeding the ecological screening values were detected in a fill soil sample collected from EJ_MW28 at a depth of 0.25 mg.

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[3] US EPA Region 4. 2009. *Soil Screening Levels for Perfluorooctanoic Acid (PFOA) and Perfluorooctyl Sulfonate (PFOS)*, Memorandum.

Based on a review of the bore log, foreign (likely anthropogenic) material was recorded for these soils. This location was adjacent to the cooling towers and was therefore unlikely to pose a significant risk to ecological receptors, given the operational activities undertaken in the immediate vicinity of the location.

The remaining elevated metals concentrations in soil were generally <250% of the relevant screening level and consistent with background conditions at the Site. In particular, metal concentrations in excess of the adopted ecological screening values were identified at locations EJ_MW03 and EJ_MW06 which were up gradient of operational areas, and adjacent to areas of remnant bushland.

Elevated heavy metals concentrations, particularly copper and zinc, were detected in groundwater sampled from locations across the Site. Concentrations were consistent at up- and down- gradient locations however, which indicated that background conditions contribute to these results. Concentrations of copper, nickel, zinc (and in EJ_MW07 also lead) were reported within monitoring wells selected as indicative of background conditions (refer to *Section 5.6*).

Elevated concentrations of copper, lead, nickel, selenium and zinc were measured in groundwater at location EJ_MW30, which is immediately down gradient of a bushland area and topographically isolated from the operational area (AEC EI) and the Attemperation Reservoir. Whilst a low pH (of 4.16) was identified at EJ_MW30, based on the elevation, the lack of evidence of significant historical ground disturbance and the geology encountered, the presence of potential or actual acid sulfate soils at this location is considered unlikely. It is acknowledged that the low pH may however be contributing, in part, to the elevated metals identified in groundwater at EJ_MW30.

Mercury was identified in two monitoring wells surrounding the Attemperation Reservoir at concentrations marginally exceeding the adopted ecological screening value. Subsequent analysis of down-gradient monitoring wells reported concentrations of mercury below the laboratory LOR indicating the minor mercury impacts are likely to be localised at the boundary of the Attemperation Reservoir and unlikely to migrate to receiving water bodies off-site. Therefore, based on the analytical results from the wells on the down-gradient site boundary it is considered that the identified impacts are limited in extent and, unlikely to present a significant risk to human health or the environment

At the western boundary of the Site, down-gradient of the Operational Area and the Switchyard and Oil Retention Weir, pH was noted to be around 6 with minor detections of copper and zinc (consistent with background concentrations) identified in EJ_MW03 and EJ_MW39.

Further south along the western boundary, monitoring wells EJ_MW02 and EJ_MW01 reported pH levels around 4 with slightly elevated concentrations of metals (including copper, lead and zinc) reported in both monitoring wells. The presence of low pH at these locations is likely due to historical soil disturbance within up-gradient areas (such as the Attemperation Reservoir and Intake Canal). The presence of elevated metals within these locations is likely to be primarily due to up-gradient sources with low pH providing a secondary driver for elevated metals. Whilst monitoring well EJ_MW02 reported concentrations of cadmium, nickel and zinc above the adopted freshwater screening values, monitoring wells north and south of this location (EJ_MW39 and EJ_MW01) reported metals at an order of magnitude lower in concentration. Minor detections of copper and zinc were noted in groundwater (above the adopted freshwater screening values) however, these were considered consistent with broader concentrations identified across the site and likely indicative of background levels. Lead and selenium impacts are noted to be above background levels.

Concentrations of PAHs in excess of the adopted screening values were detected in groundwater sample EJ_MW18, which is located directly to the east of the fuel oil installation. Based on a review of bore log information, groundwater at this location was associated with the presence of a subsurface coal layer, but these impacts may also be associated with fuel storage activities. Concentrations of PAHs were below the LOR in all remaining groundwater samples analysed in this AEC, including the wells located on the down gradient Site boundary. A connection between the surface water flow path east of this area is considered unlikely (based on the topographic change and groundwater divide). However, surface water and sediment sampling at EG_SS21 and EG_SS22, a the discharge point east of the surface water flow path, did not report concentrations of PAHs significantly above the LOR with Benzo(a)Pyrene noted to be below the LOR. On this basis these impacts are considered unlikely to represent a risk to human health or the environment.

Asbestos fibres were detected in two samples of fibre cement sheeting collected from within the former fire training area. Asbestos fibres were not detected in any of the soil samples, and no other ACM fragments were recorded for this AEC. The source of the ACM is not known. Based on the sampling results, field observations and the current usage of the AEC, the risk to human health from ACM at this location is considered low.

The residential community of Dora Creek is located approximately 480 m to the south of this AEC and although this distance is considered to be sufficient to minimise any risk associated with exposure to Site impacts, the data from AEC EJ was compared against the HILs/HSLs for direct contact with soil by residents (HIL - A and HSL - A). Concentrations were found to be below the residential screening values (where available) in all instances, suggesting that risks to offsite residents are likely to be low.

Intrusive investigation works within the historical/current fire training area identified perfluorochemicals (including PFOS and PFOA) in groundwater above the adopted human health drinking water screening value and in some locations above the ecological (marine) screening value. Whilst groundwater is not used for potable supply, in the absence of a more appropriate guideline, health screening values of 0.2 µg/L and 0.4 µg/L for PFOS and PFOA respectively in groundwater have been adopted. These values are proposed by US EPA Office of Water Provisional Health Advisory (2009) and reflect reasonable, health based hazard concentrations above which action should be taken to reduce exposure to contaminants in drinking water (USEPA, 2014).

Concentrations of PFOS in EJ_MW20, EJ_MW55, EJ_MW56 and EJ_MW57 exceeded this screening value. Ecological screening values were not identified for PFOA however a value of 7.2 µg/L (from RIVM MAC for marine ecosystems) was adopted for PFOS. All concentrations were below this screening value for protection of marine ecosystems with the exception of EJ_MW56 and EJ_MW57. It is noted that the down-gradient monitoring well location EJ_MW58 reported concentrations of PFOS and PFOA below the laboratory LOR indicating that significant migration of the impacts is not apparent outside the area of fire training. This is further supported by the absence of PFOS and PFOA in groundwater wells (down-gradient and) east of the fire training area, such as EJ_MW33, EA_MW23, EA_MW22, EJ_MW50, EJ_MW52 and EJ_MW53. Furthermore, limited groundwater may also flow from the current fire training area west and south west towards the operational area (although this is not considered the primary flow path). This direction of groundwater flow would account for PFC detections in EJ_MW20, AEC EH and potentially AEC EI.

As identified during review of surface water interactions and sub-catchments within the site, the fire training area is sited on the division of a sub-catchment and hence may have some surface water flows both east and west. Surface flows west towards AEC EH or some surface water interactions with the conveyor M1 silt trap (*Annex P*) may provide a source for the impacts observed at EH_MW01 (adjacent to the sausage pond). However, given the magnitude of concentrations and the location of EH_MW01, the risk to human health or the environment is not considered significant.

Based on a review of drainage diagrams for the site (refer to *Annex O*) and the topography and drainage features presented as sub-catchment figures (*Annex A*), a potential surface flow path is present from the fire training area to the return water dam. It is noted that given the presence of soft ground within the fire training area, substantial infiltration may also occur prior to surface flows entering this intermittent surface water body or gully. It is noted that the current fire training area might be utilised as a disposal area for reclaimed water on the site (*Annex O*).

PFCs are very stable in the environment, relatively soluble and hydrophilic. As such, once applied to surface soils (during training), the AFFF product would likely soak into the soft ground and then be mobilised by rainfall or treated water/effluent infiltration (within the fire training area). Given the properties of the PFCs and the activities in the fire training area, effluent disposal and rainfall are likely to be the primary mechanisms resulting in 'flushing' of PFCs into groundwater. However, it should be noted that groundwater monitoring wells down-gradient and adjacent to the nearest ecological receptor (Myuna Bay) reported concentrations of PFOS and PFOA below the laboratory LOR indicating that any potential discrete site impacts have not migrated significantly beyond the initially identified areas.

It is noted that fire accelerants (or compounds expected to be associated with these, such as TRH and BTEX) were not identified within the fire training area, either in the soil or groundwater samples collected.

Advancement of EJ_MW39 was completed (in agreement with Origin and AECOM) within the down-gradient vicinity of the settle pond and oil retention weir. Groundwater sampling results did not indicate the presence of impacts associated with the power station such as hydrocarbons, PCBs, VOCs and metals.

5.5.11 *Visual Inspections of Non – Operational Lots*

Background

Visual inspections of specified non-operational areas were completed within lands transferred to Origin as part of the transaction but not occupied or subject to a lease at the time of the assessment, for the purpose of assessing the potential for contamination issues not previously identified during the Preliminary ESA (ERM, 2013a). Visual inspections of leased areas (operational lots) owned by Origin were undertaken by Origin (refer to *Annex L*).

The visual inspections were carried out on 16 and 17 September 2013 and comprised a walkover of each lot, to identify indicators of significant contamination.

Inspections were largely restricted to walking along existing track and paths through densely vegetated areas. Inspections were not conducted on a grid basis in accordance with Western Australian (WA) Department of Health (DOH) Guidance for the Assessment, Remediation and Management of Asbestos-Contaminated Sites due to time and logistical constraints (including dense vegetation restricting access).

Given the preliminary nature of the inspections, this methodology was considered appropriate, as the majority of dumped waste and other potentially contaminated materials observed were found either on, or in close proximity to existing roads, tracks or paths.

For the purpose of the assessment, indicators of significant contamination were considered to be the presence of dead or stressed vegetation dead or stressed animals, unexplained bare patches, chemical substances, empty, part-filled or filled cans or drums that do or may have contained hazardous substances, stained soil, unusual odours, discoloured water in drains or natural water courses or excavations or by the presence of fly-tipped waste.

A full list of non-operational property is presented within *Annex L* and graphically presented on *Figure 4* of *Annex A*. Site Inspection Forms are included as *Annex E*.

Field Observations

Lots 8 – 9/U/6747 & Lots 11 – 12/U/6747

This portion of land is comprised of four vacant blocks separated by an occupied residential property, being Lot 10/U/6747. The surrounding area consists of Border Street and Point Piper Road to the north, a residential property to the west and crown land to the east and south, followed by Lake Eraring. The total area of the vacant lots is approximately 4.35 ha.

These lots are occupied by dense bushland, open bushland and grassland. A dilapidated fence line surrounds Lots 8 & 9 and 11 & 12 but access by the general public is largely unrestricted.

No evidence of illegal dumping of waste was identified, with the exception of a number of car tyres observed on Lots 8 - 9/U/6747 (appeared to be utilised as garden bed borders), as presented in *Photograph 1* of *Annex G.2.1*.

There were no visible signs of contamination or odours of concern noted on any of the four vacant blocks at the time of the inspection. Completed Site Inspection Forms are included as *Annex E*. Inspections within these lots were largely restricted to open bushland, grassland and walking trails through densely vegetated areas.

Lots 13 – 16/U/6747

This portion of land is comprised of four vacant blocks, with a total area approximately 3.196 ha occupied predominantly by dense bushland (80%) and grassland (20%). The surrounding area consists of Point Piper Road to the north, Origin land to the west and crown land to the east and south followed by Lake Eraring. A dilapidated fence line exists surrounding the lots, however access is by the general public is largely unrestricted.

It appears Lot 14/U/6747 was historically developed with evidence of a concrete hardstand and remnant building materials on site, indication of a former residence, as presented in *Photograph 3* of *Annex G.2.2*. A number of minor stockpiles, as a result of the former development, and fly tipping were evident on Lot 14 and 15/U/6747, with stockpiles made up predominantly of building waste including steel, timber and bricks, as presented in *Photographs 2* and *4* of *Annex G.2.2*. No visible signs of potentially asbestos containing material were observed on this portion of land at the time of the site visit however given the presence of fly tipped building materials the presence of ACM cannot be ruled out.

A creek was identified to the east of Lot 16/U/6747 which appears to accept surface and stormwater run-off from the surrounding area, discharging to Lake Eraring, as presented in *Photograph 1* of *Annex G.2.2*. No other sensitive environments were noted on any of the four vacant blocks of land.

Completed Site Inspection Forms are included as *Annex E*. Inspections within these lots were mostly restricted to grassland and walking trails through densely vegetated areas.

Lots 10 - 14/262501 & 16/262501

This area is comprised of six parcels of land separated by a tenanted residential property owned by Origin, being Lot 15/262501. The surrounding area consists of Wangi Road to the north, Origin land to the east and west and Point Piper Road to the south followed by crown land and Lake Eraring. The six parcels of land have a total area of approximately 9.5 ha and are occupied by dense bushland, open bushland and grazing paddocks. Lot 16/262501 was inaccessible at the time of the investigation due to the dense vegetation occupying this portion of land. Lots 10 - 14/262501 including the adjoining parcels of land (13 - 16/O/6747 and 9/262501) appeared to be occupied and utilised for grazing purposes.

It appears a residential property historically existed in the southeast and southwest portion of Lot 14 and 13/262501, respectively with evidence of residential fencing (picket) and remnant residential waste (garden beds, flagpole, etc.) scattered throughout this part of the property. A number of timber and corrugated iron structures exist in the southwest portion of Lot 13/262501 which appear to be associated with a former small livestock facility with evidence of cattle fencing and loading ramps.

Fly tipping was noted in the southern portion of Lots 10 - 13/262501 with evidence of buried and surficial potential asbestos containing material, car batteries and building materials, as presented in *Photographs 3 - 7* and *10* of *Annex G.2.3*.

It should be noted that an asbestos sample collected from the potential surficial asbestos containing material observed in the southern portion of Lot 12/262501 and submitted for laboratory analysis, returned a negative result for the presence of asbestos, however the potential for other fragments observed in this area to contain asbestos remains to exist. A sample was not collected from the buried potential asbestos containing material observed in this area due health and safety constraints and the preliminary nature of the investigations; therefore the presence/absence of asbestos within this material could not be determined.

A creek bed was identified which intersects Lots 11 - 13/262501 and appears to accept surface and stormwater run-off from the surrounding area, discharging to Lake Eraring, as presented in *Photograph 17* of *Annex G.2.3.* Completed Site Inspection Forms are included as *Annex E.* Inspections within these lots were mostly restricted to open bushland and walking trails through densely vegetated areas. Inspections within grazing paddocks were restricted due to the presence of livestock, as a result, visual inspections were undertaken from the site boundary.

Lots 13 – 16/O/6747 & 9/262501

This area is comprised of five parcels of land, with a total area of approximately 11 ha occupied by dense bushland, open bushland and grazing paddocks, as presented in *Photographs 1 - 2* of *Annex G.2.3.* The surrounding area consists of Rocky Point Road to the north, Origin land to the west and east beyond an electrical easement/Chelmsford Avenue and Origin and crown land to the south followed by Lake Eraring. Barbed wire agricultural fencing was observed around the perimeter of this area restricting access to the public. Lots 13 - 16/O/6747 and 9/262501 including the adjoining parcels of land (10 - 14/262501) appeared to be occupied and utilised for grazing purposes (horse paddock).

No evidence of illegal dumping of waste was identified within this area and there was no visible sign on contamination or odours of concern on either of the four vacant blocks at the time of the inspection. Inspections within these lots were mostly restricted to open bushland and walking trails through densely vegetated areas. Inspections within grazing paddocks were restricted due to the presence of livestock, as a result, visual inspections were undertaken from the site boundary.

Completed Site Inspection Forms are included as *Annex E.*

Based on a review of recent aerial photographs, a creek appears to intersect all five parcels of land and discharge into Lake Eraring to the southwest, however due to the dense vegetation; this area was inaccessible at the time of the investigation.

Lots A – B/378498

This portion of land is comprised of two occupied blocks, with a total area of approximately 2.1 ha covered by intermittent bushland, grassland and grazing paddocks. The surrounding area consists of Origin owned land to the north and west beyond Chelmsford Avenue/electrical easement, a residential property to the east, and Origin land to the south beyond Point Piper Road. Barbed wire agricultural fencing was observed around the perimeter of this area restricting access to the public.

It should be noted that both lots appeared to be tenanted at the time of the investigation, with Lot A/378498 being utilised by the adjoining residential property to the east for general storage purposes and Lot B/378498 utilised for grazing purposes (horse paddock). As a result, access was restricted to these properties.

Completed Site Inspection Forms are included as *Annex E*.

Lots 3 – 6/L/6747 & 7 – 8/262501

This area is comprised of six vacant parcels of land, with a total area of approximately 10.5ha entirely covered by dense bushland. The surrounding area consists of Rocky Point Road to the north, Origin land to the east (including a tenanted residence) and west (beyond Chelmsford Avenue) and a combination of Origin land, residential properties and Eraring Public School to the south. Barbed wire agricultural fencing was observed around the perimeter to the north, west and south, restricting access to the general public in these directions.

No evidence of illegal dumping of waste was identified within this area and there were no visible signs of contamination or odours of concern on either of the six vacant blocks at the time of the inspection. Inspections within these lots were restricted due to the presence of dense bushland, as a result, visual inspections were undertaken from the site boundary.
Completed Site Inspection Forms are included as *Annex E*.

Lots 7 – 8/L/6747 & 10 – 11/L/6747

This portion of land is comprised of four vacant blocks separated by an occupied residential property, being Lot 9/L/6747. The surrounding area consists of Rocky Point Road to the north, Biddulph Street to the east and Origin owned land to the south and east. The four parcels of land have a total area of approximately 6.6 ha occupied by dense bushland intersected by a number of walking/access trails. A dilapidated barbed wire agricultural fence line exists to the east and south, and it should be noted that access by the general public is largely unrestricted.

Minor fly tipping was observed within the access trail of Lot 10/L/6747 with evidence of surficial asbestos containing material, consisting of approximately ten small fragments (up to approximately 100mm x 100mm) of bonded ACM ,and a small (< 1m^3) stockpile containing building waste. An asbestos fragment collected from this area and submitted for laboratory analysis, returned positive for the presence of asbestos in the form of amosite, chrysotile and crocidolite.

Completed Site Inspection Forms are included as *Annex E*. Inspections within these lots were mostly restricted to open bushland and walking trails through densely vegetated areas.

Lots 12 - 16/L/6747

This area is comprised of five vacant parcels of land, with a total area of approximately 7.4 ha covered predominantly by well-maintained grassland. Relatively dense bushland surrounds the western and sections of the southern boundary. The surrounding area consists of Origin owned land to the north, Eraring Public School to the west, Point Piper Road to the south and Biddulph Street to the east. Access to this area is unrestricted to the general public to the south, however a fence line exists to the east and west.

It appears a water pumping station historically operated in the eastern portion of Lots 14 & 15/L/6747 immediately adjacent a dam on-site, with evidence of remnant infrastructure (underground concrete holding tanks, pipework, electrical infrastructure, etc.), as presented in *Photographs 5 - 12* of *Annex G.2.7*. Potentially asbestos containing material associated with an electrical backing board was identified to the south of the dam, located within Lot 15/L/6747, however it appeared to be in sound condition and limited to a small area. A representative asbestos sample could not be collected without jeopardising the integrity of the material.

A small timber and corrugated iron structure/shed exists in the eastern corner of Lot 15/L/6747, as presented in Photograph 5 of Annex G.2.7, which appears to be associated with the former water pumping station.

A small volume of scattered waste (consisting of car tyres, rusted drum, scrap metal, plastics, green waste, etc.) was evident within bushland along the western and southern boundaries, as presented in Photograph 3 of Annex G.2.7.

A dam/standing water body was identified on the eastern boundary of lots 14 & 15/L/6747, related to the former water pumping station, which appears to accept surface and stormwater run-off from the surrounding area to the west, discharging to Lake Eraring during periods of heavy rainfall, as presented in *Photograph 6* of *Annex G.2.7*.

Completed Site Inspection Forms are included as *Annex E.* Inspections within these lots were mostly restricted to grasslands and walking trails through densely vegetated areas.

Lots 10 - 12/M/6747

This area is comprised of three vacant blocks of land, with a total area of approximately 2.95 ha, covered by well-maintained grassland in the north and a combination of open and dense bushland in the south and west. The surrounding area consists of Macleay Street to the north, residential properties to the east, tenanted residential properties owned by Origin to the west and crown land followed by Lake Eraring to the south. Access to this area is mostly restricted due to a fence line on the northern, western and eastern boundaries.

Minor fly tipping was observed in the northern portion of Lot 11/M/6747 with evidence of a small green waste stockpile, as presented in *Photograph* 4 of *Annex G.2.8.*

A dam/standing water body was identified in the southern portion of Lot 12/M/6747 which appears to accept surface and stormwater run-off from the surrounding area, as presented in *Photograph* 5 of *Annex G.*
Completed Site Inspection Forms are included as *Annex E.* Inspections within these lots were mostly restricted to grasslands, open bushland and walking trails through densely vegetated areas.

Lots 1 - 3/M/6747 & Lot 156/755218

This area is comprised of four vacant parcels of land, with a total area of approximately 6.1ha covered predominantly by dense bushland with small areas of open bushland and grassland to the south of Lot 156/755218. The surrounding area consists of Macleay Street and Point Piper Road to the north, residential land to the east and crown land to the south and west followed by Lake Eraring. Access to the area is restricted by a barbed wire agricultural fence line to the north, east and west.

Minor fly tipping was observed within Lot 156/755218 with evidence of small green waste stockpiles, as presented in *Photographs 3 - 4* of *Annex G.2.9.*

A dry creek bed was identified within Lot 156/755218 which is predicted to accept surface and stormwater run-off from the surrounding area during periods of heavy rainfall, discharging into Lake Eraring.

Completed Site Inspection Forms are included as *Annex E.* Inspections within these lots were mostly restricted to grasslands, open bushland and walking trails through densely vegetated areas.

Lots 7 – 10/J/6747, 12 – 17/K/6747, 18/1099798, A/954714 & 6/262501

This area consists of 13 vacant parcels of land, comprising a total area of approximately 17 ha covered by a combination of dense and open bushland intersected by a number of walking trails/access tracks. The surrounding area consists of dense bushland to the south, dense bushland to the north, Wangi Road and tenanted grazing land owned by Origin to the west and dense/open bushland to the east followed by Whiteheads Lagoon. Vehicle access to this area is restricted by a fence line to the south and west and dense bushland surrounding the area, however access is available to the general public via walking trails.

A small quantity (occupying an area <20m^2) of dumped waste (including corrugated iron sheets, general litter and a rusted car body), of was observed throughout this area, as presented in *Photographs 6 – 7* of *Annex G.2.10*. A 'campfire' area is situated within Lot 15/K/6747 thought to be utilised by the neighbouring Myuna Bay Sports and Recreation Camp, as presented in *Photographs 4 – 5* of *Annex G.2.10.*

Completed Site Inspection Forms are included as *Annex E*. Inspections within these lots were mostly restricted to open bushland and walking trails through densely vegetated areas.

Lot 2/548546

This lot consists of two portions of land separated by Summerhill Drive, comprising a total area of approximately 1.1ha. The majority of the lot is covered by bushland intersected by an electrical easement orientated east to west, in the northern portion of the lot. The surrounding area consists of Wangi Road to the west, residential properties to the south beyond Sunset Close, an electrical easement and bushland to the east and bushland to the north followed by the Myuna Colliery to Eraring Power Station conveyor. A fenced access track (as presented in *Photograph 1* of *Annex G.2.11*) restricts vehicle access to the northern portion, however access can be easily obtained to the east. The southern portion is unfenced, and occupied by relatively dense bushland, thus restricting access to the general public.

Numerous stockpiles of fly tipped waste (including building waste, a 5 L fuel container, green waste, household waste, etc.) were evident in the northern portion of the lot, within the vicinity of the electrical easement, as presented in *Photographs 2 – 6* of *Annex G.2.11.*

Completed Site Inspection Forms are included as *Annex E*. Inspections within these lots were mostly restricted to walking trails/easements through densely vegetated areas.

Discussion

Based on the results of the vacant non-operational lot inspections, the following conclusions can be drawn.

Lots were predominantly occupied by either dense bushland, open bushland or grassland intersected by walking trails/easements.

Waste has been identified on a number of parcels of land as a result of fly tipping or remnant material from previous land use activities. No significant evidence of plant stress, interpreted to be a result of contamination, was identified during the site inspections.

Potentially asbestos containing material was observed in three areas across the 57 lots inspected, most of which appeared to be surficial fragments with the exception of that observed within the southern portion of Lot 12/262501 which identified buried potential asbestos containing material. Characterisation and delineation is recommended in this area in the form of a Detailed Site Investigation to assess the nature and extent of buried and surficial potential asbestos containing material identified.

It should be noted that inspections within vacant non-operational lots were mostly restricted to open bushland, grassland and walking trails/easements through densely vegetated areas. Where grazing paddocks were observed, inspections were restricted due to the presence of livestock, as a result, visual inspections were undertaken from the site boundary. Inspections were not conducted on a grid basis in accordance with Western Australian (WA) Department of Health (DOH) *Guidance for the Assessment, Remediation and Management of Asbestos-Contaminated Sites* due to time and logistical constraints, however this was considered appropriate given the preliminary nature of this portion of the assessment. Visual inspections of leased areas (operational lots) owned by Origin were undertaken by Origin.

5.5.12 *Area EK – Coal Haul Road*

Background

The Eraring Power Station to Newstan Colliery haul road is an 11.5 km private coal haul road located to the north of the site and is used to transport material from Awaba and Newstan Colliery to the Eraring Power Station. The road is not wholly under direct ownership of Origin, but is occupied and operated under a series of leases, license and agreements as presented in *Annex N*.

Information provided by Site personnel and a review of aerial photographs (detailed in *Annex N*) indicates that the road was constructed prior to 1987 as part of the power station development.

The road is predominantly surrounded by relatively dense bushland, intersected by electrical easements, a railway corridor and public roadways. The nearest residential receptors were identified approximately 500 m to the east, within the township of Fassifern. A number of active and former coal mines exist within the immediate vicinity of the road, some of which supply coal to the Power Station.

A number of groundwater bores were identified within a 2 km radius of the Coal Haul Road, predominantly registered for domestic farming and monitoring purposes, as presented in *Section 2.7*. The closest groundwater bore, registered for domestic stock purposes is located approximately 700 m from the Coal Haul Road, almost to the east of EK_MW13.

Based on information provided by Site personnel, stormwater run-off is directed to the natural surface water courses via gross pollutant traps surrounding the area which are understood to ultimately discharge into Lake Macquarie.

Fencing was observed along the entire length of the haul road, restricting access by the general public.

A number of potential areas of environmental concern have been identified as detailed below:

- coal fines/dust as a result of current and historic coal transport was evident along the entire length of the road, however it is understood a street sweeper cleans the road regularly;

- a number of truck accidents/roll overs have been reported to have occurred over the lifetime of the road (as presented on *Figure 3.8* of *Annex A*), however it is understood from anecdotal evidence provided by knowledgeable site personnel that no fuel/oil was spilt as a result of these incidents; and

- a number of 'pollution traps' (as presented on *Figure 3.8* of *Annex A*) exist along the length of the haul road which serve as filters to catch pollution before entering the surrounding water courses.

AEC Methodology and Investigation Field Observations

Following a reconnaissance and review of background information, sampling was conducted in the EK AEC to target potential contamination of soil and groundwater from coal fines/dust, historic truck accident/roll overs, 'pollution traps', leachate and runoff. The coal haul road sampling locations are presented on *Figure 3.8* of *Annex A*.

A total of 12 groundwater monitoring wells were advanced and nine surficial soil samples collected within this AEC from 26 August 2013 through until 17 September 2013. The groundwater monitoring well locations were distributed by adopting both a systematic and targeted approach along the entire length of the roadway. A number of hazards were also identified in association with historic mine subsidence and coal haulage operations. Consequently, surficial soil samples were collected in locations where mechanical drilling could not be safely achieved. The rationale for investigation locations is detailed within *Table 1a* of *Annex B*. Borehole logs are presented in *Annex D*.

Coal fines/dust was observed along the entire length and within the immediate vicinity of the coal haul road at the time of the investigation. These observations may suggest that the periodic street sweeping undertaken along the road may be inadequate to address the build-up of dust. Surficial soil samples collected within this area with a colour descriptor of 'black', as presented within borehole logs in *Annex D,* are likely attributed to the presence of coal fines/dust. No odours or stressed vegetation associated with these coal fines were noted.

Measured concentrations of ionisable volatile compounds via headspace analysis were noted not to exceed 2.3 ppm (isobutylene equivalent) in all samples collected from this AEC.

EK_MW03 and EK_MW04 were observed to be dry during groundwater monitoring well development, however a water strike was observed during borehole advancement at 5.5m bgl within EK_MW03, and at 21.5m bgl within a coal layer of EK_MW04. As such, these monitoring wells could not be sampled during this investigation.

A summary of the field observations from the drilling works are presented within *Table 5.11*

Table 5.11 ***Field Observations Summary***

Borehole ID	Depth (m bgl)	Visual or Olfactory Evidence	PID Range (ppm)
EK_SB01 / EK_MW01	6	'Black' shallow soils	0.0 to 0.9
EK_SS03	0.05	None	0.2
EK_SB04 / EK_MW02	10.5	None	0.0 to 0.3
EK_SB07 / EK_MW03	9	None	0.0 to 0.5
EK_SS12	0.05	'Black'	0.1
EK_SS15	0.05	'Black and grey'	0.0
EK_SS16	0.05	None	0.0
EK_SS17	0.05	'Black and grey'	0.0
EK_SB20 / EK_MW04	23	None	0.1 to 0.4

Borehole ID	Depth (m bgl)	Visual or Olfactory Evidence	PID Range (ppm)
EK_SS23	0.05	'Black and grey'	0.1
EK_SB26 / EKMW06	9	'Dark grey and black' shallow soils	0.2 to 2.3
EK_SB28 / EK_MW07	7	None	0.3 to 0.4
EK_SB30 / EK_MW08	6	None	0.1 to 0.5
EK_SB31 / EK_MW09	5.1	None	0.0 to 0.2
EK_SS32	0.05	'Black'	0.1
EK_SB36 / EK_MW10	4	'Black' shallow soils	0.0 to 0.1
EK_SB37 / EK_MW11	12	None	0.0 to 0.1
EK_SS39	0.05	'Black and grey'	0.1
EK_SS41	0.05	'Black'	0.1
EK_SB43 / EK_MW12	6	None	0.0 to 1.4
EK_SB44 / EK_MW13	7	None	0.1 to 0.5

Soil Analytical Results

The soil analytical results are compared to the adopted human health and ecological screening values as presented in *Table 4v of Annex B*. Exceedences of the adopted screening values are also graphically presented in *Figures 6.1 and 6.2 of Annex A*.

Analytical concentrations of TRH and PAHs were detected in soils at concentrations greater than the laboratory LOR at a number of locations across this AEC. The concentration of TRH(C10-C16) exceeded the ESL for and open space in a single shallow (0.05 mg) soil sample located in the vicinity of the Newstan Colliery (EK_SS41).

TRH(C16-C34) was detected at concentrations in excess of the ESL for urban residential and open space in a this sample, in addition to two other shallow (0.05 m bgl) soil samples(EK_SB26 and EK_SS32).
Analytical concentrations of BTEX, VOCs, phenols and PCBs in soil were reported below the laboratory LOR in all samples analysed from within this AEC.

Various metals were detected in soils at concentrations greater than the laboratory LOR at a number of locations across the AEC. Zinc and/or nickel were detected at concentrations in excess of the EILs for open space in three shallow soil samples.

All samples analysed for asbestos within this AEC returned negative results. The limitations of assessing for the presence of asbestos using vertical boring sampling methods are, however, acknowledged.

Groundwater Analytical Results

Groundwater quality field parameters are presented in *Table 3a* of *Annex B* and groundwater analytical results compared to the adopted site screening values (including freshwater and marine ecosystem specific values) are presented in *Table 4u of Annex B*. Exceedences of the adopted screening values are also graphically presented in *Figures 6.3 and 6.4 of Annex A*.

A number of laboratory LOR non-conformances were identified within this AEC, however these are not considered to significantly affect the outcomes of the investigation (refer to *Section 5.5* for further discussion).

Analytical concentrations of TRH, BTEX, VOCs, PAHs, phenols and PCBs in groundwater were reported at or near the corresponding laboratory LOR in all samples analysed.

Cadmium, copper, lead, nickel and zinc were detected at concentrations greater than the laboratory LOR in a number of monitoring wells across the AEC. Cadmium and nickel were reported at concentrations in excess of the NHMRC (2011) ADWG values in individual wells. Nickel was also detected at a concentration in excess of the adopted marine and recreational screening values in EK_MW11, with a concentration of 254 μg/L. Cadmium, copper, lead, nickel and zine were detected at concentrations in excess of the adopted ecological screening values.

Zinc was detected above the freshwater ecological levels in nine of the ten monitoring wells analysed from this AEC with a maximum concentration of 1050 μg/L in EK_MW11.

Discussion

Coal fines/dust was observed along the entire length and within the immediate vicinity of the coal haul road at the time of the investigation.

Analytical concentrations of TRH (C_{10} - C_{16}) and TRH (C_{16} - C_{34}) in soil were reported to marginally exceed (<250%) the ASC NEPM (2013) ESLs for urban residential and open space within surficial soil samples collected at a number of locations along the coal haul road. As the coal haul road is used for industrial purposes to convey traffic, the ESLs for commercial/industrial use may also be applied. The concentrations of TRH in all soil samples within this AEC comply with the ESL for commercial/industrial use.

The presence of measureable TRH concentrations in soil can be attributed to coal fines/dust observed along the haul road as a result of long-term coal transport and possibly also hydrocarbon runoff associated with heavy vehicle operations. The runoff of petroleum hydrocarbon fuels, associated with the ongoing use of the road, may also contribute to these results. Given the marginal nature of these exceedences, these impacts are considered unlikely to indicate a significant risk to the bushland environment, other than that immediately surrounding the road.

Analytical concentrations of nickel and/or zinc in soil were reported to marginally exceed (<250%) EILs for open space (aged) within two shallow soils samples (0.05 m bgl) collected at three locations within this AEC. Although the presence of coal fines/dust may have contributed to these results, the metal concentrations reported at these locations are of the same order of magnitude as concentrations observed at other locations across the Site. Given the marginal nature of these exceedences, these impacts are considered unlikely to indicate a significant risk to the wider bushland environment, surrounding the road.

The marginal exceedences of the NHMRC (2011) ADWG values and ecological screening values for copper, measured in groundwater collected from within this AEC are consistent with background conditions at the Site.

The origin of the more elevated metal concentrations identified in EK_MW11 has not been determined but is considered unlikely to be associated with the operation of the Coal Haul Rd or the broader operation of the Site (given the main operational area is located 6 km to the south of EK_MW11). Based on the inferred northerly groundwater flow direction (for the majority of AEC EK), the concentrations observed, the current usage of the haul road and immediate surrounding area, the risk to identified receptors is considered to be low.

5.5.13 *Area EL – Asbestos Containing Pipework*

Asbestos containing pipework is located along Pipe Road to the east of the power station operational area. The pipework extends for approximately 58 m as presented on *Figure 3.7* of *Annex A*. Access to this area is easily achieved off Pipe Road, however at the time of the investigation, the asbestos containing pipework was barricaded and a site specific health and safety notice issued to all on-site employees.

Visual inspections and sampling of underlying soils was conducted within this area for presence/absence of asbestos fibres, with additional sampling targeted to areas where the pipework was visually disturbed and at connection points. A grid based inspection, in accordance with Western Australian (WA) Department of Health (DOH) Guidance for the Assessment, Remediation and Management of Asbestos-Contaminated Sites, could not be achieved due to the physical presence of piping (including asbestos) within the immediate vicinity.

Methodology and Investigation Field Observations

A total of four shallow surface soil samples were collected from beneath the asbestos containing pipework on 6 August 2013. Sampling was conducted within areas where surface soil material was available beneath the asbestos containing pipework. Due to the presence of an asphalt hardstand beneath the pipework however, sampling density of three samples per 20 m of exposed pipework, as outlined in the SAQP (ERM, 2013b) could not be achieved.

The asbestos pipework was observed to be in sound condition with the majority sealed by a water based styrene acrylic polymer (Belzona 3211 (Lagseal)). No field indicators of contamination, such as staining, odours or visible ACM were observed on the ground surface beneath or within the immediate vicinity of the asbestos containing pipework. The soil material sampled primarily consisted of sandy gravel.

Soil Analytical Results and Discussion

The soil analytical results collected within this AEC are identified by ACM_SS01 – ACM_SS04 and are presented within *Table 4w of Annex B*.

Laboratory analysis detected, 'several friable asbestos fibre bundles' (Amosite) in the sample collected at ACM_SS02. Asbestos fibres were not detected at locations, ACM_SS01, ACMSS03 and ACM_SS04.

The analysis completed as part of the Stage 2 ESA works is considered indicative in nature, and additional analysis, in accordance with ASC NEPM (2013) should be undertaken as part of further delineation. Given the friable nature of the asbestos observed, it is recommended that ongoing Workplace Health and Safety (WHS) management of this issue be undertaken.

5.6 *METAL AND METALLOID CONCENTRATIONS IN GROUNDWATER*

Metals and metalloids can occur naturally in groundwater, and an assessment of background conditions forms an integral part of the evaluation of metal and metalloid concentrations reported. This is especially relevant where potential off-site sources of metals and metalloids exist, including historical and current underground coal mining works which occur extensively in the vicinity of the Site. Mining activities may alter the hydrological system and intensify surface water and groundwater connectivity. Increased interaction on freshly exposed rock in fractures and fracture zones has the potential to mobilise elements from the rock mass (Jankowski, 2007). The following sections provide an outline of published information available for concentrations of metals and metalloids in the area, background monitoring wells installed as part of the Stage 2 ESA and the approach put forward for the evaluation of the Stage 2 ESA results in the context of background conditions.

Background Data Available in the Literature

Limited data on metal and metalloid concentrations in groundwater in the vicinity of the Site are available in published materials, with available data obtained restricted to monitoring data presented in reports for Environmental Assessments (EAs) related to mining expansions at collieries in the surrounding area. These include reports for the Awaba, Mandalong, and the Myuna collieries. Of the aforementioned collieries, only the Awaba colliery had a groundwater monitoring point identified up-gradient of the Site.

The monitoring point, known as the 10 South water bore, was used as a dewatering bore for the underground mine workings at the Awaba colliery. During operation water from the 10 South bore was directed to the Eraring CCPMF. At a predicted discharge of 174 ML/year it was reported that inflow to the CCPMF would total approximately 3% of inflows into the dam, and that with an increased recommended pumping rate of 1.2 ML/day the inflows of the Awaba Colliery in to the CCPMF would increase to approximately 8.5% of total inflows (GHD, 2010). While it is understood that the Awaba colliery ceased operation in March 2012, it has not been confirmed whether dewatering continues for operational purposes of the surrounding mine workings.

Table 5.12 *Monitoring Results available for the 10 South Dewatering Bore*[1,2,3]

Sample Date	pH	EC (µS/cm))	As	Cu	Pb	Zn
24/08/2007	7.65	4810	1	2	1	11
22/08/2008	8.51	5650	1	2	5	18
13/08/2009	7.49	6040	1	2	1	38
11/02/2010	7.59	7940	1	4	1	22
12/03/2010	7.57	9260	1	2	1	19
Average		**6740**	**1**	**2**	**2**	**22**
Max	**8.51**	**9260**	**1**	**4**	**5**	**38**

1. Source (GHD, 2010) did not specify units of metal(loid) analytes. Given the magnitude of the values provided the values presented here are assumed to present units of µg/L.
2. Source (GHD, 2010) did not specify any values below detection limits. Given the values provided (i.e. all 1 µg/L for As and the known general detection limit of < 1 µg/L) it is considered likely that some values provided represent the detection limit.
3 Metal(oid) results are for filtered samples.

While the results provide an indication of pH, EC and metal(loid) concentrations associated with groundwater from the Awaba colliery, they do not represent background conditions within groundwater in the unconsolidated sediments and weathered conglomerate (that overlie the coal seams) encountered during the Stage 2 ESA. For this reason, site specific background data points are put forward in the following section.

Site Specific Background Data Points for 2013 and 2014 Dataset

For the purposes of this assessment, the following monitoring wells have been put forward as *Background Monitoring Wells*: EJ_MW05, EJ_MW06, EJ_MW07 and EK_MW02. These monitoring wells are located up-hydraulic gradient of all identified on-site sources (including up-hydraulic gradient from water levels in the CCPMF which provides confidence that these locations are not affected by potential radial flow from the CCPMF).

In addition to the up-hydraulic gradient location of the monitoring wells seen as being representative of background conditions, pH levels and ORP (two key controls on metal and metalloid solubility) and the lithology intersected by the *Background Monitoring Wells* were considered. pH and ORP in the aforementioned monitoring wells fell within the mid-range of measurements recorded across the monitoring well network at the Site, with pH measurements from the *Background Monitoring Wells* varying between 3.9 to 6.1 and ORP between 56 mV and 397 mV (site-wide groundwater pH and ORP measurements varied between 2.7 and 10.7 and -212 mV and 496 mV respectively).

Approximately 60% of the pH measurements taken across the monitoring well network fell within the range of pH measurements for the *Background Monitoring Wells*. Samples with pH levels below 4 indicative of relatively acidic conditions were limited to two monitoring wells (EJ_X_GW1 and EJ_X_GW3) located at the Attemperation Reservoir and two (EA_X_GM1/D2 and EA_X_MW05) located between the CCPMF and Myuna Bay. The distribution of pH levels below 5 is presented in *Figure 6.6* (of *Annex A*) which indicates that sub-neutral pH levels were present within all areas of the site and likely due to both natural and human influences.

Samples with pH levels above 8 indicative of relatively alkaline conditions were in-turn limited to two monitoring wells, ED_X_EP5MW7 and EE_MW02 (with respective pH levels of 9.9 and 10.6) located at the operational and decommissioned UST area and the workshops respectively. The pH range in the *Background Monitoring Wells* was therefore seen as representative of the majority of monitoring wells.

Approximately two thirds of the ORP measurements taken across the monitoring well network fell within the range of ORP measurements for the *Background Monitoring Wells* (56 mV and 397 mV), and the lithology screened within the *Background Monitoring Wells* is similar to the geology encountered for the majority of the Site as described in *Section 5.1* of the report.

For the reasons outlined above, monitoring wells EJ_MW05, EJ_MW06, EJ_MW07 and EK_MW02 were considered suitable data points to present background conditions at the Site.

Approach to Assessing Groundwater Results in terms of Background Conditions

The concentrations of metals in groundwater have been compared to the data available for the *Background Monitoring Wells*. The limited nature of the available background dataset (consisting of a total of 5 samples) did not facilitate the use of standard statistical methods for the estimation of background concentrations from the *Background Monitoring Wells* (which would include methods such as the derivation of upper tolerance limits with an associated statistical confidence level based on the data distribution of the background dataset).

For cases where there are insufficient data to meet the statistical assumptions for a detailed statistical analysis, the State of Idaho Department of Environmental Quality has put forward an approach that can be used as outlined in their guidance document titled *Statistical Guidance for Determining Background Ground Water Quality and Degradation* (State of Idaho DEQ, 2014). The aforementioned document provides guidance on the estimation of so called alternative concentration levels, which can be used an estimation of background concentrations. The approach specifies three methods for the estimation of upper concentrations limits, and specifies the use of the lowest concentration derived for the alternative concentration levels.

This approach has been adopted to provide an estimation of background concentrations at the Site and *Table 5.13* summarises the calculations associated with this approach as well as the concentrations subsequently adopted to present background values. For all metals in the table the maximum reported concentration was adopted as the estimated upper concentration of background conditions as these present the lowest calculated values. Note that the table presents data only for those metals where one or more samples were reported above the laboratory LOR (that excludes arsenic, chromium, mercury and selenium for which all results were below the laboratory LOR).

Table 5.13 ***Background Monitoring Wells Concentrations***[4]

Sample	Sample Date	Cd	Cu	Pb	Ni	Zn
EJ_MW05	07/08/2013	0.1	<0.1	<0.1	12	53
EJ_MW06	05/09/2013	<0.1	2	<0.1	5	19
EJ_MW07	06/09/2013	<0.1	5	4	10	58
EJ_MW07	01/12/2014	0.5	7.3	4.8	9.8	67
EK_MW02	16/09/2013	<0.1	<0.1	<0.1	10	18
Maximum		0.1	7.3	4.8	12	67
Mean + 1.65SD[1]		0.1	7.5	5.2	13	77
Median + 1.65 IQR[2]		0.1	11.3	6.9	16	126
Background Concentration[3]		0.1	7.3	4.8	12	67

Notes

1 = Standard deviation

2 = Inter quartile range

3 = Concentration presenting background value in line with guidance put forward by State of

Sample	Sample Date	Cd	Cu	Pb	Ni	Zn
Idaho DEQ (2014)						

4 = Mean, median, SD and IQR calculations undertaken by replaced values reported below the LOR with ½ the LOR

In addition to the screening values, metal results were compared to the estimated background concentrations presented in *Table 5.13*.

Note that all the metal and metalloid (including arsenic and selenium) concentrations described below are for field filtered samples (filtered with single-use 0.45 µm filters), with concentration ranges and averages based on primary samples only.

Arsenic

Arsenic concentrations ranged from the LOR of <1 µg/L (with two detections at 0.5 µg/L where a lower LOR was used) to 73 µg/L with an average concentration of 3.5 µg/L across the monitoring well network. Concentrations equalling or exceeding the lowest adopted screening value of 10 µg/L (drinking water criteria) were limited to 9 of the 145 monitoring wells sampled. Samples with exceedences of the adopted screening values were taken from monitoring wells located directly down gradient of the CCPMF, the operational and decommissioned UST area, the fuel oil installation and AST area and the accessible operational area and non-operational areas.

All samples taken from the *Background Monitoring Wells* had arsenic concentrations below the LOR of <1 µg/L. Background concentrations were below the assessment criteria and the elevated arsenic concentrations are therefore not considered attributable to background concentrations.

Cadmium

Cadmium concentrations ranged from the LOR of <0.05 µg/L to 2.8 µg/L across the groundwater monitoring well network, with an average concentration of 0.14 µg/L. While an LOR of <0.05 µg/L was achieved for a number of samples, the majority of the samples had an LOR of < 0.1 µg/L and reported values exceeding the lowest adopted screening value of 0.06 µg/L (freshwater ecological screening values) amounted to 137 out of the 145 monitoring wells sampled. The number of guidance exceedences (detections only) was limited to 47 out of 145 sampling locations.

Cadmium concentrations in *Background Monitoring Wells* were below a LOR of < 0.1 µg/L in three monitoring wells and at the LOR of 0.1 µg/L in the fourth background location. Reported concentrations above the maximum reported background concentration were limited to 31 out of 145 monitoring wells. These locations including monitoring wells within the accessible operational areas in the southern part of the power block, non-operational areas, down gradient of the Return Water Dam and down gradient of the CCPMF.

Copper

Copper concentrations ranged from the LOR of <0.5 µg/L to 100 µg/L across the groundwater monitoring well network, with an average concentration of 2.6 µg/L. Concentrations equalling or exceeding the lowest adopted screening values of 1 µg/L (freshwater ecological screening values) were recorded in samples from 59 of the 145 monitoring wells sampled. Samples with exceedences of the adopted screening values were taken from monitoring wells spread across the Site.

Copper concentrations in *Background Monitoring Wells* averaged 3.5 µg/L with a maximum reported concentration of 5 µg/L. Reported concentrations above the maximum reported background concentration were limited to a total of five monitoring wells. These include monitoring wells EA_MW01 and EA_X_GM1/D2 located down gradient of the CCPMF, monitoring well EA_MW16 located down gradient of the Return Water Dam, monitoring well EH_MW06 located adjacent to the Coal Storage Area, and monitoring well EJ_MW30 located in a non-operational area.

Lead

Lead concentrations ranged from the LOR of <0.1 µg/L to 64 µg/L across the groundwater monitoring well network, with an average concentration of 1.4 µg/L. Concentrations equalling or exceeding the lowest adopted screening values of 1 µg/L (freshwater ecological screening values) were identified in samples from 16 of the 145 monitoring wells sampled.

Monitoring wells with samples exceeding the adopted screening values were located predominantly in locations down gradient of the CCPMF and the Return Water Dam, in a number of locations in non-operational areas (including *Background Monitoring Well* EJ_MW07) and in operational areas including the operational and decommissioned UST area (ED_X_EPSMW8) and the workshops (EE_MW06).

In the *Background Monitoring Wells* lead concentrations where below detection limits of <1µg/L in three monitoring wells with a maximum reported concentration of 4 µg/L in the fourth *Background Monitoring Well.*

Reported concentrations above the maximum reported background concentration were limited to a total of six monitoring wells. These include monitoring well EA_X._GM1/D2 located down gradient of the CCPMF, monitoring well EA_MW02 located adjacent to the Return Water Dam, monitoring well EA_MW16 located down gradient of the Return Water Dam, monitoring well ED_X_EPSMW8 located in the downgradient section of the power station, and monitoring wells EJ_MW08 and EJ_MW30 located in non-operation areas.

Nickel

Nickel concentrations ranged from below the LOR of <0.5 μg/L to 254 μg/L across the groundwater monitoring well network, with an average concentration of 18 μg/L. Concentrations exceeding the lowest adopted screening value of 8 μg/L (freshwater ecological screening values) were identified in samples from 72 of the 145 monitoring wells sampled. Samples with exceedences of the adopted screening values were taken from monitoring wells located across the Site.

Nickel concentrations in the *Background Monitoring Wells* averaged 9 μg/L with a maximum reported concentration of 12 μg/L. Reported concentrations a factor of two above the maximum reported background concentration were limited to 47 out of the 145 monitoring wells sampled. These included monitoring wells located in the majority of EACs. The highest nickel concentrations were reported for monitoring well EA_MW16 (226 μg/L) located down gradient of the Return Water Dam and monitoring wells EA_X_GM1/D2 (131 μg/L) and EA_X_MW03 (114 μg/L) located down gradient of the CCPMF.

Selenium

Selenium concentrations ranged from 0.5 μg/L to 205 μg/L across the groundwater monitoring well network, with an average concentration of 6.8 μg/L. Concentrations exceeding the screening value of 5 μg/L (freshwater ecological screening values) were identified in samples from 13 of 145 monitoring wells (not accounting for samples where the LOR exceeded the screening value).

Monitoring wells with samples that exceeded the adopted screening values were limited to monitoring wells located at the transformer area, the workshops, non-operational areas, and locations down gradient of the CPPMF (with the highest concentration of 205 μg/L reported for monitoring well EA_X_GM1/D2).

Selenium concentrations in the *Background Monitoring Wells* were all below a laboratory LOR of <10 μg/L and exeedences of the assessment criteria are therefore not considered attributable to background conditions.

Zinc

Zinc concentrations ranged from 4 µg/L to 1 050 µg/L across the groundwater monitoring well network, with an average concentration of 57 µg/L. The majority of monitoring wells (134/145) exceeded the adopted screening values of 2.4µg/L (freshwater ecological screening values). Samples with exceedences of the adopted screening values were taken from monitoring wells spread across the Site.

Zinc concentrations in the *Background Monitoring Wells* averaged 37 µg/L, with a maximum reported concentration of 58 µg/L. Reported concentrations above the maximum reported background concentration included samples taken from 27 monitoring wells. These locations including monitoring wells within the accessible operational areas in the southern part of the power block, non-operational areas, down gradient of the Return Water Dam and down gradient of the CCPMF.

Low pH Distribution and Potential Influence of Acid Sulfate Soils

The pH of groundwater observed across the Site was typically low, and pH values within the nominated background monitoring wells ranged between 3.91 and 6.05 indicating that the groundwater is naturally somewhat acidic. Measured pH levels below 5 across the Site have been plotted on *Figure 6.6* (of *Annex A*), and the broad site distribution of groundwater with pH below 5, coupled with the pH levels observed in the background monitoring wells indicates that the majority of low pH measurements are attributable to natural conditions. In addition, areas of historical soil disturbance may have led to generation of actual acid sulfate soils (which would typically exhibit a pH level below 4). Measured pH levels below 4 were observed in 11 monitoring wells as follows:

- EA_MW01 (pH of 3.86) located adjacent to the CCPMF;
- EA_X_GM1/D2 (pH of 3.62) and EA_X_MW05 (pH of 2.82) between the CCPMF and Myuna Bay;
- EJ_MW52 (pH of 3.39) located down-gradient of the CCPMF and adjacent to Crooked Creek and Myuna Bay;
- EI_MW05 (pH of 3.81) located in the south eastern section of the power block. It is noted that the pH at this location in 2013 was 5.74;
- EJ_MW07 (pH of 3.91) located north of the CCPMF (noted to be a nominated background monitoring well);
- EJ_MW41 (pH of 3.75), EJ_X_GW1 (pH of 3.44) and EJ_X_GW3 (pH of 3.57) located adjacent to and down-gradient of the Attemperation Reservoir; and
- EJ_MW12 (pH of 3.7) located down gradient of the Attemperation Reservoir and adjacent to the Intake Canal.

Areas of suspected actual acid sulfate soils include the Attemperation Reservoir (and adjacent area) and the areas between the CCPMF and Myuna Bay. These areas have been highlighted within *Figure 6.6* (*Annex A*) and the estimated areas are based on an assessment of the measured field pH in groundwater, review of the geology encountered during the investigations, review of the topography of the areas with low pH and review of the areas of historically disturbed ground. While actual acid sulfate soils may be contributing to elevated metal and metalloid concentrations in near shore locations underlain by alluvial sediments in the vicinity of the Attemperation Reservoir and between the CCPMF and Myuna Bay, the distribution of elevated metal(loid) concentrations across the site and adjacent to site sources, suggests that the suspected actual acid sulfate soils in these locations is not the dominant influence on the elevated metal(loid) concentrations. Furthermore, pH levels in groundwater monitoring wells further down-gradient of these two areas (for example adjacent to Muddy Lake or Myuna Bay) suggests the areas of actual acid sulfate soils are spatially limited.

Relationship between Groundwater Salinity and Metal(loid) Concentrations

The relationship between groundwater salinity and metal(loid) concentrations were assessed by plotting arsenic, cadmium, chromium, nickel, selenium and zinc data against the field EC measurements. Two plots were created for each metal(loid), one that contained all groundwater sampling data (refer to *Plot R1a* through to *Plot R8a* in *Annex R*) for the metal(loid) in question and one that included all data with the exception of EA_X_MW03 that had an anomalously high EC measurement when sampled in July 2013 (refer to *Plot R1b* through to *R8b* in *Annex R*).

The first series (the a-series) of plots that contain all data were provided for completeness (and indicate that the metal and metalloid concentrations in EA_X_MW03 were not particularly elevated when compared to the other data points). The second series (b-series) of plots provided better resolution on the dataset with the anomalously high EC measurement for EA_X_MW03 excluded.

To assess the level of correlation between EC measurements and metal(loid) concentrations, a linear trendline with associated R^2 value (representing the goodness of fit of the trendline to the data) were fitted to the data in each of the b-series plots. These plots and the R^2 values indicate that that there is no clear correlation between EC measurements and metal(loid) concentrations, and the inference is therefore made that groundwater salinity does not have a key site-wide influence on metal and metalloid concentrations.

Summary

Across the Site, the majority of monitoring wells reported metals and metalloid results less than the maximum concentrations seen in the *Background Monitoring Wells*. For copper and zinc, the number of monitoring wells with samples that have concentrations above background values were an order of magnitude less than the number of monitoring wells with exceedences of the adopted assessment criteria (i.e. one tenth of the number of samples exceeding the adopted screening values). For cadmium, lead and nickel, the number of samples with concentrations above background values was approximately a factor of two less than the number of samples exceeding the adopted screening values.

Conversely, based on the approach to assessing background conditions as discussed above, the arsenic and selenium exceedences of the assessment criteria cannot be attributed to background conditions. Where concentrations of metal(loids) in groundwater were measured above background values, impact appears to be localised in distinct areas of the site with the main potential source areas appearing to be the CCPMF and to a lesser extent the Return Water Dam.

Evaluation of 2014 Data In Comparison to 2013 Dataset

Additional groundwater field parameter and metal(loid) concentration data collected during the November /December 2014 groundwater sampling event are presented in *Table 6* of *Annex B* along with data collected in July to September 2013.

A review of Site wide pH measurements for both the 2013 and 2014 datasets confirm that relatively acidic conditions (with pH levels below 5) occurring predominantly in the southern section of the power block, the Attemperation Reservoir area, directly adjacent to the CCPMF and between the CCPMF and Myuna Bay. In addition to the low pH areas outlined above, the sampling conducted in 2014 further identified low pH conditions in the north western section of the Site (in close proximity to the northern gas turbine location and the truck wash-out puts) and in the western section of the site at monitoring wells EJ_MW01 and EJ_MW02.

Additional characterization work conducted down-gradient of the CCPMF in 2014, reviewed together with the 2013 data, suggest that pH levels below 4.5 are relatively localised. Over both sampling rounds monitoring wells with pH levels below 4.5 located between the CCPMF and Myuna Bay have been restricted to five monitoring wells (EA_X_GM1/D2, EA_MW01, EA_X_MW05, EJ_MW50 and EJ_MW52).

The majority of groundwater pH measurements taken from monitoring wells located to the south and down-gradient of the CCPMF during the sampling events have been above 5.5, indicating that groundwater seepage from the CCPMF is acidic. In the lower laying areas adjacent to Myuna Bay (and in the Attemperation Reservoir area) the pH conditions <4.5 may be in part attributable to acid sulfate soil conditions (with suspect areas estimated on *Figure 6.6* of *Annex A*).

While some variation in reported metal and metalloid concentrations were observed for monitoring wells sampled during both the 2013 and 2014 groundwater monitoring events, general patterns of impact were broadly similar across the sampling events. Where concentrations of metal(loids) in groundwater considered to be above background values were observed, the impact appears to be localised in distinct areas of the Site with the main potential source areas appearing to be the CCPMF and to a lesser extent the Return Water Dam. There is a degree of correlation with low pH samples and elevated metal concentrations, but not all samples with elevated metal concentrations have low pH levels (e.g. EJ_MW51 and EK_MW11). It is therefore regarded that potential sources such as the CCPMF provide the primary loading of metal(loids) concentrations in groundwater (above background).

Additional monitoring wells installed to the south and down-gradient of the CCPMF have improved the delineation of the metals impact, indicating that elevated metals concentrations remain higher adjacent to the CCPMF with an order of magnitude reduction in concentrations within down-gradient monitoring wells (towards Myuna Bay). Comparison of metals concentrations within monitoring wells EA_MW03, EA_MW23 (additional monitoring well), EA_X_D29, EA_X_D26, EJ_MW50 (additional monitoring well) and EA_MW21 (which all flank the far down gradient edge of the CCPMF) show metals concentrations either below the adopted human health and ecological screening values or at significantly lower concentrations than those observed up-gradient at the 'toedrain' (directly adjacent to the CCPMF).

One exception was the additional monitoring well EJ_MW51 which was installed at the eastern most down-gradient edge of the CCPMF and reported elevated metals above human health and ecological screening values (including zinc, nickel and copper). No discernible source was noted near EJ_MW51 and monitoring wells EA_MW21 and EJ_MW08 cross gradient reported significantly lower metals concentrations. A similar metals signature to EJ_MW51 was also identified within EJ_MW02 at the western boundary of the power station. This location is also noted to have no discernible contamination sources within the vicinity. It is considered that the metals concentrations observed at EJ_MW51 (and EJ_MW02) are likely to be a reflection of the broader groundwater quality surrounding the site.

Groundwater monitoring wells EJ_MW47 and EJ_MW49 were installed during the Additional Stage 2 ESA within down-gradient lots 'offsite' from the operational area of the power station and the Attemperation Reservoir. These monitoring wells reported concentrations of metals below the adopted human health and ecological screening values with the exception of minor detections of copper and zinc. Concentrations of copper and zinc were both of magnitudes similar to background levels measured at the site boundaries. Groundwater monitoring wells EJ_MW52 and EJ_MW53 were installed during the Additional Stage ESA works within the Myuna Bay Sport and Recreation Facility. Both monitoring wells were located adjacent to Crooked Creek (a receiving surface water body of potential excess flows from the CCPMF). Concentrations of metals in groundwater at EJ_MW52 were significantly lower than those measured up-gradient at the CCPMF toe drain with metal concentrations in EJ_MW53 (further down gradient) reported below the adopted human health and ecological screening values. These metals results in consideration with other down-gradient monitoring wells indicate the CCPMF has a limited impact on the groundwater quality at far down-gradient locations.

It is noted that arsenic and selenium (which have not been identified in background monitoring wells) were detected in groundwater monitoring wells at the toe drain of the CCPMF but not detected in groundwater monitoring wells further down-gradient of the CCPMF. Monitoring wells with arsenic above the human health drinking water screening value were noted within the operational area and adjacent to the CCPMF with groundwater impacts beyond these areas not observed during the 2013 or 2014 sampling events. The adopted ecological or recreational screening values were not exceeded across the site for arsenic in groundwater. Selenium was not identified above the human health or ecological screening values within groundwater monitoring wells down-gradient of the CCPMF with the exception of those well adjacent to the toe drain.

The 2014 sampling event confirms that selenium impacts observed are limited to directly adjacent to the CCPMF and are not present within groundwater far down-gradient from the site.

5.7 *DATA QUALITY*

A detailed evaluation of the QA/QC results for this assessment is provided in *Annex F.* There were a number of instances during the initial Stage 2 ESA, where the adopted screening values were less than the laboratory LOR. Subsequent analysis during the Additional Stage 2 ESA was completed (where appropriate) to achieve the required laboratory LOR.

These specific instances are discussed below.

- Pentachlorophenol in groundwater (LOR of 2 µg/L for a limited number of samples) - the LOR exceeded the NHMRC (2008) screening level for recreational use within individual wells in all of the AECs, with the exception of AEC EK. A lower LOR (0.05 µg/L) was achieved for pentachlorophenol for the remaining samples. Pentachlorophenol was detected at the LOR (0.05 µg/L) in one sample (EK_MW07) and was not detected above the LOR at any other location. Hence pentachlorophenol is not considered to be constituent of concern for the Site and this non-conformance is not considered to affect the outcomes of this investigation.

- Benzo(a)pyrene in groundwater (LOR of 0.05 µg/L and 0.5 µg/L) - the LOR exceeded the NHMRC (2011) ADWG value (0.01 µg/L) in the majority of samples and in some instances the LOR also exceeded the NHMRC (2008) screening level for recreational use (0.1 µg/L). An LOR of 0.005 µg/L was achieved during the initial Stage 2 ESA at individual locations in AEC EB, EE and EI. Benzo(a)pyrene was detected above the LOR at five locations; in AEC EJ, EI EE and EC. These impacts are not considered likely to pose a direct potential human health risk in the absence of potable groundwater use in the vicinity of the Site but the reporting of these impacts to the NSW EPA may be required on the basis of exceedences of trigger values outlined in the NSW EPA (2015) Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997. Subsequent analysis (achieving an LOR of 0.005 µg/L) was completed at selected groundwater monitoring wells sampled (as part of the Additional Stage 2 ESA) to determine the nature and extent of the previously identified PAH impacts. As noted previously, the minor exceedence of Benzo(a)pyrene was not considered to pose a risk to human health but may require report to the EPA (refer to *Section 5.8.3.*)

- Benzo(g,h,i)perylene in groundwater (LOR of 1 µg/L) - the LOR exceeded the marine ecological screening level which are derived from the Dutch screening values (RIVM, 2001; 0.18 µg/L), in a large number of samples. A lower LOR (0.1 µg/L) was achieved at the majority of locations for the initial Stage 2 ESA. Two exceedences were detected in AEC EJ, however these were marginally above the LOR and less the 250% of the screening value, hence was not considered to be significant. Furthermore, subsequent resampling of these locations during the Additional Stage 2 ESA (with a 'super ultra-trace' method) achieved a laboratory LOR of 0.01 µg/L and reported concentrations of Benzo(g,h,i)perylene below the adopted screening values. Therefore, this LOR non-conformance is not expected to have affected the outcomes of this investigation.

- Benzo(k)fluoranthene in groundwater (LOR of 1 µg/L) – the LOR exceeded the marine ecological screening level which are derived from the Dutch screening values (RIVM, 2001; 0.36 µg/L), in a large number of samples. A lower LOR (0.1 µg/L) was achieved at the majority of locations (during the initial Stage 2 ESA) with an LOR of 0.02 µg/L achieved during the Additional Stage 2 ESA. All recorded concentrations were found to be below the LOR. Therefore, this LOR non-conformance is not expected to have affected the outcomes of this investigation.

- Indeno(1,2,3-c,d)pyrene in groundwater and surface water (LOR of 0.1 µg/L and 1 µg/L) – the LOR exceeded the marine ecological screening level which are derived from the Dutch screening values (RIVM, 2001; 0.036 µg/L). A lower LOR (0.02 µg/L) was achieved in a small number of samples (during the initial Stage 2 ESA) with an LOR of 0.01 µg/L achieved during the Additional Stage 2 ESA. Concentrations were found to be below the LOR, with the exception of one instance (EJ_MW18) during the 2013 sampling event. Subsequent resampling of EJ_MW18 in 2014 reported concentrations of indeno(1,2,3-c,d)pyrene below all adopted screening values. Indeno(1,2,3-c,d)pyrene is therefore not considered to be a primary constituent of concern and this LOR non-conformance is not considered to have affected the outcome of the investigation.

- 1,2-dibromoethane, 1,2-dichloroethane and hexachlorobutadiene (LOR of 5 µg/L) – the LORs for these chemicals exceeded the corresponding NHMRC (2011) ADWG values in all the samples analysed. Concentrations of these analytes were generally below the LOR in all instances and complied with the relevant recreational and ecological screening values. VOC ultra-trace analysis was completed during the Additional Stage 2 ESA on a selected number of monitoring wells. Although these compounds are not considered to be primary constituents of concern for the Site, the additional analysis also confirmed the absence of significant VOC impacts.

- Bromomethane and chloromethane (LOR of 50 µg/L) – the LORs for these chemicals exceeded the adopted recreational screening values and the NHMRC (2008) ADWG values. Halogenated hydrocarbon compounds were below the LOR in all samples collected at the Site. Hence these compounds are not considered to be primary constituents of concern for the Site and these LOR non-conformances are considered unlikely to have affected the outcomes of this investigation.

- Vinyl chloride (LOR of 50 µg/L) - the LOR exceeded the adopted recreational screening values and the NHMRC (2011) ADWG values. This issue was raised in the SAQP and across the majority of the Site, this LOR non-conformance is not considered likely to affect the outcomes of the assessment, as chlorinated hydrocarbon constituents have not been identified as COPC. Further investigation of potential vinyl chloride impacts were undertaken (including ultra-trace VOC analysis) within AEC EE, where the historic use of TCE has been reported and in AEC EI, where tetrachloroethene was identified in groundwater.

- Ecological screening values for freshwater ecosystems were adopted for AEC EJ, and the LOR for 1,2,3-trichlorobenzene, selenium, mercury and cadmium were above these screening values. The LORs for these chemicals did however not exceed the adopted marine screening values or NHMRC (2011) ADWG values. Additional ultra-trace metals analysis (including achieving LORs below the aforementioned constituents) was completed as part of the Additional Stage 2 ESA and has been report as part of Section 5.

- PAHs - the LOR for a variety of PAH constituents in sediment collected from AEC EJ exceeded the adopted ISQG-low values. The LOR for total PAHs did not exceed the ISQG-low value however and total PAHs were not detected in any of the sediment samples. On this basis this LOR non-conformance is not considered likely to affect the outcomes of this assessment.

5.8 *OVERALL DISCUSSION*

The primary objective of this Stage 2 ESA was to develop a baseline assessment of environmental conditions at the Site and immediate surrounding receiving environments at or near the time of the transaction. The results of the assessment have also been used to assess;

- The nature and extent of soil, sediment, surface water and/or groundwater impact on / beneath the Site and in relation to neighbouring sensitive receptors.

- Whether the impacts at the Site represent a potential risk to human health and/or the environment, based on the continuation of the current use (in consideration of the current zoning).

- Whether the impacts at the Site is likely to warrant reporting and / or regulation under the *Contaminated Land Management Act 1997.*

- Whether the data collected during the assessment was of a suitable quality and completeness to provide a baseline of environmental conditions at the Site and immediate surrounding receiving environments.

The overall results of the assessment are discussed herein, with reference to these objectives.

5.8.1 *Summary - The Nature and Extent of Soil, Sediment, Groundwater and Surface Water Impact*

A CSM was developed (as presented graphically in *Annex C*), which identified the following ecological and human receptors:

- terrestrial ecological receptors within the open space areas both on and surrounding the Site, particularly to the north and west;
- onsite employees, including intrusive workers labouring within shallow trenches/excavations and works conducting groundwater monitoring;
- recreational users of the Myuna Bay Sports and Recreation Centre and Lake Macquarie, including Myuna Bay and Bonnells Bay and their tributaries;
- freshwater aquatic organisms within the Muddy Creek wetland;
- residents of Dora Creek, although this residential area is located approximately 480 m from the Site boundary;
- marine aquatic organisms within the estuarine environment of Lake Macquarie, Bonnells Bay, Lake Eraring and Whiteheads Lagoon.

The soil, sediment, surface water and groundwater data was compared against published environmental quality levels to provide a screening level assessment of potential risks to these identified receptors. The findings of this screening indicated that concentrations in soil, sediment, groundwater and surface water complied with the adopted screening values, with the following exceptions:

Onsite Soil

- TRH were detected at concentrations in excess of the ecological screening values for commercial/industrial sites in soil samples, collected within the Transformer Area, Fuel Oil Installation Area and Coal Storage Area.
- TRH were detected in excess of the ecological screening values for open space areas in soil samples collected along the Coal Haul Rd.
- Benzo(a)pyrene was detected at a concentration in excess of the ecological screening values for commercial/industrial sites in soil samples collected from within the Workshop Area and Accessible Operation Areas.
- Arsenic, copper, nickel and/or zinc were detected at concentrations in excess of the ecological screening values for commercial/industrial sites in soil samples collected from within the CCPMF Area, Transformer Area, Workshops and Accessible Operational Areas.

- Arsenic, copper, nickel and/or zinc were detected at concentrations in excess of the ecological screening values for open space areas in soil samples collected from within the Nonoperational Areas and adjacent to the Coal Haul Rd.

- Lead was detected at a concentration in excess of the human health screening level in a single soil sample collected from within the Accessible Operation Areas. This sample also reported an elevated zinc concentration.

Onsite Groundwater

- Copper, lead, mercury and zinc were detected at concentrations in excess of the ecological screening values for marine environments in groundwater samples collected from across the Site.

- Cadmium, copper, lead, nickel, selenium and zinc were detected at concentrations in excess of the ecological screening values for freshwater environments in groundwater samples collected from the Nonoperational Areas.

- Arsenic, nickel, selenium were detected at concentrations in excess of the NHMRC (2011) ADWG values in groundwater samples collected from across the Site.

- PFOS and PFOA were detected in groundwater collected from within the Transformer Area, Coal Storage Area and Current Fire Training Area.

- PAH were detected at a concentration in excess of the NHMRC (2011) ADWG value in individual wells located within the Fuel Oil Installation Area and Workshop Area. PAH concentrations also exceeded the adopted recreational screening values in a groundwater sample collected from the Nonoperational Area, down gradient of the Fuel Oil Installation.

- Naphthalene was detected at a concentration in excess of the ANZECC (2000) marine trigger value in an individual well in the area surrounding the Operational and Decommissioned USTs.

- Vinyl chloride was detected at concentrations in excess of the NHMRC (2011) ADWG value in three monitoring wells located within the Workshop Area.

Crooked Creek, Return Water Dam, Whiteheads Lagoon, Myuna Bay and Lake Eraring

- Arsenic, copper, and zinc were detected at concentrations in excess of the ISQG-Low values in sediment samples collected from within Crooked Creek, the Return Water Dam, Myuna Bay, Bonnells Bay and Whiteheads Lagoon.

- Nickel was detected at concentrations in excess of the ISQG-low and/or ISQG-high value in sediment samples collected at a single location within Whiteheads Lagoon.

- In the absence of ANZECC and ARMCANZ (2000) screening values for selenium in sediment, the British Columbia Ministry of Environment (2001) *Ambient Water Quality Guideline* marine sediment screening value for selenium of 2 mg/kg has been adopted in this assessment. This value is designed to be protective of selenium bioaccumulation through the food chain and direct selenium toxicity. Selenium concentrations in sediment ranged from 0.1 to 42 mg/kg across the aquatic areas sampled. The highest selenium concentrations were observed in sediment samples collected from within the Return Water Dam and Crooked Creek. Concentrations of selenium in sediments were significantly lower in Whiteheads Lagoon with concentrations of selenium in Myuna Bay being of the same order of magnitude as those measured in the Control locations.

- Zinc, copper and nickel concentrations were reported at concentrations in excess of the ANZECC (2000) marine trigger values in surface water samples collected from within Crooked Creek, the Return Water Dam, Myuna Bay, Bonnells Bay and Whitehead Lagoon.

- There was no marine water screening value identified for selenium but the highest selenium concentrations were reported in surface water samples collected from within the Return Water Dam and Crooked Creek.

- The highest zinc concentrations were recorded in surface water samples collected from Crooked Creek, immediately down gradient of the CCPMF.

- Sediment samples were collected from the base of four drainage channels on Eraring land to the north of Wangi Road, which drain to Lake Eraring, to allow for assessment of potential impacts to Lake Eraring from the Site. Constituents were reported at concentrations below the adopted screening values in these samples.

General Observations

No free-phase product was observed at any of the sampling locations. A sheen was identified in EJ_MW22 (2013) and in EE_MW10 (2014).

Asbestos was identified in shallow soil in the vicinity of the pipework located along Pipe Road to the east of the Power Station operational area. Asbestos fibres were also detected in samples of fibre cement sheeting collected from within the former fire training area and CCPMF Area and in a surface soil sample collected from the Accessible Operational Areas.

It is also noted that the vertical boring of soils is not a comprehensive method via which to identify asbestos. The absence of asbestos in other areas across the Site therefore cannot be guaranteed on the basis of the results of this assessment.

Suspected actual acid sulfate conditions were identified in groundwater monitoring wells located to the south of the CCPMF and in the vicinity of the Attemperation Reservoir, inlet canal and southern Site boundary (refer to *Figure 6.6* of *Annex A*). Potential acid sulfate conditions were also identified in surface water samples collected to the north of the Attemperation Reservoir. Previous earthworks noted to have occurred in these areas may have contributed to these conditions.

The findings of the buried waste investigation were consistent with anecdotal evidence provided by Eraring Power Station personnel on the extent of the onsite landfills. No field indicators of contamination, such as staining, odours, stressed vegetation or ACM were noted in borelogs or on the Site surface, outside the landfill areas designated by Eraring Power Station personnel. Additional investigation locations east and west of the General Waste Landfill confirmed the lateral extent (consistent with previous findings).

5.8.2 *Summary - Does the Identified Impact Represent a Risk to Human Health and/or the Environment?*

The approach to the screening of the data gathered in this assessment was to initially adopt the most appropriate potential assessment values. The exceedences of the screening values outlined in *Section 5.8.1* were subsequently assessed on a case by case basis, in light of the specific characteristics of the individual sample and the area from which the sample was collected. The conclusions of these further assessments were as follows;

Onsite Soil

The TRH ($>C_{10}$-C_{16}), copper and/or benzo(a)pyrene impacts identified within the Transformer Area, Fuel Oil Installation Area, Workshop Area, Accessible Operational Area and Coal Storage Area at concentrations in excess of the adopted ecological screening values are likely to represent localised hotspots. These impacts are either located at depth or are located in operational areas beneath asphalt. These impacts are therefore considered to represent a low potential risk to the terrestrial environment under the ongoing use of the Site as a Power Station and associated activities, in line with the current zoning as outlined within the revised 2014 Local Environment Plan (LEP).

TRHs were also detected in excess of the ecological screening values for open space in shallow soil samples collected along the Coal Haul Rd. These impacts are likely to be attributable to coal fines/dust observed along the road as a result of long-term coal transport. Given the marginal nature of these exceedences, these impacts indicate a low potential risk to the wider surrounding bushland environment.

Nickel and zinc were detected at concentrations in excess of the ecological screening values in a number of samples within the CCPMF Area and Accessible Operational Area. These impacts were generally <250% of the relevant screening level and consistent with background conditions at the Site. These impacts are present a low potential risk to the terrestrial environment under the ongoing use of the Site as a Power Station and associated activities, in line with the current zoning as outlined within the revised LEP.

The one exception to this was a shallow soil sample collected from the vicinity of the demountable contractor sheds in the Accessible Operational Area, where more elevated concentrations of metals were detected and the measured concentration of lead exceeded the adopted human health screening level. Further investigation results confirmed the limited spatial extent of this lead impact. Access to the soil in this area is restricted by the presence of compacted gravel, which is considered to mitigate any potential health risk associated with these impacts. Significant exposure to these metals may occur in the event that the overlying compacted gravel was removed or excavation of the area was undertaken. As such, an EMP should be developed and implemented as a control measure for future ground disturbance in this area.

More elevated concentrations of arsenic, copper, nickel and zinc were also observed in a shallow soil sample collected from adjacent to the cooling towers within the non-operational Areas. Likely anthropogenic material was recorded in this sample. Given the operational activities undertaken in the immediate vicinity of the location, these impacts are unlikely to represent a risk to the terrestrial environment under the ongoing use of the Site as a Power Station and associated activities, in line with the current zoning as outlined within the revised LEP.

Nickel and zinc were detected at concentration marginally in excess of the ecological screening values in soil samples collected adjacent to the Coal Haul Rd. Although the presence of coal fines/dust is likely to have contributed to these results, the metal concentrations reported are of the same order of magnitude as concentrations observed across the Site. Given the marginal nature of these exceedences, these impacts are considered unlikely to indicate a risk to the wider surrounding bushland environment.

PFCs were detected within shallow soils within three parts of the Site however the measured concentrations were below the adopted screening values. Within the operational area, impacts were limited to two locations with no known or observed onsite source. At the western site boundary, PFOS was identified (limited to shallow soils) at one location which was delineated during additional investigations. The PFCs were noted to be isolated at this location with no known or observed source. Within the fire training area, PFCs were identified within shallow soils (consistent with historical activities in the area) however all results were below the adopted screening values.

The lateral distribution of PFCs observed is consistent with the surface water flow path to the east as well as the properties of PFCs (which are environmentally stable, relatively soluble and hydrophilic). Based on the observed occurrences of PFCs within limited parts of the Site, the impacts are unlikely to present a risk to human health or the environment.

Potential areas of acid sulfate soils have been identified in the vicinity of the CCPMF, Attemperation Reservoir and southern Site boundary. Published acid sulfate soil information (www.asris.csiro/mapping/viewer.htm, accessed on 24 May 2013) also indicates a high probability of encountering acid sulfate soils immediately to the south of the Site. The comprehensive delineation of areas of ASS and Potential Acid Sulfate Soils (PASS) was not however undertaken within the scope of this investigation. Monitoring wells surrounding and down-gradient of the Attemperation Reservoir identified varying pH impacts with some monitoring wells exhibiting low pH indicative of oxidised acid sulfate soils. Correlating metals impacts were not observed in all monitoring wells however elevated nickel was apparent surrounding the Attemperation Reservoir. Down gradient of the CCPMF, potential acid sulfate soil conditions were only identified within two monitoring wells. The estimated areas of suspect actual acid sulfate soils is presented in *Figure 6.6* of *Annex A* and is based on a qualitative assessment of field pH measured during groundwater monitoring well sampling, review of the geology encountered during the investigations, review of the topography of the areas with low pH and review of the areas historically disturbed ground.

On-site Groundwater

Groundwater beneath the Site is not extracted for potable use and licensed groundwater bores have not been identified in the area down gradient of the Site. The saline groundwater conditions are also likely to reduce the opportunity for the potable or domestic use of groundwater in the vicinity of the Site in the future. Similarly, the groundwater beneath the Site is not considered to be an aquatic environment of significance for the purpose of this assessment.

The ANZECC (2000) marine ecological trigger values and NHMRC (2008) recreational screening values were adopted in this assessment to evaluate potential risks to the aquatic environment and recreational users of Lake Macquarie and its tributaries. The NHMRC (2011) ADWG were also adopted to evaluate the requirement to report groundwater contamination across the Site, in accordance with the NSW EPA (2015) *Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997* (refer to *Section 5.8.3)*.

Measured concentrations of metals in groundwater exceeded the ANZECC (2000) marine trigger values and NHMRC (2011) ADWG values in a large number of wells across the Site. Exceedences of the NHMRC (2008) recreational screening values were only reported in a small number of wells. The widespread occurrence of these elevated metal concentrations and the groundwater results from up gradient wells in nonoperational areas (e.g. up gradient wells in AEC EJ) demonstrate that background conditions at the Site are likely to contribute to these metal detections.

Nickel, zinc and selenium concentrations greater than those measured in background areas were however identified in groundwater samples collected directly downgradient of the CCPMF Area in particular. Based on the Additional Stage 2 ESA and subsequent resampling of groundwater monitoring wells (forming a significant network) adjacent to and down-gradient of the CCPMF, it is therefore considered that the operation of the CCPMF may have contributed to metals impacts in groundwater directly down-gradient of and adjacent to the CCPMF and 'toe drain'. However, these impacts are not observed within groundwater at further down-gradient locations (150 – 300 m away) indicating the absence of broader down-gradient metals impacts (in groundwater). Suspected actual acid sulfate conditions in the area downgradient of the CCPMF may also be contributing to the mobilisation of metals in groundwater. Whilst a small number of monitoring wells reported concentrations of metals above recreational (direct contact) screening values, based on the decreasing concentrations in down-gradient monitoring wells away from the known sources, the concentrations in monitoring wells at the site boundary and the results of surface water sampling within the surface water receptors, it is considered that the groundwater impacts emanating from the site represent a low risk to human health. Based on the distribution of metals in downgradient monitoring wells from known sources such as the CCPMF, it is noted that exceedences of ecological screening values are present at site boundary locations. In the context of the current and historic urban and industrial inputs (including the broader site operational processes such as historical influences on sediments from operational discharges to surface water), the risk to the environment from metals in groundwater emanating from the site is considered low.

PAHs were detected at a concentration in excess of the NHMRC (2011) ADWG value and/or ANZECC (2000) marine trigger value in individual wells located within the Fuel Oil Installation Area and Workshop Area and in the area surrounding the Operational and Decommissioned USTs. PAH concentrations also exceeded the adopted recreational screening values in a sample collected from the nonoperational area downgradient of the Fuel Oil Installation. Concentrations of PAHs were below the adopted screening level in all remaining groundwater samples collected across the Site, including the wells located on the downgradient Site boundary. On this basis these impacts are unlikely to indicate the potential for significant migration of PAH compounds into offsite surface water bodies, where they may represent a risk to human health or the environment.

PAH constituents were detected in sediment samples collected from throughout the sampling area at concentrations below the adopted screening values but the samples collected from Bonnells Bay and Myuna Bay reported results of a similar order of magnitude to those collected from Whiteheads Lagoon and Crooked Creek.

These results suggest that a range of activities may have contributed to the PAH impacts measured within the sediment, potentially including a range of current and historic urban and industrial inputs and recreational boating activities, in addition to potential outputs from power generation activities (eg coal fines).

In the absence of a more appropriate guideline, UK Health Protection Agency (UK HPA, 2009) screening values for the protection of drinking water were adopted to evaluate identified PFOS and PFOA impacts in groundwater. Concentrations of PFOS and PFOA were below these screening values in the groundwater samples across the Site with the exception of monitoring wells installed within the current fire training area.

PFOS/PFOA impacts detected in groundwater across the site were identified within the operational area, the coal storage area and the fire training area. Based on the sub-catchment analysis and the inferred groundwater flow direction, impacts within the coal storage area and operational area are noted to decrease significantly with down-gradient monitoring wells reporting concentrations of PFOS/PFOA below the laboratory LOR. PFC impacts in groundwater within the fire training area appear to be limited to the immediate fire training area with wells located downgradient reporting PFCs below the laboratory LOR. This is further supported by monitoring wells adjacent to Whiteheads Lagoon and Crooked Creek reporting concentrations of PFCs below the laboratory LOR. Ecological screening values were not identified for PFOA however a value of 7.2 µg/L (from RIVM MAC for marine ecosystems) was adopted for PFOS. Site wide PFOS concentrations were below this screening value for protection of marine ecosystems with the exception of one monitoring well within the current fire training area. Whilst a connection between surface water flows from the fire training area to the east is present, based on the absence of PFOS and PFOA in the down-gradient monitoring wells, the detections of PFOS and PFOA are unlikely to represent a risk to ecology or offsite recreation users of Lake Macquarie and its tributaries. Groundwater monitoring wells down-gradient of the operational area and at the site boundary also reported PFCs below the laboratory LOR indicating that current offsite migration is unlikely.

Vinyl chloride was detected within a limited number of monitoring wells adjacent to the workshops and within the operational area of the power station. Based on detections of other VOC compounds such as trichloroethene, tetrachloroethylene and chloroform) (at minor levels), these impacts can be attributable to the operation of the workshops and the historical use of solvents.

The minor exceedences of the drinking water screening value for vinyl chloride are not considered to pose a risk to human health based on the magnitude of the detection and the absence of groundwater abstraction for potable use.

Crooked Creek, Return Water Dam, Whiteheads Lagoon, Myuna Bay and Lake Eraring

Arsenic, copper, nickel and zinc have been detected in sediment samples collected from within Crooked Creek, Whiteheads Lagoon and Myuna Bay at concentrations in excess of the adopted screening values. The distribution of these impacts however, suggests the contribution of a wide range of sources, including a range of current and historic urban and industrial inputs, in addition to potential outputs from power generation activities over a long period of time.

The selenium seepage and discharges associated with the operation of the CCPMF and/or the historical operation of the Wangi Ash Dam appear to have resulted in impacts to the Return Water Dam, Crooked Creek and to a lesser extent Whiteheads Lagoon. These impacts do not however appear to have translated into elevated selenium concentrations in sediment or surface water within Myuna Bay.

Furthermore, selenium and arsenic impacts are not apparent within groundwater far down-gradient of the CCPMF, which could be expected to discharge to (or be in connection with the aforementioned surface water features). The risk to human health (recreational users) from direct contact with selenium impacted surface water, groundwater or sediments is considered low based on the concentrations observed. Based on the results, there is a potential risk to the environment (including ecological exposure and ingestion of fish) from selenium impacts. The implications of site derived releases relative to other sources of COPCs (e.g. selenium) to Lake Macquarie and the potential for exposures for fish ingestion has not been determined as part of this assessment (and would be very difficult to achieve). It is noted that broader more holistic assessments of surface water and sediment impacts in Lake Macquarie have already been conducted and published (Nobbs *et al.* 1997, Kirby *et. al.*, 2001, Lake Macquarie City Council, 1995). To this end, a more detailed assessment or risk assessment for the recreational users is not considered warranted.

Nickel impacts to groundwater downgradient of the CCPMF may also have resulted in nickel impacts to sediment within the Whiteheads Lagoon, although nickel concentrations in excess of the ISQG values were only identified in a single sediment sampling location. These results do not suggest that historical discharges to Whiteheads Lagoon have resulted in widespread nickel impacts.

The highest zinc concentrations were recorded in surface water samples collected from Crooked Creek, immediately downgradient of the CCPMF. There may be temporal variability associated with these results due to flow changes with the operation of the CCPMF and due to seasonal variations. As such this investigation does not account for these variations. Zinc concentrations in surface water collected from the lower reaches of Crooked Creek at were consistent with those measured in the broader study area.

The sediment samples collected from the base of drainage channels to the north of Wangi Road generally reported at concentrations below the adopted screening values in these samples. These results suggest that the impact of the Site on Lake Eraring is unlikely to be significant.

General Observations

The asbestos and ASS identified on the Site have the potential to represent a risk to the health of onsite employees if disturbed. The most appropriate methodology via which to manage these potential risks is considered to be the implementation of appropriate management procedures (such as updating the asbestos register) which manage and reduce the potential risk of exposure to these impacts to an acceptable level. Bases on the current site conditions, the risk to human health from the asbestos or ACM fragments identified during the Stage 2 ESA works (at EA, EI, EJ and EL) is considered low.

Where low pH conditions have been identified (in association with potential or suspected actual acid sulfate soils), appropriate site controls/procedures (such as an EMP) could be implemented (in line with industry best practice) to control future ground disturbance activities within these areas.

5.8.3 *Summary - Does the Impact Warrant Notification and/or Regulation under the Contaminated Land Management Act 1997?*

Under section 60 of the CLM Act, a person whose activities have contaminated land or a landowner whose land has been contaminated is required to notify NSW EPA when they become aware of the contamination. The NSW EPA (2015) *Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997*, state that an owner of land which is contaminated or a person whose activities have contaminated land is required to notify NSW EPA that the land is contaminated if;

- "the level of the contaminant in, or on, soil is equal to or above a level of contamination set out in Schedule B1 of the *National Environment Protection (Assessment of Site Contamination) Measure 1999* (NEPC 2013) or other approved guideline values with respect to a current or approved use of the land, and people have been, or foreseeably will be, exposed to the contaminant; OR

- the contamination meets a criterion prescribed by the regulations; OR
- the contaminant or a by-product has entered, or will foreseeably enter, neighbouring land, the atmosphere, groundwater or surface water, and is above, or will foreseeably be above, a level of contamination set out in *National Environment Protection (Assessment of Site Contamination) Measure 1999* (NEPC 2013) or other approved guidelines and will foreseeably continue to remain equal to or above that level."

The soil, groundwater, surface water and sediment results obtained in this assessment have been compared against the screening values specified in the ASC NEPM (2013) and a number of exceedences have been identified. Every exceedence of these screening values is not however required to be reported to the NSW EPA; it is the potential for receptors (human or environmental) to be exposed to the contamination and the risks posed by that exposure, which drives the need for action.

An evaluation of the Section 60 notification triggers as outlined in *Section 2.3* of the NSW EPA (2015) *Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997* has been summarised in the table below and further discussion is provided in this section.

Table 5.14 Summary of Duty to Report Requirements under S.60 CLM Act

NSW EPA (2015) Notification Trigger under S.60 of the CLM Act	Evaluation of Site Data Notification Trigger
On-site soil EITHER the 95% upper confidence limit on the arithmetic average concentration of a contaminant in, or on, soil on the land is equal to, or above the HIL or HSL for that contaminant for the current or approved use of the respective on-site land, as specified in S.6, Schedule B1 of the ASC NEPM (2013): OR the concentration of a contaminant in an individual soil sample from the land is equal to, or above, two and a half times the HIL or HSL for that contaminant for the current or approved use of the respective on-site land, as specified in S.6, Schedule B1 of the ASC NEPM (2013): AND	Lead was detected at a concentration in excess of the HIL-D in a single soil sample collected from within AEC EI. The 95% UCL for lead in surface soils within AEC EI was less than the HIL-D, and the individual soil concentration was less than two and a half times the HIL-D. Therefore this condition has not been met.
a person has been, or foreseeably will be, exposed to the contaminant or any by-product of the contaminant.	The ground surface is compacted gravel overlying fill which limits pathways for potential exposure. As the first condition has not been met, and there are limited pathways for direct exposure, this condition has not been met.
Duty to report?	The triggers for the duty to report have not been met for on-site soils.

NSW EPA (2015) Notification Trigger under S.60 of the CLM Act	Evaluation of Site Data Notification Trigger
Foreseeable contamination of neighbouring land	
the contaminant will foreseeably enter neighbouring land; AND	The soil conditions the do not indicate potential for contaminants foreseeably entering neighbouring land. However, the identified sediments above the adopted guidelines may warrant consideration as they may represent foreseeable contamination of neighbouring land, although by definition sediments are not on land.
the concentration of the contaminant on the neighbouring land will foreseeably be above the health investigation level and/or health screening level for that contaminant for the current or approved use of the respective off-site land, as specified in S.6, Schedule B1 of the ASC NEPM (2013); AND	As discussed in Section 5, 5.8.1 and 5.8.2, sediment concentrations were reported in off-site locations above the adopted guidelines.
the concentration of the contaminant in, or on, the soil on the neighbouring land will foreseeably continue to remain above the specified concentration.	The concentrations in sediments may foreseeably continue to remain above the specified concentrations.
Duty to report?	A duty to report may exist. The triggers for the duty to report have not technically been met, however consideration should be given to reporting off-site impacts in sediments as a precautionary measure.
Asbestos in, or on, soil	
friable asbestos is present in or on soil on the land AND the level of asbestos (% weight for weight) in an individual soil sample is equal to or above the health screening level of friable asbestos in soil (0.001%) specified in S.4.8, Schedule B1 of the ASC NEPM (2013) AND a person has been, or foreseeably will be, exposed to elevated levels of asbestos fibres by breathing them into their lungs.	As discussed in Section 5, 5.8.1 and 5.8.2, asbestos fibres were identified in shallow soils.
Duty to Report?	A duty to report exists. Asbestos above the specified criterion has been detected which has the potential to represent a risk to the health of onsite employees if disturbed. If appropriate management procedures were implemented the potential risk of exposure to these impacts could be reduced to an acceptable level. It is therefore considered unlikely that NSW EPA would consider this warrants regulation.

NSW EPA (2015) Notification Trigger under S.60 of the CLM Act	Evaluation of Site Data Notification Trigger
Groundwater	
the contaminant has entered, or will foreseeably enter, groundwater or surface water; AND	The contaminant has been detected in groundwater at concentrations above the specific concentrations therefore the contaminant has entered the groundwater. Where concentrations are below or equal to indicative background conditions, this condition may not been met, as the presence of the contaminant is intrinsic rather than having entered groundwater.
the concentration of the contaminant in the groundwater or surface water is, or will foreseeably be, above the groundwater investigation level for that contaminant as specified in S.6, Schedule B1 of the ASC NEPM (2013); AND	As discussed in Section 5 and in Section 5.8.1, concentrations in groundwater were reported in monitoring wells at the site which exceeded the ASC NEPM (2013) GILs for drinking water, freshwater and/or marine environments.
the concentration of the contaminant in the groundwater or surface water will foreseeably continue to remain above the specified concentration.	Two separate sampling events in 2013 and 2014 reported largely consistent results, therefore indicating that the concentration of the contaminant may foreseeably remain above the specified concentration and may satisfy the third condition.
In addition, separate-phase contamination of groundwater if found, requires notification regardless of the concentration in the groundwater.	Separate-phase contamination of groundwater was not identified.
Duty to report?	A duty to report exists as the above conditions have been met. *Drinking Water* These conditions are considered unlikely to pose a direct potential human health risk in the absence of potable groundwater use in the vicinity of the Site. The reporting of the concentrations of arsenic, nickel, selenium, benzo[a]pyrene and vinyl chloride measured in onsite groundwater may be warranted in order to maintain strict compliance with the CLM Act (1997) on the basis of the exceedences of the GIL for drinking water. *Ecological* These conditions are considered unlikely to pose a risk to off-site ecological receptors, as conditions on the downgradient boundary are generally below the GILs indicating limited potential for off-site migration. The reporting of concentrations of various metals (including cadmium, copper, lead, nickel, selenium, zinc and naphthalene) measured in onsite groundwater may be warranted in order to maintain strict compliance with the CLM Act (1997) on the basis of the exceedences of the GIL for freshwater or marine environments.

NSW EPA (2015) Notification Trigger under S.60 of the CLM Act	Evaluation of Site Data Notification Trigger
	PFOS and PFOA concentrations in groundwater were detected at a concentration in excess of the adopted criteria. There is no GIL for PFOS and PFOA in the ASC NEPM (2013). As discussed in Section 5.8.2, concentrations of PFOS and PFOA above the adopted criteria were localised to the fire training area, with downgradient wells indicating limited potential for off-site migration.

5.8.4 *Summary – Is the Data Suitable to Provide a Baseline of Environmental Conditions at the Site and Immediate Surrounding Receiving Environments*

The data collected during the initial and Additional Stage 2 ESAs presented as this consolidated ESA is considered to be of a suitable quality and completeness to provide a baseline of environmental conditions at the Site and immediate surrounding receiving environments.

6 CONCLUSIONS

The majority of the impacts identified in soil, sediment, surface water and groundwater at the Site and within relevant surrounding receiving environments are unlikely to represent a risk to human health and/or the environment, based on the current and continued use of the Site as a Power Station (and for associated activities, in line with the current zoning) with some exceptions as noted below:

- The selenium seepage and discharge associated with the operation of the CCPMF (and / or the historical operation of the Wangi Ash Dam) appears to have resulted in sediment and surface water impacts to Crooked Creek and to a lesser extent Whiteheads Lagoon. These impacts do not however appear to have translated into elevated selenium concentrations within the sampled sediments or surface water of Myuna Bay.

- The selenium and metal impacts to groundwater and sediments (offsite) in the vicinity of the CCPMF have occurred as a result of the operations of the CCPMF.

- The risk to human health (recreational users) from direct contact with selenium impacted surface water, groundwater or sediments (offsite) is considered low based on the concentrations observed. Based on the results, there is a potential risk to the environment (including ecological exposure and ingestion of fish) from selenium impacts.

- There is a potential risk to the environment from metals concentrations in groundwater at certain site boundaries above ecological screening values.

- The localised elevated PFC impacts within the current fire training area and detection of PFCs in AEC EH and EI are unlikely to represent a risk to human health or the environment.

- Areas of suspected actual acid sulfate soils identified by ERM's investigation have been estimated within *Figure 6.6* of *Annex A*.

- Asbestos identified in soils and acid sulfate soils within the Site represent a potential risk to human health and the environment, if disturbed, although in their current state and if left undisturbed, this risk is considered to be minimal.

- The localised VOC impacts identified within the operational area are unlikely to represent a risk to human health or the environment.

- The data presented in the ESA was of a suitable quality and completeness to provide a baseline of environmental conditions at the Site and immediate surrounding receiving environments.

7 REFERENCES

Australia and New Zealand Environmental and Conservation Council (ANZECC) (2000) *Australia and New Zealand Guidelines for Fresh and Marine Water Quality*

Australian Standard AS 1726-1993 (1993) *Geotechnical Site Investigations.*

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

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

Baker and McKenzie (2013) *NSW Electricity Generation Assets Transactions - Eraring Energy Legal review report*

British Colombia Ministry for Environment (2001) *Ambient Water Quality Guidelines* . 2001.

Cooperative Research Centre for Contamination Assessment and Remediation of the Environment, CRC Care (2013) *Petroleum Hydrocarbon vapour intrusion assessment: Australian Guidance*, Dated July 2013.

Environmental Resources Management (ERM) (2012) *Standard Operating Procedure Manual*

ERM (2013a). *Eraring Power Station – Preliminary Environmental Site Assessment.* ERM Reference 0194708RP02. Dated June 2013.

ERM (2013b). *Sampling Analysis and Quality Plan, Project Symphony – Eraring.* ERM Reference 0207419RP01_SAQP_FINAL. Dated July 2013.

ERM (2013c). *Environmental Consultant's Environmental Management Plan, Stage 2 Environmental Site Assessment, Eraring Power Station.* ERM Reference 0207419RP02_EMP_FINAL. Dated August 2013.

Friebel and Nadebaum (2011). *Health Screening Levels for Petroleum Hydrocarbons in Soil and Groundwater. Technical Report No. 10.* Part 1: Technical development document. Cooperative Research Centre for Contaminant Assessment and Remediation of the Environment (CRC CARE), Adelaide, Australia.

Friebel, E & Nadebaum, P. (2011). *Health screening levels for petroleum hydrocarbons in soil and groundwater. Technical Report No. 10.* Part 2: Application document, CR CARE Technical Report no. 10, CRC for Contamination Assessment and Remediation of the Environment, Adelaide, Australia.

Geological Survey of New South Wales (2003) *Gosford-Lake Macquarie 1:100 000 Geological Sheets 9131 & 9231*. Provisional Edition, Sydney.

Geoscience Australia: *1 second national DEM Version 1.0.4*, 2011

Geo_Logix Pty Ltd (2011a) *Groundwater Monitoring Well Installation Report - Vehicle and Plant Workshop, Eraring Power Station.* Reference: 1101018Rpt01FinalV01_22Jun11

Geo_Logix Pty Ltd (2011b) *Groundwater Monitoring Well Installation Report - Unit 1 Turbine House Basement, Eraring Power Station.* Reference: 1101018Rpt02FinalV01_31Aug11

Geo_Logix Pty Ltd (2011c) *Contamination Investigation Report – Stores Building UPSS, Eraring Power Station.* Reference: 1101018Rpt03FinalV01_31Aug11

GHD, (2010) Awaba Colliery Water Management Assessment. Report completed for Centennial Newstan Pty Ltd. May 2010.

GHD, (2012) Centennial Mandalong Subsidence Management Plan LW 15-17: Groundwater Impact Assessment.

GHD, (2013) Groundwater Impact Assessment, Mandalong Southern Extension Project, Centennial Mandalong.

GSS Environmental, (2011) Environmental Assessment. The Awaba Colliery Mining Project. Project Approval 10_0038. Prepared on Behalf of Centennial Coal Company Limited.

Jankowski, J. and Spies, B. (2007) *Impact of longwall mining on surface water-ground water interaction and changes in chemical composition of creek water*

Kirby, J. Maher, W. Krikowa, F (2001) *Selenium, Cadmium, Copper, and Zinc Concentrations in Sediments and Mullet (Mugil cephalus) from the Southern Basin of Lake Macquarie, NSW, Australia.*

Lake Macquarie City Council (1995) *Lake Macquarie Estuary Process Study, Volume I - Report*, Prepared by Australian Water and Coastal Studies Pty. Ltd. and JH&ES Laxton, Pty. Ltd.

Lake Macquarie City Council (2014) Local Environment Plan

Minnesota Department of Health (2011) *Human Health Based Water Guidance Table.* s.l. : MDH, 2011.

National Environment Protection Council (NEPC) (April 2013) *National Environment Protection (Assessment of Site Contamination) Measure 1999*, NEPC, Canberra.

National Health and Medical Research Council (NHMRC) - *Australian Drinking Water Guidelines (ADWG) (2001)*

Nobbs, DM, Barford, JP, Carroll, BI and Peters, GM (1997) *An integrated investigation of anthropogenic selenium contamination in Lake Macquarie, NSW.* Pure and Applied Chemistry. 69: 2387-2401.

National Institute of Public Health and the Environment (RIVM) (2001) *Technical Evaluation of the Intervention Values for Soil/sediment and Groundwater: Human and Ecotoxicological Risk Assessment and Derivation of Risk Limits for Soil, Aquatic Sediments and Groundwater.*

New South Wales Department of Environmental and Conservation (NSW DEC) (2006) *Guidelines for the Assessment and Management of Groundwater Contamination.* Department of Environment and Conservation, Sydney.

New South Wales Department of Environment and Climate Change (DECC) (2009) *Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997*

New South Wales Department of Environment, Climate Change and Water (NSW DECCW) (2009) *Waste Classification Guidelines.*

New South Wales Environmental Protection Authority (NSW EPA) (1994) *Guidelines for Service Station Sites.*

NSW EPA (1997) *Guidelines for Consultants Reporting on Contaminated Sites.*

NSW EPA (1997) *Sampling Design Guidelines*

NSW EPA (2006) *Guidelines for the NSW Site Auditor Scheme* (2nd Edition).

NSW EPA (July 2015) *Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997*

Natural Resource Atlas (NRA) (2012) *New South Wales Natural Resource Atlas* (accessed at www.nratlas.nsw.gov.au)

RIVM (2010) *Environmental risk limits for PFOS; A proposal for water quality standards in accordance with the Water.* 2010.

RIVM (2001) *Ecotoxicological serious risk concentrations for soil, sediment and (ground)water; updated proposals for first series of compounds.* 2001.

Rose G. (1966) *Wollongong 1:250 000 Geological Sheet SI/56-09.* 2nd edition. Geological Survey of New South Wales. Sydney.

Simpson, S.L., Batley, G.E., Chariton, A.A., Stauber, J.L., King, C.K., Chapman, J.C., Hyne, R.V., Gale, S.A., Roach, A.C. and Maher, W.A. (2005) *Handbook for Sediment Quality Assessment.* CSIRO: Bangor, NSW.

State of Idaho Department of Environmental Quality, (2014) Statistical Guidance for Determining Background Ground Water Quality and Degradation.

Western Australian Department of Health (2009) *Guidelines for the Assessment, remediation and Management of Asbestos-Contaminated Sites in Western Australia* (May 2009)

US EPA (2014). *Emerging Contaminants – Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA),* 2014.

Van Dam, R.A, Camillieri,C. and Turley,C. (1998). *Preliminary assessment of petroleum hydrocarbons in water and sediment at Yellow River, Kakadu National Park.* Environmental Research Institute of the Supervising Scientist (eriss).