Urban Growth NSW
Environmental Site Assessment

Riverstone Scheduled Lands
Precinct A (Stages A1 to A3)

11 August 2014
43210-57075 (Rev 1)
JBS&G

www.jbsg.com.au

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List of Abbreviations

A list of the common abbreviations used throughout this report is provided below.

ACM	Asbestos Containing Material
AHD	Australian Height Datum
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, xylenes
COC	Chain of Custody
COPC	Contaminant of potential concern
CSM	Conceptual site model
BTEX	Benzene, toluene, ethylbenzene and xylenes
B(a)P	Benzo(a)pyrene
DEC	NSW Department of Environment and Conservation
DECCW	NSW Department of Environment, Climate Change and Water
DQI	Data quality indicator
DQOs	Data Quality Objectives
DWE	NSW Department of Water and Energy
EPA	NSW Environment Protection Authority
ESA	Environmental Site Assessment
ha	Hectare
HIL	Health based investigation level
JBS&G	JBS&G (NSW & WA) Pty Ltd (formerly JBS Environmental Pty Ltd)
LOR	Limit of Reporting
NEPM	National Environment Protection Measure
OEH	Office of Environment and Heritage
OCP	Organochlorine Pesticides
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PID	Photo-ionisation Detector
PQL	Practical Quantitation Limit
QA/QC	Quality Assurance/Quality Control
RAP	Remedial Action Plan
RPD	Relative Percentage Difference
SAQP	Sampling, Analysis and Quality Plan
SAR	Site Audit Report
SAS	Site Audit Statement

SMF	Synthetic Mineral Fibres
TPH	Total Petroleum Hydrocarbons
VOC	Volatile Organic Compound

Executive Summary

JBS&G Australia Pty Ltd (JBS&G) has been engaged by UrbanGrowth NSW (UGNSW) to provide environmental site assessment (ESA) services for the site identified as the Riverstone Scheduled Lands: Precinct A (Stages 1 to 3) (the site) at Riverstone, NSW. The site location is show in **Figure 1**.

The Riverstone Precinct is situated in the North-West Growth Centre, being approximately 1149 hectares (ha) in area. The Precinct includes a range of urban areas, rural residential areas and the 'Scheduled Lands' in the north comprising generally unoccupied forested/bushland areas. In May 2010 the Scheduled Lands were rezoned from rural zoning to allow a range of residential and light industrial land uses, although this did not necessarily allow owners to develop their land. The site layout is shown in **Figures 2a** and **2b.** Parcels 1, 2, 3, 56 and 79 were not included within the site boundary and are not included in this assessment.

The objective was to conduct environmental and geotechnical investigation works to facilitate management of potential contamination including containment of non-leachable hazardous and contaminated materials, thereby maximising the potential to retain impacted materials onsite and minimise potential offsite disposal fees, and assist development of service infrastructure following subdivision.

The scope of works completed for this assessment comprised:

- Review and summary of relevant published geological and hydrogeological data, including a review of licensed groundwater bore information;
- Review of existing site investigation information;
- A detailed site inspection to identify potential areas of environmental concern (AECs) and contaminants of potential concern (COPCs) identified in the historical review;
- Soil sampling within 66 Parcels within the site;
- Analysis of selected soil samples for various COPCs;
- A detailed site inspection for hazardous building materials and preparation of a hazardous materials assessment report;
- Geotechnical assessment of the site, roadways and conservation area; and
- Preparation of this ESA report in general accordance with guidelines made or approved by the NSW EPA.

Based on the findings of this investigation and subject to the limitations in **Section 11**, the following conclusions are made with respect to the site:

- Lead concentrations were reported in six soil samples exceeding the adopted health criterion and ecological criteria from four separate Parcels (5, 12, 21, 45, 50 and 84).
- Concentrations of carcinogenic PAHs as B(a)P equivalents were reported to exceed the adopted health criterion in soil samples collected from five Parcels (9, 12, 40, 48 and 89);
- Fourteen sample locations exceeded the ecological criterion for TRH fractions, with these being located within ten Parcels (5, 7, 12, 20, 21, 22, 36, 38, 45, 48, 54 and 55).
- Four sample locations exceeded the health based criterion for TRH fractions, with these being located within four Parcels (20, 21, 45 and 54).
- One stockpile sample location (SS-SP01B), from stockpiles within the road reserve, located along Sydney Street, identified PCB compounds in exceedance of the adopted HIL and ESL criteria. Stockpile SS-SP01B additionally contained concentrations of TRH (C_{16}-C_{34}) above the ESL criteria, lead and zinc concentrations above the adopted HIL criteria and friable asbestos present.

- Non-friable ACM was observed across the site in 19 Parcels. It should be noted that Parcels with vegetation may obscure the occurrence of additional potential ACM fragment impacts. Further assessment of those Parcels should be completed following the removal of the vegetation to confirm the extent of ACM impact at the site.
- Evaluation of potential remedial/management options has identified that a portion of the identified impacted material could be reused within the proposed road reserves without ongoing management. The ACM impacted material and any material not suitable for reuse within the road reserves could be the subject of a suitable cap and containment strategy with ongoing management via an Environmental Management Plan (EMP).
- Evaluation of the individual Parcels resulted in identification of 6 Parcels as High Risk, comprising site activities and/or site soil conditions that will likely result in a requirement for management of broader scale soil contamination at the site.
- Twenty four parcels plus the stockpiled material within the Sydney St road reserve are considered to be Medium Risk, being properties that have localised areas of potentially impacted soil (ie. ACM on the ground surface in minor areas, small stockpiles, etc.) that will require management for the Parcels to be considered suitable for future sensitive uses.
- The balance of the Parcels and areas of road reserve are considered to have a Low Risk, where isolated occurrences of ACM impacts or similar may be identified during site subdivision works but which are considered to be easily managed by the implementation of site management protocols such that the site(s) would then be considered suitable for the proposed sensitive use(s).

It is recommended that a management strategy and/or Remedial Action Plan (RAP) be developed in accordance with the relevant regulatory requirements to address the identified contamination issues to render the site suitable for the proposed residential landuse.

1 Introduction and Background

1.1 Background

JBS&G Australia Pty Ltd (JBS&G) has been engaged by UrbanGrowth NSW (UGNSW) to provide environmental site assessment (ESA) services for the site identified as the Riverstone Scheduled Lands: Precinct A (Stages 1 to 3) (the site) at Riverstone, NSW. The site location is shown in **Figure 1**.

The Riverstone Precinct is situated in the North-West Growth Centre, being approximately 1149 hectares (ha) in area. The Precinct includes a range of urban areas, rural residential areas and the 'Scheduled Lands' in the north comprising generally unoccupied forested/bushland areas. In May 2010 the Scheduled Lands were rezoned from rural zoning to allow a range of residential and light industrial land uses, although this did not necessarily allow owners to develop their land. The site layout is shown in **Figures 2a** and **2b.**

The NSW Government is assisting land owners within the site to create a new residential community in the Riverstone Scheduled Lands, given the following challenges faced prior to any development:

- The area is mainly un-serviced without typical infrastructure needed for such communities, including water, sewer, underground electricity and urban roads;
- Many lots are too narrow for standard homes;
- Some owners do not have upfront funding access to fund development; and
- The large number and diversity of landowners is making it difficult to coordinate services delivery.

The Precinct is situated within the Blacktown City Council (BCC) area, bound by the sealed portion of Loftus Street and part of a 'conservation area' to the north, Crown Street to the south, Junction and Windsor Roads to the east and Edmund Street to the west. Hobart Street roughly bisects the site, and Sydney Street passes through the southern half of the site.

The site, being Precinct A (Stages 1 to 3), is approximately 16 ha in area, with approximately 50 landowners. There are a number of rural residential buildings, industrial workshops, stockpiles and infrastructure. Prior to provision of services/infrastructure and development on individual lots, a process of subdivision is required, involving lodgement of a development application (DA) with BCC.

A precinct wide integrated strategy was recommended to deal with contamination on the site given the small lot sizes, complicated land ownership, and that the responsibility for remediation and/or management of contamination lies with individual land owners.

From the Invitation to Tender (ITT[1]) it is understood UGNSW considers it likely that primary contaminants of concern at the site will include asbestos and other non-leachable materials, which have the potential to be contained within an encapsulation cell. UGNSW have identified a 'conservation area', as shown in **Figure 2a**, extending west (and partially to the north) of the site as an area that may be suitable for a future containment cell. A tributary of First Ponds Creek flows northward through the 'conservation area' and passes the site's north-west boundary towards the main creek line north-east of Windsor Road. The 'conservation area' is reported to be generally unoccupied and vegetated with tall woodland. Review of aerial photographs by JBS&G suggests a significant number of

[1] *Invitation to Tender 1884/13 in respect of Environmental and Geotechnical Investigation of Riverstone Scheduled Lands: Precincts A (Stages 1 to 3).* UrbanGrowth NSW, 2013

vehicles (presumably dumped/derelict) within wooded areas, and the potential for substantial 'fly-tipping' of wastes including ACM. It should be noted that the 'conservation area' is not included as part of this assessment site.

For the purposes of this assessment, reference is made to ''Parcels'' which comprise portions of the site based on existing ownership into which the site is proposed to be subdivided, as shown in **Figure 3**. The Parcels are numbered 1 to 55 and then 80 to 89. It should be noted that during the current assessment Parcel 23 could not be accessed and as such, assessment of this was limited to historical information and inspection from the land adjoining the properties. Parcels 1, 2, 3, 56 and 79 were not included within the site boundary and are not included in this assessment.

The scope of the assessment has been developed in general accordance with relevant guidelines made or approved by the NSW Environment Protection Authority (EPA).

1.2 Objectives

The objectives of the assessment were to complete:

- Environmental and geotechnical investigation activities to facilitate consideration of potential site contamination management requirements;
- Provide site characterisation information to assist with development of service infrastructure for the subdivision; and
- An evaluation of the potential opportunities for on-site containment of suspected non-leachable hazardous and for contaminated materials, thereby maximising the potential to retain impacted materials onsite and minimise potential offsite disposal fees.

1.3 Scope of Works

The scope of works completed for this assessment comprised:

- Review and summary of relevant published geological and hydrogeological data, including a review of licensed groundwater bore information;
- Review of existing site investigation information;
- A detailed site inspection to identify potential areas of environmental concern (AECs) and contaminants of potential concern (COPCs) identified in the historical review;
- Soil sampling within 66 Parcels within the site;
- Analysis of selected soil samples for various COPCs;
- A detailed site inspection for hazardous building materials and preparation of a hazardous materials assessment report;
- Geotechnical assessment of the site, roadways and conservation area; and
- Preparation of this ESA report in general accordance with guidelines made or approved by the NSW EPA.

2 Background Information

2.1 Site Identification and Condition

The location of the site is shown in **Figure 1**, and current layout is shown in **Figure 2a** and **2b**. The site details are summarised in **Table 2.1**.

Table 2.1 Summary Site Details

Lot/DP	Lots 40-45 DP790369 Lots 21-39 DP 456639 Lot 1 DP790369 Lots 21-39 & 52-70 Section 29 DP1480 Lots 1-19,21-70 & 75-90 Section 29 DP1480 Lots 1-19, 21-70 & 72-90 Section 30 DP1480 Lots 1-19, 21-70 & 72-90 Section 31 DP1480 Lots 1-19, 21-70 & 72-90 Section 32 DP1480
Address	Hobart St and Sydney St, Riverstone, NSW
Local Government Authority	Blacktown City Council
Site Zoning	R2 Low Density Residential and RE1 Public Recreation (**Section 3.5**)
Current Use	Residential and Commercial/industrial and open space parkland
Proposed Use	Residential and Commercial/industrial.
Site Area	Approximately 16 Ha
MGA Coordinates (Zone 56) of approximate centre of Site	303069 (E) 6273545 (N)

2.2 Site Description

An inspection of the site was undertaken by JBS&G on 19 February 2014.

The site comprised of an approximate 16 ha area, consisting of a mixture of residential, minor industrial and undeveloped scrub bushland. The site layout is provided in **Figures 2a** and **2b**.

The site can be accessed from Windsor Road onto Hobart Street. Four Streets, running perpendicular to Windsor Road, are included within the site. These include:

- Wellington Street;
- Hobart Street;
- Sydney Street; and
- Crown Road.

In addition to the above Streets, Edmund Street runs north to south along the western site boundary and Junction Road runs along the eastern boundary of the site.

With the exception of Wellington Street, all the roads were bitumen, with Wellington Street being a gravel road. Crown Road was in good condition, however the remaining roads were all in moderate to poor condition, with cracks and potholes. Wellington Street extended half way into the site from Windsor Road and ended. Wellington Street was in moderate condition. Kerb and guttering, with drainage was observed along Junction Road only, in the vicinity of Parcel 89 and appeared to be in good condition.

The majority of the developed areas present at the site were situated along the eastern boundary of the site, facing Junction and Windsor Roads. These mainly consisted of residential housing, with a restaurant (Parcel 8) situated in the northern portion of the site. Parcel 8 was split, with half being used for the restaurant and the other half used by tradesmen during the inspection but it was unclear for what purpose.

Residences were located along all the small streets transecting the site. The condition of the residential housing present throughout the site varied, with some appearing to being

recent builds, consisting of mainly brick and corrugated steel roofs (Parcels 48 and 89), whilst others appeared to consist of aged fibro cement construction (Parcel 16).

A total of 31 of the Parcels were vegetated and vacant, with native and non-native species of trees and undergrowth present throughout. During the inspection, none of the vegetation appeared to be stressed. Vegetated stockpiles were observed along the street verge Sydney Street and within Parcels located in the south-western portion of the site. Due to the extent of the vegetation, the volume of the stockpiles was difficult to estimate.

At the time of the site inspection Sydney Water contractors were completing site work to extend underground drainage pipework along Edmund Street.

The inspection completed included a walkover from the Roads only, with access to each of the Parcels completed during the assessment works. A photographic log of each of the Parcels is provided in **Appendix A**.

During the period 18th February to 5th March 2014, detailed inspections of each accessible Parcel was completed in conjunction with soil sampling activities. A summary of the site descriptions is provided in **Table 2.2** below and documented in a photographic log in **Appendix A**.

Table 2.2 Site Inspection Summary

Parcel	Observations	Photographs
Parcel 4	A vacant and vegetated site, with suspected dumped soil and building material in small stockpile	1-3
Parcel 5	One residential property present, with several disused buildings, including a wooden shed and two metal sheds. These are in poor condition. Sandstone cutting yard, with associated equipment observed in the western portion of the parcel. Four stockpiles of material were observed. Fiberglass and ACM sheeting located in the north eastern corner of the parcel. Septic tank present in eastern portion.	4-18
Parcel 6	Two residential properties present, with four septic tanks present. A chicken coup is located in the north western portion of the parcel, with ACM sheeting used as a fence. ACM sheeting used as fence along the boundary of the parcel, which was broken in places. A rubber tyre cutting area and rusted disused cars were present. An area of burnt grass in the western portion of the site observed. Bowser present was disused and did not appear connected (potential collectible item), no evidence of underground storage tanks observed.	19-36
Parcel 7	A scrap metal yard which was unsealed and had a gravel road through the centre. ACM was present in the surface soils, various empty chemical drums were present across the site and surface soil hydrocarbon staining was observed in these areas.	37-42
Parcel 8	Consisted of a restaurant and car park, with landscaped areas. The building potentially contained asbestos eaves. Half the site was fenced off and was a vacant concreted area, with gravel and bare soil areas. The soil appeared to consist of a gravelly clay. ACM was observed on the surface and within the landscaped areas, with a partially vegetated stockpiled present in the centre of the parcel. The parcel appeared raised from Wellington Road. During the inspection tradesmen were inspecting the site.	43-48
Parcel 9	A vacant vegetated site, with a gravelly clay soil	49-50

Parcel	Observations	Photographs
Parcel 10	A vacant vegetated site, with a gravelly clay soil and some fill	51-52
Parcel 11	A fibro residential house, with landscaped areas, with a vegetable patch area, septic tank and three unlabelled metal drums that were in poor condition. A shipping container was present but no access was provided	53-58
Parcel 12	A vacant and vegetated site, with dumped material in small stockpile	59-61
Parcel 13	A vacant and vegetated site, with dumped scrap metal	62-63
Parcel 14	A fibro residential house, with landscaped areas. Large asbestos sheeting observed within a shed. Additional, rusted chemical drums observed, no staining reported and contents were unknown.	64-69
Parcel 15	A vacant and vegetated parcel	No photographs
Parcel 16	A fibro residential house, with landscaped areas. A water easement runs through part of the parcel underground. Denser vegetation was observed in this area, with the easement underground.	70-73
Parcel 17	A vacant and vegetated parcel, with suspected dumped material in small stockpile	74-76
Parcel 18	A vacant and vegetated parcel which contained ACM within the surface soils	77-81
Parcel 19	A vacant and vegetated parcel which contained ACM within the surface soils	82-84
Parcel 20	A vacant and vegetated parcel which contained rubber tyres, empty plastic drums which the labels indicated formally contained cottonseed oil, methylated spirits, canola oil and salt brine.	85-90
Parcel 21	A brick and corrugated iron roof residential building and landscaped areas. The building potentially contained ACM.	91-92
Parcel 22	The parcel was used for the storage and recycling of scrap metal. Hydrocarbon staining was observed on the surface soils of the parcel in various areas, with rubber tyres, trucks and cars parts including chassis, oil drums and various rusted machinery present. The parcel had a single corrugated metal shed, which stored a forklift and other machinery. An Intermediate bulk container (IBC) was present in the southern portion of the parcel, which was stained, the contents could not be identified.	93-105
Parcel 23	No Access	
Parcel 24	A vacant and vegetated parcel, with piles of suspected ACM vinyl tiles present on the ground surface. Various household rubbish items were present such as plastic chairs. Three rusted chemical drums were present, with two containing glass bottles.	106-108
Parcel 25	A vacant and vegetated parcel, with various car parts and burnt ground surface staining was observed.	109-111
Parcel 26	A vacant and vegetated parcel, with building waste and potential ACM within the surface soils.	112-114
Parcel 27	A vacant and vegetated parcel, with building waste and nine rusted chemical drums with 'Formula 40' labels.	115-118
Parcel 28	A brick and corrugated iron roof residential building and landscaped areas. The building potentially contained ACM.	119-122
Parcel 29	A vacant and vegetated parcel with building material waste scattered across the ground surface	123-124
Parcel 30	A vacant and vegetated parcel, with numerous chemical drums which appeared to have been used to create a camp	125-129

Parcel	Observations	Photographs
	fire area and motorcycle jump area. The chemical drums were labelled as having contained a concrete curing mix. An area of building waste and tyres was present.	
Parcel 31	A vacant and vegetated parcel which contained rubbish and tyres.	130-132
Parcel 32	A vacant and vegetated parcel	No Photographs
Parcel 33	A vacant and vegetated parcel	133
Parcel 34	A vegetated parcel with a residence on elevated concrete block footings situated in the central portion. A potential septic tank was present in the north eastern portion. A fire pit was located in the centre of the parcel	134-139
Parcel 35	A vacant and vegetated parcel which contained a gravelly clay non-vegetated stockpile approximately 5 m^3.	140-141
Parcel 36	A vacant and vegetated parcel	No Photographs
Parcel 37	The parcel consisted of a brick and metal residential house. Additionally, dog kennels and chicken coups were present along the western boundary of the parcel. ACM was observed within the surface soils. A shipping container, with unknown contents was present. Chemical drums were observed and minor surface staining in those areas. A potential septic tank was present in the southern portion of the parcel.	142-147
Parcel 38	A vacant and vegetated parcel, with building waste, machinery, railway sleepers, a boat, scrap metal and potentially a motorbike circuit being present. Potentially ACM in the surface soils was observed.	148-152
Parcel 39	A vacant and vegetated parcel	153-155
Parcel 40	The parcel was vegetated and vacant, with a disused site shed, in poor condition present. Additionally, numerous chemical drums were present, which formally contained a concrete curing mix. Corrugated sheet metal fencing enclosed a large portion of the parcel and was in poor condition. Rubber tyres were present within an enclosed portion of the Parcel.	156-160
Parcel 41	A vacant and vegetated parcel, which contained building rubble and rubber tyres.	161-162
Parcel 42	A vacant and vegetated parcel which contained large stockpiles of cut wood and ACM fragments on the ground surface.	163-165
Parcel 43	A vacant and heavily vegetated parcel. Inspection was limited by the extent of the vegetation	166
Parcel 44	A vacant and vegetated parcel	167
Parcel 45	The parcel contained a brick residence, with tiled roof and landscaped areas. ACM was observed on the surface at several locations, with a large burnt area that contained large amounts of ACM fragments.	168-171
Parcel 46	A vacant and vegetated parcel which contained some building waste, ACM on the surface soils and some small stockpiles of soil.	172-174
Parcel 47	A vacant and vegetated parcel	175
Parcel 48 & 49	The parcel contained a brick residence, with tiled roof and landscaped areas.	176-177(No photographs of Parcel 49)
Parcel 50	The parcel contained a brick residence, with tiled roof and landscaped areas. Potential septic tank associated with outhouse	178-180

Parcel	Observations	Photographs
Parcel 51	A vacant and vegetated parcel	181
Parcel 52	A vacant and vegetated parcel	182
Parcel 53 & 54	Two vacant Parcels, which were predominantly vegetated. Building materials were present across both Parcels, with two shipping container present. Various machine parts, vehicles (including cars and a boat) and rusted metal was present. A portable toilet was present within dense vegetation along the boundary of the parcel and a potential stockpile of soil was located adjacent to the toilet. However, this was unclear due to the heavy vegetation. Adjacent to the shipping containers was an area used for burning, with melted plastic and staining present. Potential ACM sheeting was observed within building materials stored adjacent to the shipping containers.	183-192
Parcel 55	The parcel was vacant and vegetated. Building waste materials including tyres, metal and corrugated sheeting were present within the parcel. ACM on the surface soils and potential ACM containing pipes were observed. Stockpiled soil consisting of a gravelly clay which contained building rubble including ACM was present.	193-198
Parcel 80	A vacant and vegetated parcel which contained some building waste, ACM on the surface soils and some small stockpiles of soil	199-201
Parcel 81	The parcel contained a brick residence, with tiled roof and landscaped areas.	202-204
Parcel 82	Unknown fill material	No Photographs
Parcel 83	A vacant and vegetated parcel	205
Parcel 84-87	A vacant and vegetated parcel	206-207
Parcel 88	A fibro cement clad residential property which also contained a storage yard for building materials. The parcel was predominantly surface with loose gravel. Potential ACM was observed on the ground surface and in pipework stored at the site.	208-214
Parcel 89	The parcel contained a brick residence, with tiled roof and landscaped areas	2015-2016

2.3 Surrounding Landuse

Current landuse of adjacent properties or properties across adjacent roads is summarised as follows:

- North – Junction Road, becoming Windsor Road with residential, agricultural and cleared grassland beyond;
- East – Windsor Road, with cleared grassland with residential and agricultural properties;
- South – Cleared grassland and residential properties; and
- West – Bushland and residential properties, with commercial properties and cleared grassland beyond.

2.4 Topography

A review of the 1:100 000 topographic map for Penrith (9030) identified that the site is located within a low lying, gently undulating regional topography.

The site itself is characterised by gentle falls in various directions, falling away from approximately the centre of the site. This results in falls towards Windsor and Junction

Roads in the north and east of the site; falls to the north-east in this portion of Crown Street, and towards the north along Edmund Street. The ground slopes are generally in the vicinity of 1-3^0, with some minor areas of greater ground slopes.

2.5 Hydrology

The closet surface water body to the site, is an unnamed creek which runs south to north approximately 90 m to the north of Wellington Street. This creek is connected to Killarney Chain of Ponds which is approximately 370 m to the north of the site. Additionally, First Ponds Creek, which is also connected to the Killarney Chain of Ponds is approximately 160 m to the south-east of Sydney Street.

At a whole site level, it is expected that in the western portion of the site, drainage would be to the north-west, towards the unnamed tributary. Whilst in the eastern portion of the site, the drainage is anticipated to be the east towards the main First Ponds Creek tributary.

Additionally, the surrounding area has also several dams associated with agriculture.

The various creeks of the area are tributaries which feed into the Hawkesbury River approximately 7 km to the north of the site.

It is anticipated that rainfall in the vacant, vegetated Parcels within the site will either infiltrate into the soil or be taken up by the vegetation present. For residential/landscaped Parcels this is also anticipated, although possibly to a lesser degree. Rainfall is anticipated to follow the local topography towards the creeks once rainfall is too great for infiltration into unsealed ground surfaces within the Parcels

Stormwater drainage infrastructure is only present in localised areas of the site, such as along Junction and Sydney Street. Where rainfall falls on this part of the site, runoff is anticipated to flow into the constructed drains which flow to Windsor Road. For the remainder of the site, flows are likely to continue overland based on topographical levels.

2.6 Geology

A review of the 1:100 000 Geological Series for Penrith (Geological Survey of NSW Sheet 9030) indicates the site and surrounds are underlain by Quaternary alluvium consisting of fine grained sand, silt and clay and by Triassic Bringelly Shales of the Wianamatta Group which consist of dark grey to black claystone-siltstone and fine sandstone-siltstone laminate.

A review of the Soil landscape map Series (9030) indicates that the soils at the site are shallow to moderately deep hard setting mottled texture contrast soils, red and brown podzolic soils on crests grading to yellow podzolic soils on lower slopes and in drainage lines.

Areas of South Creek Fluvial geology also exist onsite, containing deep layered sediments over bedrock or relict soils, structured plastic clays and loams, red and yellow podzolic soils, leached clays and yellow solodic soils.

The current investigation generally observed brown silty clay across the area.

2.7 Hydrogeology

Registered groundwater bore information obtained from the National Resource Atlas database on the 6th March 2014 is included in **Appendix B**. A review of the registered bore information indicated that 10 bores are located within a 1.0 km radius of the site. However, of the 10 bores information is only provided for one location on the database.

The one registered monitoring well is located approximately 370 m to the north-west of the site and comprises a monitoring well on the Woolworths branded service station. Installation observations identified an alluvial clay geology with saturated soils at approximately 2.8 m during installation. It is noted that the service station adjoins the unnamed creek line noted in **Section 2.5** and as such, the shallow perched groundwater may be a reflection of these conditions.

Based on the information extracted from the one registered groundwater bore search it is anticipated that perched groundwater may be present at depths of approximately 1.5 to 2.0 m below ground surface (bgs).

On a regional level it is anticipated that perched groundwater seepage may occur, particularly in the vicinity of surface water drainage channels close to the soil-bedrock interface. These flows are typically of low quality and relatively low overall volume reflective of the short residence time. Groundwater movement is anticipated to occur in sympathy with the surface topography.

Regional groundwater flows are expected to occur in the Hawkesbury sandstone at depths of >20 m bgs, with regional flows towards the Hawkesbury River to the north-west of the site.

2.8 Acid Sulfate Soils

Review of the Acid Sulfate Soil Risk Map for Springwood/Riverstone[2] indicates that the site is located within an area of 'no known occurrence of Acid Sulfate Soils'. Acid sulfate soils are not known or expected to occur in areas having this classification and as such no further assessment of acid sulfate soil management is necessary.

[2] *Acid Sulfate Soil Risk Map – Springwood/Riverstone River,* Edition 2, 1997 1:25 000 Ref: 9130N3. NSW DLWC.

3 Site History

3.1 Aerial Photographs

Aerial photographs were obtained from the Department of Land and Property Information and are included as **Appendix C**. Site conditions in relation to historical use of the site are discussed below for each image.

1947 - The site and region in general appeared comprised of agricultural and vacant lots. Additionally, a total of 11 buildings were present across the Parcels, with a mixture of what appeared to be residential buildings and site sheds.

Notable site features included market gardening activities on parcel 16 and 28 and farming (cropping) on Parcels 14 and 48.

Windsor Road to the north-east of the site was already present, whilst Junction Road, Crown Road, Hobart Street, Sydney Street and Wellington Street appeared to be unsealed dirt roads.

A surface water drainage line was apparent diagonally across Parcels 32 to 16 and 17 in the west of the site.

The area to the south and south-west of the site appeared to be moderately vegetated (as though previously cleared and returning towards original state), with some agriculture adjacent to Crown Road in the south in addition to large areas further to the north-west.

1955 - The site appeared similar to the previous photograph, with a mixture of farming/residential properties and vacant bush. Including the Parcels identified in 1947, Parcels 7, 21, 38, 45, 48, 50, 82 and 89 appeared to have had residential properties present, with Parcel 7 having a dirt track transecting the site. An overhead power easement had been installed in this area.

The building on Parcel 7 appeared to consist of a shed in association with the large building to the north of the overall site. Parcel 14 had a number of buildings added to the north-eastern section of the parcel possibly comprising animal barns (chicken sheds or similar) with other being stables or animal shelters for pigs or similar.

Parcel 16 and 28 appeared to have had removed the market garden formally present and residential houses had been constructed.

Crown Street appeared to now be paved.

The surrounding areas appear unchanged from the 1947 aerial.

The trees at the site appeared to be significantly larger in scale than the 1947 photograph.

1961 - The site appeared similar to the 1955 photograph, with a mixture of farming/residential properties and vacant bush with the exception of Parcels 1, 2, 3 and 6 which appeared to have three large commercial/industrial buildings attached to a smaller residential building on the north western boundary of Parcel 7. Significant additional vegetation/tree growth was apparent. The former sheds/buildings in the north-west had been removed.

The buildings present on Parcel 14 in the1955 photograph were no longer present. The heavily agricultural area in the north-western section of the Parcel 14 that appeared in the previous photograph now appeared to be disused.

Parcel 28 appeared to have large shed or warehouse in the northern section of the parcel.

Parcels 45, 84 and 88 appeared to have had residential buildings constructed.

The conservation area appeared unchanged from the previous aerial photograph. Windsor Road appeared more developed, with further residential housing to the south of Crown Road. A dam appeared to the north-west of Wellington Street.

Hobart Street appeared to now be paved.

1970 – The site appeared generally similar to the previous photograph.

The large commercial/industrial building in the middle of Parcel 1 and 2 had been removed and Parcel 3 appeared to have multiple small structures scattered across the cleared south-eastern portion.

Within Parcel 28 further structures were present, with a further warehouse along Parcel 28 western boundary. Additional vegetation clearing had occurred in the southern portion of the parcel.

The surrounding areas appeared largely unchanged from the previous photograph, with the exception of further residential buildings to the south of Crown Road. Racing tracks had been constructed further to the west and east of the site.

Sydney Street now appeared to be paved.

1986 - The site appeared generally similar to the previous photograph.

Parcel 6 appeared to contain two residential structures. Parcel 8 appeared to have a commercial building present, similar to the current site structure present at the site.

The surrounding areas appear generally unchanged from the previous photograph with the exception of commercial properties to the south-east of Junction Road, some of which included significant ground disturbance activities along the First Ponds Creek line.

1994 – The site appeared generally similar to the previous photograph.

Parcel 37 had been cleared, with two structures present. The photograph is unclear but the structures appeared to be residential.

2002 - The site appeared generally similar to the previous photograph.

Further development appeared on Parcel 8's northern portion. The northern portion appeared to have been paved and containers present. Parcel 22 appeared to have a warehouse constructed over the majority of the parcel.

Additionally, large scale commercial activities were apparent to the north of the site, with possibly chicken sheds having been constructed. Further residential housing was been constructed to the south of the site.

2011 - The site and surrounding areas appeared generally similar to the 2002 photograph, although the roof on the residential property in Parcel 21 appeared to have been changed and industrial development had occurred to the east of Junction Road.

A large residential property had now been constructed on Parcel 89.

3.2 Title Details

The current title deeds for each of the Parcels were provided by UGNSW, with a further ten Parcels having a historical title review completed by Mark Groll. A summary of the title search and titles deeds is provided in **Appendix D**.

For the historical titles obtained for the further ten Parcels, a summary is presented in **Table 3.1**.

Table 3.1 Summary of Historical Title Records

Parcel	Address	Lot	Title
Parcel 7	38-39 Windsor Rd Riverstone	Lots 40-45 DP135718	1915-1930: NSW Realty Co Ltd 1930-1934: Raymond Edward Vaughan (Carpenter) 1934-1935: Barbara Ellen Newton (Married Woman) 1935-1947: Joseph Edward Newton (Farmer) 1947-1973: Harry Lewis Newton (Poultry Farmer) 1973-2006: Edmund John Pike (Poultry Farmer), Norma Jean Pike (Married Woman) 2006 to date: Norma Jean Pike (Widow)
		Lots 46-51 DP456639	(1891 to 1933) John Johnston (Labourer) (1933 to 1947) Barbara Ellen Newton (Married Woman) (1947 to 1957) Joseph Newton (Retired Store Keeper) (1957 to 1967) Phyllis Doreen Sibthorpe (Married Woman) (1967 to 1975) Arthur Sydney Barr (Garage Proprietor) (1975 to 1976) Hector Irving Powell (Accountant)& Alexander William Black (Electrical Operator) (1976 to 1976) Colin Sidney Barr (Labourer) & Selwyn Arthur Barr (Labourer) (1976 to 2006) Edmond (or Edmund) John Pike (Poultry Farmer) & Norma Jean Pike (Married Woman) (2006 to date) Norma Jean Pike (Widow)
Parcel 8	1378-1386 Windsor Rd Riverstone	Lots 40-51 Sec 30 DP1480	(1887 to 1930) Jacob Prout (Draper) (1930 to 1930) Joseph Newton (Farmer) (1930 to 1935) Joseph Edward Newton (Farmer) (1935 to 1947) Joseph Newton (Store Keeper) (1947 to 1954) Ernest William Wormleaton (Store Keeper) & Winifred Elizabeth Wormleaton (Married Woman) (1954 to 1968) John Hope Sibthorpe (Member of the R.A.A.F) & Phyllis Doreen Sibthorpe (Married Woman) (1968 to date), Michele Burzese (Fruiter), Teresa Burzese (Married Woman), Francesco Taranto (Fruiterer), Nancy Taranto (Married Woman)
Parcel 14	201 Hobart St Riverstone	Lots 21-32 Sec 30 DP1480	(1915 to 1924) N.S.W. Realty Co Limited (1924 to 1945) Eric Russell Wormleaton (Engine Driver) (1945 to 1988) William John Withers (Labourer) (1988 to 1991) Esma Sylve Withers (1991 to date), Nazarene Paul Teuma
		63-70 and Sec 30 DP1480	(1917 to 1939) Ludovic Blackwood (Merchant) (1939 to 1945) William Withers (Farmer) (1945 to 1988) William John Withers (Labourer) (1915 to 1924) N.S.W. Realty Co Limited (1924 to 1945) Eric Russell Wormleaton (Engine Driver) (1945 to 1988) William John Withers (Labourer)
Parcel 22	1 Hobart St Riverstone	Lot 1 DP790369	(1897 to 1939) Lucy Wright Packwood (Married Woman) (1939 to 1970) Harry Allan Husselbee (A Minor) (1970 to 1970) John Cowan (Machinist) (1970 to 1988) Jessie Cowan Standen (Married Woman) (1988 to 2004) Joseph Pace & Lena Pace (2004 to date), Joseph Pace
Parcel 21	114 Edmund St Riverstone	Lot 86-90 Sec 30 DP1480	(1887 to 1892) George Hunt (Hotel Keeper) (1892 to 1939) Hugh Downes (Merchant) (1939 to 1951) William Withers (Farmer) (1917 to 1939) Ludovic Blackwood (Merchant) (1939 to 1951) William Withers (Farmer) (1951 to 1958) Cecil John Overton (Labourer) (1958 to 1971) Henry Abbott Joyce (Pensioner)

			(1971 to 1972) Theodorus Wilhelmus Wonderleung (Contractor) (1972 to 1980) Maisie Betty White (Femme Sole) (1980 to 1981) Irene Rose Reilly (Sales Representative) (1981 to 1997) Jennifer Ruth Brennan & Ronald Peter Boyd (1997 to 2013) Ronald Peter Boyd (2013 to date), Arun Bose, Susmita Bose
Parcel 38	# Sydney St Riverstone	Lot 80-81 Sec 31 DP1480	(1891 to 1951) James Cusack (Farmer) (1951 to 1963) Kathleen Mason (Spinster) (1963 to 1970) Josef Konezal (Farmer) & Golan Konezal (Married Woman) (1970 to 1982) Joseph Konezal (Boot Maker) (1982 to 1991) Joseph Konezal (Life Estate), Also Gina Teresa Burzese & Rosemary Burzese (As to Estate in remainder) (1991 to 1998) Joseph Konezal (Life Estate), Also Gina Teresa Laguzza, Rosemary Burzese, Marisa Burzese, Graziella Burzese (As to Estate in remainder) (1998 to date), Gina Teresa Laguzza, Rosemary Burzese, Marisa Burzese, Graziella Burzese
Parcel 28	101 Junction St Riverstone	Lot 36-51 Sec 31 DP1480	(1904 to 1962) Thomas Isaac Boyd (Auctioneer) (1907 to 1962) Bank of New South Wales (Mortgagee in possession) (1962 to 1970) Stanley Edward Joseph Sheehy (Farmer) (purchased – pursuant to unpaid rates) (1970 to 1971) Elspeth Scott Sheehy (Widow) (1971 to date), Thomas Gillespie (Dairy Farmer), Kay Marion Pauline Gillespie (Married Woman) (1910 to 1930) Thomas George Phelts (Store Keeper) (1930 to 1947) Ridge & Company Limited (1947 to 1947) Edward Albert Ellis (Carpenter) & Laura May Ellis (Married Woman) (1947 to 1951) Florence Agnes Sheehy (Married Woman) (1951 to 1970) Stanley Edward Joseph Sheehy (Farmer) (purchased – pursuant to unpaid rates) (1970 to 1971) Elspeth Scott Sheehy (Widow) (1971 to date), Thomas Gillespie (Dairy Farmer), Kay Marion Pauline Gillespie (Married Women)
Parcel 89	91 Junction St Riverstone	Lots 48-49 Sec 32 DP1480	(1915 to 1924) N.S.W. Realty Co Limited (1924 to 1945) Enid Lucy Effie Day (Spinster) (1945 to 1947) Ernest William Wormleaton (Carrier) (1947 to 1961) Joseph Newton (Store Keeper) (1961 to 1978) Alfred Beckinsall (Plastic Moulder) & Enid Beckinsall (Married Woman) (1978 to 1978) Alfred Beckinsall (Plastic Moulder) (1978 to 1981) Sarina Nucifora (Secretary) (1981 to 1985) Donvito Pty Limited (1985 to 1985) Maureen Dorothy Donvito (Home Duties) (1985 to 1995) William Lloyd Stephenson (1995 to 1999) Taveshare Pty Limited (1999 to 2002) Edmund Kevin Bridgewater & Robyn Lynette Bridgewater (2002 to 2012) Guido Tonini (2012 to 2012) Andrew Dean Tonini (Administrator of the Estate of Guido Tonini) (2012 to date), Marli Jade Blewitt, Trent Wayne Blewitt
Parcel 48	228 Sydney St Riverstone	Lots 28-37 Sec 32 DP1480	(1893 to 1995) Isabella Bartlett (Spinster) (1995 to date), Noelene Gay Gillespie (Acquired pursuant to possessory application)
		56-61 Sec 32 DP1480	(1915 to 1920) N.S.W. Realty Co Limited (1920 to 1944) William Wormleaton (Tile Burner) & Eliza Jane Wormleaton (Married Woman)

			(1944 to 1970) Eliza Jane Wormleaton (Widow) (1970 to 1970) Phyllis Doreen Sibthorpe (Married Woman) & Eric Russell Wormleaton (Contractor) (1970 to 1993) William John Gillespie (Fireman) (1993 to date), Noelene Gay Gillespie
Parcel 81	190 Crown St Riverstone	Lots 80-85 Sec 32 DP1480	(1892 to 1937) Emily Jane Williams (Married Woman) (1937 to 1937) William Charles Stead (Retired) (1937 to 1953) James Mason (Poultry Farmer) (1953 to 1976) Kathleen Mason (Spinster) (1976 to date), John Edward Mason (1890 to 1972) Samuel Mason (Laborer) (1972 to 1976) Kathleen Mason (Spinster) (1976 to date), John Edward Mason (1912 to 1953) Samuel Mason (Laborer) (1953 to 1976) Kathleen Mason (Spinster) (1976 to date), John Edward Mason

3.3 EPA Records

A search of the NSW EPA's public register maintained under the *Protection of the Environment Operations Act 1997* was undertaken for the subject site and surrounding properties. The results of the search are presented in **Appendix E**. The search identified that there were no current or former prevention, clean-up or prohibition notices for the site and immediate surrounds.

A search of the EPA's public register for current and historical environmental protection licence (EPL) records issued under the POEO Act has not identified any documents associated with the site or surrounding properties.

A search was also undertaken through the EPA public contaminated land register and relevant records are included in **Appendix E**. The search identified that there have been no notices issued for the site under the *Contaminated Land Management Act 1997* or any nearby surrounding properties.

A search of the NSW EPA register of notified sites did not identify any registered sites in the vicinity of the site.

3.4 Heritage

3.4.1 Australian and NSW Heritage Register

A search of the Australian Heritage Trust database and the NSW Heritage Inventory was undertaken and the resulting records are included in **Appendix F.** The search indicated that the site has no heritage items present.

3.4.2 Riverstone and Alex Avenue Precinct Heritage Assessment (AECOM ENSR 2008)

A previous heritage assessment of the Riverstone and Alex Avenue Precincts has previously been completed by ENSR (ENSR 2008[3]). The study identified a total of 92 heritage sites within the Riverstone and Alex Avenue precincts, with 30 being previously identified and the remaining 62 being identified during the field works. No heritage items were reported within the site.

General historical information on the development of the site and surrounding precincts are noted in the following points:

- Early European activities in the area commenced with Governor King reserving a reserve of approximately 26 539 acres, including the site as Rooty Hill Stock Farm for

[3] *Historic Heritage of the Riverstone and Alex Avenue Precincts,* ENSR 2008 (ENSR 2008).

the raising of livestock to build the capacity of the colony. The reserve extended from east of South Creek, including Eastern Creek and surrounds, with Windsor Road as the northern boundary and an arbitrary east-west line forming the southern boundary.

- Governor Macquarie was ordered to dispose of the stock farm and did so via a series of land grants. Information indicates that the Parish of St Mathew Portion 95 which included the site and surrounds comprising 2500 acres was granted in 1810 to Maurice O' Connell and became known as Riverstone.
- At the time of the 1928 census, O'Connell's Estate was shown as substantially forested apart from two farms, one located off Windsor Road, comprising of three buildings and some small fenced areas located within the Riverstone Precinct. The second farm was located on Eastern Creek to the south of the Riverstone Precinct and the site.
- During the early settlement period of the 1820-1850s the pattern of development comprised the establishment of small farms along Eastern Creek and Windsor Rd that typically included a residence, cultivated areas, outbuildings and cleared land. Between farms the area was mostly forested with original Castlereagh Woodland, although vegetation would become impacted by grazing animals and the felling of timber for fences, building construction and firewood.
- The railway line from Blacktown to Richmond was opened in December 1864 and included a station at Riverstone, nearby to the site.
- Approximately 200 acres of O'Connell's estate was sold off in 1846 to the Australian Trust Company whom later sold the property to Andrew McCullough. The balance of O' Connell's Estate was subdivided to sale upon his death in 1865. In an 1859 plan of subdivision of the Riverstone Estate (Reuss and Browne surveyors), this land was divided into 59 blocks of between 25 and 83 acres intended for sale as small farm. However it is reported that this subdivision was apparently not implemented.
- A further subdivision plan dated 1864 by Reuss shows the land following construction of the railway which resulted in re-orientation of the proposed blocks. The small size of the farms was reported to indicate farms were more likely to comprise more intensive activities such as dairying and/or orchards.
- The Riverstone timber mill was established in 1874 by Andrew McCulloch and operated for approximately 11 years. Reports of brick making have also been recorded in the area to the west of Eastern Creek.
- In October 1877 the Riverstone Township subdivision further subdivided land from the 1864 subdivision into 157 blocks each 1 acre in size and associated streets. The subdivision was located adjacent to Riverstone Railway Station. A second subdivision located on former O' Connell's Estate land was made in May 1881 resulting in a mixture of 1 acre township lots and 5 acres orchard blocks.
- Further subdivision of the Riverstone Estate occurred in 1881 with Riverstone Heights and Grantham subdivisions occurring in the late 1880s. The allotments on the final two subdivisions were 200 ft by 30 ft (60 x 9 m) in size. From information included in ENSR 2008 it is unclear as to which subdivision the lots within the site were created.
- A topographic map of Windsor (1:63360) indicated that the area to the north of Crown St was only lightly settled, with the population of Riverstone held tightly close to the station.
- In 1947-1948 the County of Cumberland Plan was adopted which included the implementation of a green belt around the urban area of Sydney. This resulted in a ban of construction for all sites of less than 5 acres (2 ha) in size. As such properties within the site in what has now become known as the 'scheduled lands' were no longer allowed to be developed having been zoned as rural. These blocks were originally subdivided in the 1880s as the Grantham and Riverstone Heights Estates with small blocks of land averaging approximately 558 m^2.

- The 'scheduled lands' cover approximately 300 hectares falling predominantly within the Riverstone North Precinct.

3.5 Council Records

A total of ten s.149 certificates were ordered for ten different Parcels from Blacktown City Council (BCC), with the s.149 planning certificates included in **Appendix G**. The following information is noted in the certificates for the relevant Parcels:

- All ten Parcels are zoned R2 Low Density Residential, one parcel (Parcel 81) is also zoned as RE1 Public Recreation;
- The land is not located in a heritage conservation area;
- The land is not affected by any road widening or road realignment under Roads Act 1993;
- The land is not affected by any of the matters contained in Clause 59(2) as amended in the Contaminated Land Management Act 1997 as listed:
- That the land to which the certificate relates is significantly contaminated land;
- That the land to which the certificate relates is subject to a management order;
- That the land to which the certificate relates is the subject of an approved voluntary management proposal;
- That the land to which the certificate relates is subject to an ongoing maintenance order; and
- That the land to which the certificate relates is the subject of a site audit statement.
- The land is not subject to a Tree Preservation Order.
- The land is not identified as being affected by implementation of the Coastal Protection Act 1979 or proclaimed to be within a mine subsidence district within the meaning of Section 15 of the Mine Subsidence Compensation Act 1961.
- The land is subject to flooding but further investigation is required.

3.6 WorkCover Dangerous Goods Database

Of the 65 Parcels that make up the site, ten were selected, based on the site history review, to have a Dangerous Goods Licence search of the Stored Chemical Information Database maintained by WorkCover NSW completed.

Of those ten Parcels, permission to complete the Dangerous Goods Licence search was provided by seven Parcels only. WorkCover documentation obtained for those seven sites are provided in **Appendix H**.

The WorkCover NSW documentation did not locate any records pertaining to dangerous goods at the Parcels selected.

3.7 Previous Investigations

During the assessment period, JBS&G were provided with a previous study report entitled "*Riverstone Precinct, Land Capability and Contamination Report, Revision 2*" prepared for the Growth Centres Commission by SMEC Australia Pty Ltd, February 2008 (SMEC 2008). The study are comprised the whole of the Riverstone Precinct (1149 ha) and was designed in scope to support the preparation of a precinct plan for the Riverstone Precinct.

The objectives of the study were to:

- Identified and document existing soil conditions including salinity risks, soil contamination, groundwater and land capability risks with respect to future urban development at the site;

- Determine the potential for land contamination to present particular environmental constraints in the release area; and
- Make recommendations in relation to the management of land with respect to contamination, salinity, groundwater and land capability risks.

The scope of works included a desktop study of available information and limited soil sampling activities including soil sampling at 8 locations across the precinct and subsequent analysis of limited samples for salinity parameters and heavy metals.

The reports also identified an earlier Riverstone Release Area: Contaminated Lands Study, prepared by Coffey in 1999. The reported data indicated that subsurface conditions in the area typically consisted of 0.2 – 0.3 m topsoil overlying 1-3 m of residual soil or colluvium consisting of medium to high plasticity clay.

The Coffey (1999) report was reported to have included the laboratory analysis of a total of 126 surface soil samples from areas of intense agriculture/horticultural land, treed and grazing land, poultry farms a suspected cattle dip site and an informal car yard, all located within the broader Riverstone Precinct. A series of groundwater monitoring bores were also installed across the precinct during this assessment. The assessment identified the presence of slightly elevated heavy metals in soil in highly disturbed (agricultural/ horticultural area), however the results did not exceed the adopted health based assessment criteria. Other analyte concentrations were less than the adopted limits of laboratory reporting (LOR). Significant groundwater impacts were not identified at the sampled monitoring well locations. This report indicated that large scale site contamination impacts were unlikely to be present at the site, however there were areas considered to be of moderate to high potential contamination risk based on previous of current land uses at the time of the assessment. The risk map indicated that all Parcels within the site fell within either a low or moderate potential risk.

The SMEC (2008) assessment was reported to have been designed to complement the Coffey (1999) preliminary investigation. Review of the sample location plan indicated that one of eight selected sampling locations (DUR5) may have been situated at the southern extent of the site. No soil samples from this borehole were selected for contaminant analysis.

3.8 Integrity Assessment

The information obtained from formal published sources noted above has been found to be in general agreement regarding the history of the site.

Although the dangerous goods, titles and council searches were not completed for all Parcels, the information gathered during the site inspection and the historical search were generally in agreement as to the location of former infrastructure and AECs.

Based on the range of sources and the general consistency of the historical information, it is considered that the historical assessment has an acceptable level of accuracy with respect to the potentially contaminating activities historically occurring at the site.

4 Conceptual Site Model

The information presented herein, together with the report figures, provides a conceptual site model (CSM) for the site based on the current understanding of the site and the specific project objectives.

4.1 Potential Areas of Environmental Concern

Based on the site history review, the site inspections, and in consideration of the specific project objectives, potential areas/aspects of environmental concern (AEC) and associated contaminants of potential concern (COPC) have been identified and are presented in **Table 4.1**.

Table 4.1 Areas of Environmental Concern and associated Contaminants of Potential Concern

Parcel ID	Area of Environmental Concern (AEC)	Contaminants of Potential Concern (COPCs)	Risk Ranking[1]		
			High	Med	Low
Parcel 4	Illegally dumped material	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos		√	
Parcel 5	ACM sheeting, septic tank, stockpiles of unknown material, unknown source of fill material, hazardous building materials, potential spills from sandstone cutting equipment	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos		√	
Parcel 6	ACM sheeting, septic tanks, chicken coup, tyres. unknown source of fill material	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos		√	
Parcel 7	Metal Scrap Yard, ACM on the surface soils, Above ground storage tank (disused), surface soil hydrocarbon staining	Heavy metals , TPH/BTEX, PAHs, PCBs, asbestos	√		
Parcel 8	Hazardous building materials (takeaway shop), unknown source of fill material	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos			√
Parcel 9	Unknown source of fill material	Heavy metals, PAHs, asbestos			√
Parcel 10	Unknown source of fill material	Heavy metals, PAHs, asbestos			√
Parcel 11	Hazardous building materials, septic tank, unknown source of fill material, garden beds	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos			√
Parcel 12	Illegally dumped material and unknown source of fill material	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos			√
Parcel 13	Illegally dumped material and unknown source of fill material	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos			√
Parcel 14	Former agricultural use, hazardous building materials (house), ACM sheeting and drums (unknown contents), surface staining, scrap metal stockpiles	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos		√	
Parcel 15	Unknown source of fill material	Heavy metals, PAHs, asbestos			√
Parcel 16	Former agricultural use, unknown source of fill material, hazardous building materials (house)	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos		√	
Parcel 17	Illegally dumped material	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos			√

Parcel ID	Area of Environmental Concern (AEC)	Contaminants of Potential Concern (COPCs)	Risk Ranking[1]		
			High	Med	Low
Parcel 18	Illegally dumped material, ACM observed on surface	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos		√	
Parcel 19	Illegally dumped material, ACM observed on surface	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos		√	
Parcel 20	Illegally dumped material, with plastic drums	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos			√
Parcel 21	Unknown source of fill material	Heavy metals, PAHs, asbestos			√
Parcel 22	Scrap metal and plant, unknown source of fill material, surface hydrocarbon staining.	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos	√		
Parcel 23	No Access				
Parcel 24	Illegally dumped material, suspected ACM vinyl tiles	Heavy metals, PAHs, asbestos			√
Parcel 25	Unknown source of fill material, Car parts and burnt surface staining	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos		√	
Parcel 26	Unknown source of fill material, Illegally dumped material, ACM and building waste	Heavy metals, PAHs, asbestos		√	
Parcel 27	Unknown source of fill material, Illegally dumped material	Heavy metals, PAHs, asbestos		√	
Parcel 28	Former agricultural use, hazardous building materials. Unknown source of fill material	Heavy metals, PAHs OCP/OPPs, asbestos			√
Parcel 29	Unknown source of fill material, building material waste	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos			√
Parcel 30	Unknown source of fill material, concrete curing compound drums	Heavy metals, TPH/BTEX, PAHs		√	
Parcel 31	Unknown source of fill material	Heavy metals, PAHs, asbestos			√
Parcel 32	Unknown source of fill material	Heavy metals, PAHs, asbestos			√
Parcel 33	Unknown source of fill material	Heavy metals, PAHs, asbestos			√
Parcel 34	Hazardous building materials, septic tank, unknown source of fill material	Heavy metals, TPH/BTEX, PAHs, asbestos			√
Parcel 35	Unknown source of fill material, Illegally dumped material	Heavy metals, PAHs, asbestos		√	
Parcel 36	Unknown source of fill material	Heavy metals, PAHs, asbestos			√
Parcel 37	Hazardous building materials, chicken coups, dog kennels, unknown fill material, ACM in surface soils	Heavy metals, PAHs asbestos		√	
Parcel 38	Building waste, machinery, railway sleepers, engine oil bottles, scrap metal, motorbike circuit	Heavy metals, TPH/BTEX, PAHs, asbestos		√	
Parcel 39	Unknown source of fill material	Heavy metals, PAHs, asbestos			√
Parcel 40	Unknown source of fill material, concrete curing compound drums	Heavy metals, TPH/BTEX, PAHs		√	
Parcel 41	Unknown source of fill material	Heavy metals, PAHs, asbestos			√

Parcel ID	Area of Environmental Concern (AEC)	Contaminants of Potential Concern (COPCs)	Risk Ranking[1]		
			High	Med	Low
Parcel 42	Unknown source of fill material, Illegally dumped material	Heavy metals, PAHs, asbestos			√
Parcel 43	Unknown source of fill material	Heavy metals, PAHs, asbestos			√
Parcel 44	Unknown source of fill material	Heavy metals, PAHs, asbestos			√
Parcel 45	Hazardous building materials, ACM in surface soils	Asbestos		√	
Parcel 46	Unknown source of fill material, Illegally dumped material, ACM in surface soils	Heavy metals, PAHs, asbestos			√
Parcel 47	Unknown source of fill material	Heavy metals, PAHs, asbestos			√
Parcel 48	Former agricultural use, Unknown source of fill material	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos		√	
Parcel 49	Unknown source of fill material	Heavy metals, PAHs, asbestos			√
Parcel 50	Hazardous building materials, ACM in surface soils	Asbestos		√	
Parcel 51	Unknown source of fill material	Heavy metals, PAHs, asbestos			√
Parcel 52	Storage yard for boats and for a building company, unknown fill material	Heavy metals, TPH/BTEX, asbestos			√
Parcel 53	Unknown source of fill material and engine oil drum	Heavy metals, PAHs, asbestos			√
Parcel 54	Storage yard for boats and for a building company, unknown fill material, fuel drums and surface staining	Heavy metals, TPH/BTEX, asbestos	√		
Parcel 55	Unknown source of fill material, Above ground storage tank, , Illegally dumped material, ACM in surface soils	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos	√		
Parcel 80	Unknown fill material, ACM in surface soils	Heavy metals, PAHs, asbestos			√
Parcel 81	Unknown fill material	Heavy metals, PAHs, asbestos			√
Parcel 82	Unknown fill material	Heavy metals, PAHs, asbestos			√
Parcel 83	Unknown fill material	Heavy metals, PAHs, asbestos			√
Parcel 84	Unknown fill material	Heavy metals, PAHs, asbestos			√
Parcel 85	Former agriculture, unknown fill material	Heavy metals, PAHs, OCP/OPPs asbestos		√	
Parcel 86	Former agriculture, unknown fill material	Heavy metals, PAHs, OCP/OPPs asbestos		√	
Parcel 87	Former agriculture, unknown fill material	Heavy metals, PAHs, OCP/OPPs, asbestos		√	
Parcel 88	Hazardous building materials, ACM in surface soils, chlorine plastic drums	Asbestos, chlorine			√
Parcel 89	Unknown fill material	Heavy metals, PAHs, asbestos			√

[1] Risk Ranking is based on the likelihood of widespread impact associated with AEC and COPCs.

4.2 Potentially Contaminated Media

Potentially contaminated media targeted for this investigation:

- Fill material;
- Natural soils;
- Surface water; and
- Groundwater.

Some potential for filling has been reported at the site, including possible historical burial of waste material, as well as stockpiles of waste including building materials, chemical containers/drums, tyres and asbestos. Based on this the fill material is considered a potentially contaminated medium.

Surface and near surface natural soils at the site are considered to comprise potentially contaminant media based on the following: where natural soils are exposed at the ground surface there is the potential for impacted materials on the ground surface to have impacted natural soil; where natural soils are exposed at the ground surface, direct impacts from historical site activities; and the potential leachability of the identified contaminants which may result in impacts to natural soils underlying fill material and/or stockpiles at the site.

The potential leachability of identified contaminants of concern and shallow groundwater contribute to groundwater being nominated as a potentially contaminated medium. As with the natural soils, the potential for contamination of groundwater will depend upon the actual nature, occurrence and characteristics of contamination within stockpiled material, overlying fill material (where present) and/or potentially natural soils.

Given the close proximity of surface water bodies to the site and that rainfall would flow into these surface water bodies through overland flow, the surface water is also considered to be a potentially contained media.

4.3 Potential for Migration

Contaminants generally migrate from site via a combination of windblown dusts, rainwater infiltration, groundwater migration and surface water runoff. The potential for contaminants to migrate is a combination of:

- The nature of the contaminants (solid/liquid and mobility characteristics);
- The extent of the contaminants (isolated or widespread);
- The location of the contaminants (surface soils or at depth); and
- The site topography, geology, hydrology and hydrogeology.

The potential contaminants identified at the site are present in solid (e.g. impacted soil or fill, asbestos) and liquid (e.g. dissolved in water) forms.

Rainfall infiltration at the site is expected to occur in unsealed areas investigated. There is therefore the potential for contaminants in fill to leach into underlying natural soils and into the perched groundwater.

As the site is covered primarily with vegetation, the potential for windblown dust migration of contamination from the site is generally low, however non-friable ACM fragments are potentially present at the site. Consequently, if the ACM fragments are at the surface, these exposed fragments may weather and produce friable asbestos and therefore the potential for windblown dust contamination increases.

It is considered there is limited potential for generation of vapours or ground gases associated with volatile contaminants given the unlikely presence of significant volatile contaminants at the site.

4.4 Potential Exposure Pathways

Based on the contaminants of potential concern identified in various media as discussed above, existing site uses and with consideration of future potential site development activities, the exposure pathways considered to be potentially complete for the site currently, during and following development works include:

- Potential dermal and oral contact to impacted soils (and associated dust) as present at shallow depths and/or accessible by future service excavations across the extent of the Site; and/or
- Potential oral and dermal contact to shallow groundwater, where present as accessible by potential future service excavations and/or installed services pits; and/or
- Potential contaminant uptake by vegetation established in the various vegetated areas of the site, potentially including large street tree plantings and landscaped areas; and/or
- Potential contaminant uptake by site occupants as a result of ingestion via eating edible plant (including fruit and vegetable) matter grown in areas of the site and/or
- Direct ingestion of soil, particularly by young children playing on the ground surface in non-paved areas of the site.

Given the low probability of occurrence of contaminants in vapour at the site, the inhalation of contaminant vapours migrating upward to the ground surface and/or accumulating within future service excavations and/or installed service pits is considered low. However, in the event that significant contaminated impacts are identified, these potential exposure pathways will require further consideration.

At this stage, it is not anticipated that any groundwater extraction will occur over the area of the site in the future. However, short term dewatering may occur to facilitate installation of services and depth, where required.

4.5 Receptors

Potential receptors of environmental impact present within the site which will require to be addressed with respect to the suitability of the site for the proposed use include:

- Future site occupants whom may potentially be exposed to COPCs through direct contact with impacted soils and/or inhalation of dusts / fibres associated with impacted soils; and/or
- Excavation / construction / maintenance workers conducting activities at or in the vicinity of the site, whom may potentially be exposed to COPCs through direct contact with impacted soils and/or groundwater present within excavations and/or inhalation of dusts / fibres associated with impacted soils;
- Flora species established in the vegetated areas of the site inclusive of large trees and edible plants; and/or
- The aquatic ecosystem of various localised creek lines located hydro-geologically downgradient of the site.

In the event that petroleum or other volatile hydrocarbon compound impact is identified, potential inhalation exposure to vapours will also require to be considered.

4.6 Preferential Pathways

For the purpose of this assessment, preferential pathways have been identified as natural and/or man-made pathways that result in the preferential migration of COPCs as either liquids or gases.

Man-made preferential pathways are present in limited areas of the site, generally associated with historical and/or current underground services infrastructure and in areas of fill material at the site. Fill materials are anticipated to have a higher permeability than the underlying natural soil and/or bedrock.

Where sub-surface infrastructure easement occur at the site, preferential pathways can be formed by the generally higher permeability backfill used to re-instate these trenches.

Preferential pathways are also important in the assessment of potential off-site sources of COPCs. Preferential pathways are potentially present in the adjoining road network, as associated with service easements.

5 Sampling and Analysis Plan

5.1 Data Quality Objectives

Data quality objectives (DQOs) were developed for the investigation, as discussed in the following sections.

5.1.1 State the Problem

The Riverstone Precinct is situated in the North-West Growth Centre, being approximately 1149 hectares (ha) in area. The Precinct includes a range of urban areas, rural residential areas and the 'Scheduled Lands' in the north comprising generally unoccupied forested/bushland areas.

The site, comprising Precinct A of the overall Riverstone Precinct development, is approximately 16 ha in area, with approximately 50 landowners. Prior to provision of services/infrastructure and development on individual lots, a process of subdivision is required, involving lodgement of a development application (DA) with the Council. Previous broad scale preliminary site assessment activities completed by others have identified the potential presence of site contamination issues on a number of parcels within the site (resulting from historical site uses and/or the presence of impacted imported materials).

To confirm the broad assumptions made in preparation of the recommendations in the previous reports and in turn the preparation of the conceptual site model (CSM), implementation of a detailed investigation is necessary to assess whether the site is currently suitable, or can be made suitable for one or more potential future site uses. In conjunction with a geotechnical investigation, the intent was also to provide suitable information such that evaluation can be completed of the potential opportunities for on-site containment of any impacted material should it be identified during the assessment. .

5.1.2 Identify the Decision

Based on the decision making process for assessing urban redevelopment site detailed in DEC (2006), modified to meet the specific project objectives, the following decisions must be made:

- Are there any unacceptable risks to likely future onsite receptors for the proposed land use scenarios?
- Are there any impacts of chemical mixtures?
- Are there any aesthetic concerns in soils present at the site?
- Is there potential for migration of contaminants from the site?
- Is a management strategy required?
- If a management strategy is required, can impacted material be retained on-site in areas of lower land use sensitivity than "residential with accessible soils" without ongoing management?
- If a management strategy is required, can identified contaminated soils remain at the site under management using a cap and containment strategy based on physical separation?
- If removal offsite is required, can current data provide waste classification under the DECCW 2009?

5.1.3 Identify Inputs to the Decision

Inputs to the decisions are:

- The results of previous investigations relevant to the areas of investigation, including background historical information, site observations, laboratory results and report findings;
- New environmental data as collected by sampling and analysis and site observations made during this investigation;
- Assessment criteria to be achieved on the site as based on the intended landuse and previous investigations, and project objectives, as defined by assessment criteria nominated in **Section 6**;
- Confirmation that data generated by sampling and analysis are of an acceptable quality to allow reliable comparison to assessment criteria as undertaken by assessment of quality assurance / quality control (QA/QC) as per the data quality indicators (DQIs) established in **Section 5.1.6**;
- Hazardous materials survey from investigations completed in conjunction with the ESA; and
- Geotechnical data from investigations completed in conjunction with the ESA.

5.1.4 Define the Study Boundaries

The study boundaries are limited to those portions of the nominated site as described in **Section 1.2** and shown on **Figure 2a** and **2b**.

The vertical extent of the investigation was approximately 0.2 to 0.3 m beneath the site surface.

Due to the project objectives, seasonality was not be assessed as part of this investigation. Data was therefore representative of the timing and duration of the current investigation.

5.1.5 Develop a Decision Rule

Laboratory analytical data was assessed against EPA endorsed criteria as identified in **Section 6**.

The decision rules adopted to answer the decisions identified in **Section 5.1.2** are summarised in **Table 5.1**.

Table 5.1 Summary of Decision Rules

Decision Required to be Made	Decision Rule
1. Are there any unacceptable risks to onsite future receptors from soil?	The nature and extent of soil impacts was assessed, and soil analytical data was compared against EPA endorsed criteria. If the concentrations for each contaminant in each analysed sample were less than the stated criteria and an assessment of risk indicated no unacceptable risks, the answer to the decision was No. Otherwise, the answer to the decision was Yes.
2. Are there any chemical mixtures?	Are there more than one group of contaminants present which increase the risk of harm? If there is, the decision was Yes. Otherwise, the decision was No.
3. Are there any aesthetics issues in soils at the site?	If there were any unacceptable odours, staining/ discoloration or similar, the answer to the decision was Yes. Otherwise, the answer to the decision was No.
4. Is there a potential risk of migration of contaminants from the Site?	Soil contaminant data was evaluated with the consideration of the potential for migration of contaminants via bulk disturbance of soils (ie. dust, surface water, etc) and the potential mobility of contaminants in soil and groundwater. In the event that significant contaminant concentrations was identified and there is the potential for migration of these contaminants from the site via either bulk movement and/or migration in soil and/or groundwater, the answer to the decision was Yes. Otherwise, the answer to the decision was No.
5. Is a management strategy required?	Was the answer to any of the above decisions Yes? If not, then the answer to the decision was No and the site is considered suitable for the proposed use.

Decision Required to be Made	Decision Rule
	If yes, then the answer to the decision was Yes and further evaluation of potential management requirements is necessary.
6. If a management strategy is required, can impacted material be retained on-site in areas of lower land use sensitivity than "residential with accessible soils" without ongoing management	In the event the answer to Decision 1 was Yes, soil analytical data was then also compared against NSW EPA endorsed criteria applicable to less sensitive land use categories including "parks and recreational open space" and/or "commercial/industrial" as would be applicable to areas within public open space and/or paved road footprints. Individual soil contaminant concentrations were compared against these adopted alternative site assessment criteria. If all individual contaminant concentrations for all samples were less than the adopted criterion, the answer to the decision was Yes. Otherwise, the answer to the decision was No
7. If a management strategy is required, can identified contaminated soils remain at the site under management using a cap and containment strategy based on physical separation?	Soil contaminant data was assessed by comparison with ANZECC (1999[4]) and EPA endorsed documents as appropriate. If the contaminants were considered suitable for management via installation of a capping system based on physical separation, the answer to the decision was Yes. If the contaminants still represent a potential risk in relation to future site users/the environment following installation of a physical separation layer, the answer to the decision would be No.
8. If removal offsite is required, can current data provide waste classification under the DECCW 2009?	Analytical data collected from areas of potential excavation were compared against EPA endorsed waste classification criteria. Statistical analysis of the data was completed where appropriate, to classify the material in accordance with the Waste Classification Guidelines (DECCW 2009). If the material was considered to have met the applicable guideline thresholds, the answer to the decision was Yes. If the material could not be provided with an appropriate classification, the answer to the decision was No.

5.1.6 Specify Limits of Decision Error

This step is to establish the decision maker's tolerable limits on decision errors, which are used to establish performance goals for limiting uncertainty in the data. Data generated during this project must be appropriate to allow decisions to be made with confidence.

Specific limits for this project have been adopted in accordance with the appropriate guidance from the NSW EPA, NEPC (2013), appropriate indicators of data quality (DQIs used to assess QA/QC) and standard JBS&G's procedures for field sampling and handling.

To assess the usability of the data prior to making decisions, the data was assessed against pre-determined Data Quality Indicators (DQIs) for completeness, comparability, representativeness, precision and accuracy. The acceptable limit on decision error is 95% compliance with DQIs.

The pre-determined Data Quality Indicators (DQIs) established for the project are discussed below in relation to precision, accuracy, representativeness, comparability, completeness and sensitivity (PARCCS parameters), and are shown in **Table 5.2**.

- **Precision** - measures the reproducibility of measurements under a given set of conditions. The precision of the laboratory data and sampling techniques is assessed by calculating the Relative Percent Difference (RPD) of duplicate samples.
- **Accuracy** - measures the bias in a measurement system. The accuracy of the laboratory data that are generated during this study is a measure of the closeness of the analytical results obtained by a method to the 'true' value. Accuracy is assessed by reference to the analytical results of laboratory control samples, laboratory spikes and analyses against reference standards.
- **Representativeness** –expresses the degree which sample data accurately and precisely represent a characteristic of a population or an environmental condition.

[4] *Guidelines for the Assessment of On-site Containment of Contaminated Soil*. Australian and New Zealand Environment and Conservation Council. September 1999 (ANZEC 1999)

Representativeness is achieved by collecting samples on a representative basis across the site, and by using an adequate number of sample locations to characterise the site to the required accuracy.

- **Comparability** - expresses the confidence with which one data set can be compared with another. This is achieved through maintaining a level of consistency in techniques used to collect samples; ensuring analysing laboratories use consistent analysis techniques and reporting methods.
- **Completeness** – is defined as the percentage of measurements made which are judged to be valid measurements. The completeness goal is set at there being sufficient valid data generated during the study.
- **Sensitivity –** expresses the appropriateness of the chosen laboratory methods, including the limits of reporting, in producing reliable data in relation to the adopted site assessment criteria.

If any of the DQIs are not met, further assessment was necessary to determine whether the non-conformance significantly affected the usefulness of the data. Corrective actions may include requesting further information from samplers and/or analytical laboratories, downgrading of the quality of the data or alternatively, re-collection of the data.

Table 5.2 Summary of Quality Assurance / Quality Control Program

Data Quality Objective	Frequency	Data Quality Indicator
Precision		
Blind duplicates (intra laboratory)	1 / 20 samples	<50% RPD[1]
Blind duplicates (inter laboratory)	1 / 20 samples	<50% RPD[1]
Laboratory Duplicates	1 per batch	<50% RPD[1]
Accuracy		
Surrogate spikes	All organic samples	70-130%
Laboratory control samples	1 per lab batch	70-130%
Matrix spikes	1 per lab batch	70-130%
Representativeness		
Sampling appropriate for media and analytes		-
Samples extracted and analysed within holding times.	-	organics (14 days), inorganics (6 months)
Trip spike (for volatiles)	1 per sampling event when sampling for volatile or semi-volatile COPC	70-130% recovery
Storage blank	1 per sampling event	<LOR
Rinsate	1 per sampling date where reusable sampling equipment used	<LOR
Comparability		
Standard operating procedures for sample collection & handling	All Samples	All samples
Standard analytical methods used for all analyses	All Samples	All samples
Consistent field conditions, sampling staff and laboratory analysis	All Samples	All samples
Limits of reporting appropriate and consistent	All Samples	All samples
Completeness		
Sample description and COCs completed and appropriate	All Samples	All samples
Appropriate documentation	All Samples	All samples
Satisfactory frequency and result for QC samples	All QA/QC samples	-
Sensitivity	-	Critical samples valid
Analytical methods and limits of recovery appropriate for media and adopted Site assessment criteria	All samples	LOR<= Site assessment criteria

1. Relative per cent difference

If any of the DQIs are not met, further data assessment will be necessary to evaluate whether the non-conformance significantly affect the usefulness of the data.

5.1.7 Optimise the Design for Obtaining Data

Various strategies for developing a statistically based sampling plan are identified in EPA (1995) *Contaminated Sites: Sampling Design Guidelines,* including judgemental, random, systematic and stratified sampling patterns. The (EPA 1995) provide no guidance for an appropriate sampling density for sites greater than 5 ha. Instead, EPA (1995) recommends that the site should be broken up into smaller land Parcels.

Based on the size of the site, the available historical and current use information and the potential areas of concern as identified in **Section 4.1**, a stratified sampling plan was considered most appropriate to provide an appropriate level of investigation data with which to make decisions regarding suitability of the site and opportunities for remediation.

The following design was implemented to obtain data:

Table 5.3 Implemented Sampling Strategy

Parcel	AEC	Sampling Regime	Number of Sampling Locations	Justification	Contaminants of Concern	Sampling Depths	Number of samples for analysis
4	Illegally dumped material	Systematic	3 insitu 1 stockpile	Density appropriate to assess presence of significant widespread contamination impacts. Targeted sampling at locations related to potential impacts and stockpiles	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos	Surface, and subsurface (0.1 m, 0.3 m) and from stockpiled material	3x PAHs/metals, 2x TRH, 2X PCBs/OCPs, 1x stockpile sample
5	ACM sheeting, Unknown source of fill material	Systematic	3 insitu	Density appropriate to assess presence of significant widespread contamination impacts. Targeted sampling at locations related to potential impacts and stockpiles	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos	Surface, and subsurface (0.1 m, 0.3 m) and from stockpiled material	3x PAHs/metals, 3x TRH, 2X PCBs/OCPs, 1x asbestos, 4 stockpile samples
6	ACM sheeting, Unknown source of fill material	Systematic	3 insitu 4 stockpile	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	1x metals, asbestos, PAHs
7	Metal Scrap Yard, ACM on the surface soils, Above ground storage tank (disused), surface soil hydrocarbon staining	Targeted	3 insitu	Targeted sampling appropriate in high risk areas associated with use the soil staining.	Heavy metals , TPH/BTEX, PAHs, PCBs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	3x PAHs/metals, 2x TRH, 2x asbestos, 2x PCBs/OCPs
8	Hazardous building materials (takeaway shop), unknown source of fill material	Systematic	3 insitu 3 stockpiles	Density appropriate to assess presence of significant widespread contamination impacts. Targeted sampling at locations related to stockpiles	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos	Surface, and subsurface (0.1 m, 0.3 m) and from stockpiled material	4x PAHs/metals, 4x TRHs, 4x asbestos, 4x PCBs/OCPs, 2 stockpile samples
9	Unknown source of fill material	Systematic	3 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, PAHs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	2x PAHs/metals, 1x TRH, 1x asbestos, 1x PCB/OCPs
10	Unknown source of fill material	Systematic	2 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, PAHs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	2x PAHs/metals
11	Hazardous building materials, septic tank, unknown source of fill material, garden beds	Systematic	3 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, TPH/BTEX, PAHs, OCP, PCBs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	3x metals, 2x TRH/BTEX, 3x PAHs, 2x OCPs, 2x asbestos, 2x PCBs
12	Illegally dumped material and unknown source of fill material	Systematic	2 insitu 1 stockpile	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	2x PAHs/metals, 1x TRH, 1x asbestos, 1x PCBs/OCPs
13	Illegally dumped material and unknown source of fill material	Systematic	1 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	1xPAHs/metals

Parcel	AEC	Sampling Regime	Number of Sampling Locations	Justification	Contaminants of Concern	Sampling Depths	Number of samples for analysis
14	Former agricultural use, hazardous building materials (house), ACM sheeting and drums (unknown contents), surface staining, scrap metal stockpiles	Targeted	3 insitu	Targeted sampling appropriate in high risk areas associated with use the soil staining, scrap metal areas and drums.	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	3xPAHs/metals, 1x TRH, 1x asbestos, 1x PCBs/OCPs
15	Unknown source of fill material	Systematic	2 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, PAHs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	2xPAHs/metals
16	Former agricultural use, former in filled dam, unknown source of fill material, hazardous building materials (house)	Systematic	3 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	4xPAHs/metals, 1x TRH, 1x asbestos, 1x PCBs/OCPs
17	Illegally dumped material	Systematic	3 insitu 3 stockpiles	Density appropriate to assess presence of significant widespread contamination impacts. Targeted sampling at locations related to stockpiles	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos	Surface, and subsurface (0.1 m, 0.3 m) and from stockpiled material	3x PAHs/metals, 1x TRH, 1x asbestos, 1x PCBs/OCPs, 3x stockpile samples
18	Illegally dumped material, ACM observed on surface	Systematic	2 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	3x PAHs/metals, 1x TRH, 1x asbestos, 1x PCBs/OCPs
19	Illegally dumped material, ACM observed on surface	Systematic	3 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	3x PAHs/metals, 1x asbestos
20	Illegally dumped material, with plastic drums	Systematic/ targeted	2 insitu	Density appropriate to assess presence of significant widespread contamination impacts. Targeted sampling appropriate in high risk areas associated with use the soil staining, scrap metal areas and drums	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	4x PAHs/metals, 2x TRH, 2x asbestos, 2x PCBs/OCPs
21	Unknown source of fill material	Systematic	3 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, PAHs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	3x PAHs/metals, 1x TRH, 1x asbestos, 1x PCBs/OCPs
22	Scrap metal and plant, unknown source of fill material, surface hydrocarbon staining.	Targeted	3 insitu	Targeted sampling appropriate in high risk areas associated with use the soil staining, scrap metal areas	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	3x PAHs/metals, 3x TRH, 1x asbestos, 3x PCBs/OCPs
23	No Access						
24	Illegally dumped material, suspected ACM vinyl tiles	Systematic	2 insitu 1 stockpile	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, PAHs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	2x PAHs/metals, 1x TRH, 1x asbestos, 1x PCBs/OCPs

Parcel	AEC	Sampling Regime	Number of Sampling Locations	Justification	Contaminants of Concern	Sampling Depths	Number of samples for analysis
25	Unknown source of fill material, Car parts and burnt surface staining	Targeted	2 insitu 1stockpile	Targeted sampling appropriate in high risk areas associated with use the soil staining, scrap metal areas	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	2x PAHs/metals
26	Unknown source of fill material, Illegally dumped material, ACM and building waste	Systematic	2 insitu 1 stockpile	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, PAHs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	3x PAHs/metals, 1x TRH, 1x PCBs/OCPs
27	Unknown source of fill material, Illegally dumped material	Systematic	2 insitu 2 stockpiles	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, PAHs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	2x PAHs/metals, 1x TRH, 1x asbestos, 1x PCBs/OCPs
28	Former agricultural use, hazardous building materials. Unknown source of fill material	Systematic	3 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, PAHs OCP/OPPs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	3x PAHs/metals, 1x TRH, 1x asbestos, 1x PCBs/OCPs
29	Unknown source of fill material, building material waste	Systematic	2 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	2x PAHs/metals, 1x TRH, 1x asbestos, 1x PCBs/OCPs
30	Unknown source of fill material, concrete curing compound drums	Targeted	2 insitu	Targeted sampling appropriate in high risk areas associated with use of drums	Heavy metals, TPH/BTEX, PAHs	Surface, and subsurface (0.1 m, 0.3 m)	2x PAHs/metals, 1x TRH, 1x asbestos, 1x PCBs/OCPs
31	Unknown source of fill material	Systematic	2 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, PAHs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	2x PAHs/metals, 1x TRH, 1x asbestos, 1x PCBs/OCPs
32	Unknown source of fill material	Systematic	2 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, PAHs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	1x PAHs/metals
33	Unknown source of fill material	Systematic	2 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, PAHs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	2x PAHs/metals, 1x TRH, 1x asbestos, 1x PCBs/OCPs
34	Hazardous building materials, septic tank, unknown source of fill material	Systematic	3 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, TPH/BTEX, PAHs, OCP, PCBs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	2x metals, 2x TRH/BTEX, 2x PAHs, 2x OCPs, 2x asbestos, 2x PCBs
35	Unknown source of fill material, Illegally dumped material	Systematic	2 insitu 1 stockpile	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, PAHs, asbestos	Surface, and subsurface (0.1 m, 0.3 m) and from stockpiled material	2x PAHs/metals, 1x stockpile sample
36	Unknown source of fill material	Systematic	2 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, PAHs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	2x PAHs/metals, 1x TRH, 1x asbestos, 1x PCBs/OCPs
37	Hazardous building materials, chicken coups, dog kennels, unknown fill material, ACM in surface soils	Targeted	2 insitu	Targeted sampling appropriate in high risk areas associated with use of the site for chicken coups etc.	Heavy metals, PAHs asbestos	Surface, and subsurface (0.1 m, 0.3 m)	2x PAHs/metals, 1x TRH, 1x asbestos, 1x PCBs/OCPs

Parcel	AEC	Sampling Regime	Number of Sampling Locations	Justification	Contaminants of Concern	Sampling Depths	Number of samples for analysis
38	Building waste, machinery, railway sleepers, engine oil bottles, scrap metal, motorbike circuit	Targeted	3 insitu 1 stockpile	Targeted sampling appropriate in high risk areas associated with use the soil staining, scrap metal areas and drums. Targeted sampling at locations related to stockpiles	Heavy metals, TPH/BTEX, PAHs, asbestos	Surface, and subsurface (0.1 m, 0.3 m) and from stockpiled material	3x PAHs/metals, 1x TRH, 1x asbestos, 1x PCBs/OCPs, 2x stockpile samples
39	Unknown source of fill material	Systematic	2 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, PAHs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	2x PAHs/metals
40	Unknown source of fill material, concrete curing compound drums	Targeted	4 insitu	Targeted sampling appropriate in high risk areas associated with use of drums	Heavy metals, TPH/BTEX, PAHs	Surface, and subsurface (0.1 m, 0.3 m)	4x PAHs/metals
41	Unknown source of fill material	Systematic	2 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, PAHs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	2x PAHs/metals
42	Unknown source of fill material, Illegally dumped material	Systematic	2 insitu 1 stockpile	Density appropriate to assess presence of significant widespread contamination impacts. Targeted sampling at locations related to stockpiles	Heavy metals, PAHs, asbestos	Surface, and subsurface (0.1 m, 0.3 m) and from stockpiled material	2x PAHs/metals, 1x asbestos, 1x stockpile sample
43	Unknown source of fill material	Systematic	2 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, PAHs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	2x PAHs/metals
44	Unknown source of fill material	Systematic	2 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, PAHs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	2x PAHs/metals
45	Hazardous building materials, ACM in surface soils	Systematic	3 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Asbestos	Surface, and subsurface (0.1 m, 0.3 m)	3x PAHs/metals, 1x TRH, 1x asbestos, 1x PCBs/OCPs
46	Unknown source of fill material, Illegally dumped material, ACM in surface soils	Systematic	2 insitu 1 stockpile	Density appropriate to assess presence of significant widespread contamination impacts. Targeted sampling at locations related to stockpiles	Heavy metals, PAHs, asbestos	Surface, and subsurface (0.1 m, 0.3 m) and from stockpiled material	3x PAHs/metals, 1x asbestos, 1x stockpile sample
47	Unknown source of fill material	Systematic	2 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, PAHs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	2x PAHs/metals, 1x TRH, 1x asbestos, 1x PCBs/OCPs
48	Former agricultural use, Unknown source of fill material	Systematic	3 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	3x PAHs/metals, 1x TRH, 1x asbestos, 1x PCBs/OCPs
49	Unknown source of fill material	Systematic	2 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, PAHs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	3x PAHs/metals, 1x TRH, 1x asbestos, 1x PCBs/OCPs

Parcel	AEC	Sampling Regime	Number of Sampling Locations	Justification	Contaminants of Concern	Sampling Depths	Number of samples for analysis
50	Hazardous building materials, ACM in surface soils	Systematic	4 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Asbestos	Surface, and subsurface (0.1 m, 0.3 m)	4x PAHs/metals, 1x TRH, 1x asbestos, 1x PCBs/OCPs
51	Unknown source of fill material	Systematic	2 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, PAHs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	2x PAHs/metals, 1x TRH, 1x asbestos, 1x OCPs
52	Storage yard for boats and for a building company, unknown fill material	Targeted	2 insitu	Targeted sampling appropriate in high risk areas associated with use of the parcel for storage	Heavy metals, TPH/BTEX, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	2x PAHs/metals, 1x TRH, 1x asbestos, 1x PCBs/OCPs
53	Unknown source of fill material and engine oil drum	Systematic	3 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, PAHs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	3x PAHs/metals
54	Storage yard for boats and for a building company, unknown fill material, fuel drums and surface staining	Targeted	3 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, TPH/BTEX, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	3x PAHs/metals, 1x TRH, 1x asbestos, 1x PCBs/OCPs
55	Unknown source of fill material, Above ground storage tank, Illegally dumped material, ACM in surface soils	Targeted	3 insitu 2 stockpiles	Targeted sampling appropriate in high risk areas associated with use the soil staining, scrap metal areas and drums and burnt material. Targeted sampling at locations related to stockpiles	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos	Surface, and subsurface (0.1 m, 0.3 m) and from stockpiled material	3x PAHs/metals, 1x TRH, 1x asbestos, 1x PCBs/OCPs, 2x stockpile samples
80	Unknown fill material, ACM in surface soils	Systematic	2 insitu 2 stockpiles	Density appropriate to assess presence of significant widespread contamination impacts. Targeted sampling at locations related to stockpiles	Heavy metals, PAHs, asbestos	Surface, and subsurface (0.1 m, 0.3 m) and from stockpiled material	2x PAHs/metals, 2x stockpile samples
81	Unknown fill material	Systematic	2 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, PAHs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	2x PAHs/metals
82	Unknown fill material	Systematic	2 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, PAHs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	2x PAHs/metals, 1x TRH, 1x asbestos, 1x PCBs/OCPs
83	Unknown fill material	Systematic	2 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, PAHs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	2x PAHs/metals
84	Unknown fill material	Systematic	2 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, PAHs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	2x PAHs/metals, 1x TRH, 1x asbestos, 1x PCBs/OCPs
85	Former agriculture, unknown fill material	Systematic	2 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, PAHs, OCP/OPPs asbestos	Surface, and subsurface (0.1 m, 0.3 m)	2x PAHs/metals

Parcel	AEC	Sampling Regime	Number of Sampling Locations	Justification	Contaminants of Concern	Sampling Depths	Number of samples for analysis
86	Former agriculture, unknown fill material	Systematic	2 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, PAHs, OCP/OPPs asbestos	Surface, and subsurface (0.1 m, 0.3 m)	2x PAHs/metals, 1x TRH, 1x asbestos, 1x PCBs/OCPs
87	Former agriculture, unknown fill material	Systematic	2 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, PAHs, OCP/OPPs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	2x PAHs/metals1x TRH, 1x asbestos, 1x PCBs/OCPs
88	Hazardous building materials, ACM in surface soils, chlorine plastic drums	Targeted	3 insitu	Targeted sampling appropriate in high risk areas associated with use of drums	Asbestos, chlorine	Surface, and subsurface (0.1 m, 0.3 m)	3x PAHs/metals,1x TRH, 1x asbestos, 1x PCBs/OCPs
89	Unknown fill material	Systematic	3 insitu	Density appropriate to assess presence of significant widespread contamination impacts.	Heavy metals, PAHs, asbestos	Surface, and subsurface (0.1 m, 0.3 m)	3x PAHs/metals, 1x TRH, 1x asbestos, 1x PCBs/OCPs

5.2 Investigation Methodology

5.2.1 Soil Sampling Approach

Soil samples were collected using hand tools at locations from unsealed areas within each Parcel. Samples were typically collected from the ground surface (0-0.1 m) and subsurface (0.2-0.3 m) unless apparent strata intercepted these intervals, in which case the sample depths were revised to represent encountered strata.

Collected samples were immediately transferred to laboratory supplied sample jars and plastic resealable 'ziplock' bags, depending on the analytes required. Where soil samples are collected for volatile petroleum hydrocarbons, care was taken to minimise the potential for loss of volatile contaminants during sampling.

The sample jars were then be transferred to a chilled ice box for sample preservation prior to and during shipment to the testing laboratory. A chain-of-custody form was completed and forwarded with the samples to the testing laboratory. Based upon field observations and the PID screening results, samples were analysed in accordance with the laboratory schedule in **Table 5.3** below.

During the collection of soil samples, features such as seepage, discolouration, staining, and other indications of contamination (e.g. ACM) were noted. It is noted that where the presence of ACM was observed, a 500 mL ziplock bag soil sample was collected for laboratory submission. An asbestos in soil sample size of 500 ml was adopted in accordance with guidance provided in NEPC 2013.

During the collection of the soil samples at all sampling locations a full olfactory assessment was completed by field staff to evaluate the potential presence of odorous soil conditions. Any identified odours were documented in field records presented in **Appendix K**.

5.2.2 Decontamination

Samples were collected at the majority of locations by reusable (non-disposable) hand tools. Prior to the commencement of soil sampling activities at each location, non-disposable sampling equipment, including augers, sampling trowel, etc were cleaned with a high pressure water/detergent spray, rinsed with water and then air dried. The equipment were then inspected to ensure that no soil, oil, debris or other contaminants are apparent on the equipment prior to the commencement of works. A representative sample of the final rinse water was collected at suitable intervals as a QA/QC rinsate sample to verify the satisfactory performance of the decontamination measures.

5.2.3 Duplicate and Triplicate Sampling

Field soil duplicate and triplicate samples were obtained using the above sampling methods. The collected samples were divided laterally into three samples with minimal disturbance to reduce the potential for loss of volatiles and placed in three clean glass jars or sample bags as appropriate. Each sample were then be labelled with a primary, duplicate or triplicate sample identification before being placed in the same chilled esky for laboratory transport.

5.2.4 Laboratory Analysis

JBS&G contracted project laboratories which are NATA accredited for the required analyses. In addition, the laboratories were required to meet JBS&G's internal Quality Assurance requirements.

The completed laboratory analysis program is outlined in **Table 5.4**.

Bulk soil samples (500 mL) for asbestos analysis were collected where analysis for asbestos was proposed or where visible asbestos containing material (ACM) was observed or has previously been reported at surface or in fill.

Table 5.4 Sampling and Analytical Program

Sample Type	Target Area	# Sampling Locations	Analyses (ex QA/QC)
Soil	Stages A1-A3	Parcels 4-22, 24-55, 80-89	Heavy metals (As, Cd, Cr, Cu, Hg, Ni, Pb, Zn) – 159 samples PAH – 159 samples TPH/BTEX – 51 samples PCBs – 45 samples OCPs – 50 samples Asbestos – 51 samples

In addition to the above analyses, for QA/QC purposes field duplicates and triplicates were collected and submitted for analysis at the rates specified in **Section 7**. Rinsate samples were obtained from all reusable sampling equipment per day of sampling, and trip spike and storage blank samples accompanied the samples for each batch of samples submitted to the laboratory.

5.3 Geotechnical Investigation

The objective of the geotechnical investigation was to develop sufficient geotechnical information on subsurface soil, bedrock and groundwater conditions to support evaluation of cell containment options for conservation area and assist in the subdivision design.

The geotechnical report is included in **Appendix I** of the report.

5.4 Hazardous Materials Survey

The purpose of the hazardous materials survey was to identify the presence of hazardous and contaminated materials to facilitate their management, thereby maximising the potential to retain impacted materials onsite and to minimise potential offsite disposal fees, and assist development of service infrastructure following subdivision.

The hazardous Materials Survey is included in **Appendix J** of the report.

6 Assessment Criteria

6.1 Regulatory and Technical Guidelines

The investigation was undertaken with consideration to aspects of the following guidelines and technical documents, as relevant:

- National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No. 1), National Environment Protection Council (NEPC 2013);
- Contaminated Sites: Guidelines for Assessing Service Station Sites, NSW EPA, 1994 (EPA 1994);
- Contaminated Sites: Sampling Design Guidelines, NSW EPA, 1995 (EPA 1995);
- Contaminated Sites: Guidelines for Consultants Reporting on Contaminated Sites, NSW EPA, 1997 (OEH 2011);
- Contaminated Sites: Guidelines for the NSW Site Auditor Scheme, 2nd Edition, NSW EPA, 2006 (DEC 2006); AND
- Contaminated Sites: Guidelines on Duty to Report Contamination under the Contaminated Land Management Act 1997, NSW DECC, June 2009 (DECC 2009).

6.2 Soil Criteria

Based on the proposed subdivision of the site for residential land use, concentrations of contaminants in soil were compared against NEPC (2013) health-based investigation and screening levels (HILs and HSLs), and ecological investigation and screening levels (EILs and ESLs) for residential with accessible soil (HIL-A) exposure settings as the most sensitive potential future land use. Where appropriate, after consideration of relevant ESLs and HSLs for TPH fractions, NEPC (2013) Management Limits for TPH fractions were also utilised.

The results of asbestos observations and analysis were assessed in general accordance with NEPC (2013) and WA DOH (2009) guidance, although no asbestos quantification was undertaken.

It is noted that consideration of less sensitive land use scenarios and the associated contaminant thresholds may be required to address the decision making rules adopted for this assessment to provide UGNSW with a complete understanding of site characteristics.

On this basis health and ecological based investigation levels for a broader range of potential land uses have been presented in **Appendix M** to this report.

Table 6.1 Soil Criteria (all units in mg/kg)

	Limit of Reporting	Laboratory Method	Health Investigation/Screening Levels
			Residential – Access HIL-A
Metal			
Arsenic	2.0	ICP-AES (USEPA 200.7)	100
Cadmium	0.4	ICP-AES (USEPA 200.7)	20
Chromium	1.0	ICP-AES (USEPA 200.7)	100[1]
Copper	5.0	ICP-AES (USEPA 200.7)	6000
Nickel	5.0	ICP-AES (USEPA 200.7)	400
Lead	5.0	ICP-AES (USEPA 200.7)	300
Zinc	1.0	ICP-AES (USEPA 200.7)	7400
Mercury (inorganic)	0..05	Cold Vapour ASS (USEPA 7471A)	40[2]
POLYCYCLIC AROMATIC HYDROCARBONS			
Carcinogenic PAHs (as B(a)P TPE)[3]	0.5	GCMS (USEPA8270)	3
Total PAHs[4]	0.5	GCMS (USEPA8270)	300
BTEX			
Benzene	0.1	Purge Trap-GCMS (USEPA8260)	0.5[5]
Toluene	0.1	Purge Trap-GCMS (USEPA8260)	160[5]
Ethylbenzene	0.1	Purge Trap-GCMS (USEPA8260)	55[5]
Total Xylenes	0.3	Purge Trap-GCMS (USEPA8260)	40
TOTAL RECOVERABLE HYDROCARBONS			
F1 C_6-C_{10}	20	TRH Purge Trap-GCMS (USEPA8260)	45[6,7]
F2 >C_{10}-C_{16}	50	TRH Purge Trap-GCMS (USEPA8260)	110[6]
F3 >C_{16}-C_{34}	100	Purge Trap-GCFID (USEPA8000)	-
F4 >C_{34}-C_{40}	100	Purge Trap-GCFID (USEPA8000)	-
ORGANOCHLORINE PESTICIDES			
DDT + DDD + DDE	0.175	GCECD (USEPA8140,8080)	240
Aldrin + Dieldrin	0.1	GCECD (USEPA8140,8080)	6
Chlordane	0.1	GCECD (USEPA8140,8080)	50
Endosulfan	0.15	GCECD (USEPA8140,8080)	270
Endrin	0.05	GCECD (USEPA8140,8080)	10
Heptachlor	0.05	GCECD (USEPA8140,8080)	6
HCB	0.05	GCECD (USEPA8140,8080)	10
Methoxychlor	0.2	GCECD (USEPA8140,8080)	300
PCBs			
Total PCBs	0.5	GCECD (USEPA8140,8080)	1
OTHER			
Bonded ACM	0.1 g/kg	Field Quantification	0.02%
Asbestos	Presence	PLM / Dispersion Staining	No asbestos capable of being detected via the investigation, which comprises both visual identification and sample analysis by a NATA accredited laboratory

1. Guideline values presented are for Chromium (VI) in absence of total Chromium values. Where total Chromium results are elevated, samples will be analysed for Chromium (VI).
2. Guideline values are for inorganic mercury. Where elevated mercury concentrations are encountered and/or site information suggests the potential presence of elemental mercury and/or methyl mercury, consideration of applicability would be needed.
3. Carcinogenic PAHs calculated as per Benzo(a)pyrene Toxicity Equivalent Factor requirements presented in NEPC (2013)
4. Total PAHs calculated as per requirements presented in NEPC (2013).
5. Soil Health Screening Levels for Vapour Intrusion: Fine Soils. Values presented are those for 0 to <1 m bgs as the most conservative level. Reference should be made to results tables for further detail of levels at greater depths. NL: Non-limiting.
6. Values for F1 C_6-C_9 are obtained by subtracting BTEX (Sum) from laboratory result for C_6-C_9 TRH. Naphthalene is not subtracted as there is separate limits for Naphthalene.
7. No EPA endorsed criteria, The LOR is proposed as a screening level in the absence of endorsed site specific criteria.

Table 6.2 Ecological Based Soil Criteria (all units in mg/kg)

	Limit of Reporting	Laboratory Method	EILs/ESLs[1]
			Urban Residential and public open space
Metals			
Arsenic	2.0	ICP-AES (USEPA 200.7)	100
Chromium	5.0	ICP-AES (USEPA 200.7)	190
Copper	5.0	ICP-AES (USEPA 200.7)	130
Nickel	5.0	ICP-AES (USEPA 200.7)	30
Lead	5.0	ICP-AES (USEPA 200.7)	1100
Zinc	5.0	ICP-AES (USEPA 200.7)	180
PAHs[2]			
Benzo(a)pyrene	0.5	GCMS (USEPA8270)	0.7
Naphthalene	0.5	GCMS (USEPA8270)	170
BTEX[2]			
Benzene	0.1	Purge Trap-GCMS (USEPA8260)	50
Toluene	0.1	Purge Trap-GCMS (USEPA8260)	85
Ethylbenzene	0.1	Purge Trap-GCMS (USEPA8260)	70
Total Xylenes	0.3	Purge Trap-GCMS (USEPA8260)	105
TRH[2, 3, 4]			
F1 C_6-C_{10}	20	TRH Purge Trap-GCMS (USEPA8260)	180
F2 >C_{10}-C_{16}	50	TRH Purge Trap-GCMS (USEPA8260)	120
F3 >C_{16}-C_{34}	100	Purge Trap-GCFID (USEPA8000)	300
F4 >C_{34}-C_{40}	100	Purge Trap-GCFID (USEPA8000)	2800
OCPs			
DDT	0.05	GCECD (USEPA8140,8080)	180

1. Values for F1 C6-C9 are obtained by subtracting BTEX (Sum) from laboratory result for C6-C9 TRH.
2. Values for F2 >C10-C16 do not require subtracting naphthalene from laboratory result for >C10-C16 TRH as there is no specific ESL for naphthalene.
3. Value for Chromium (III) adopted for evaluation of total Chromium in the absence of known Chromium (VI) source.
4. Metal EILs are based on conservative added contaminant level (ACL) per NEPC (2013) Schedule B1 Tables 1B(1) to 1B(5) and no consideration of ambient background concentrations (ABCs) or site-specific pH, clay content or cation exchange capacity (CEC). The exceptions are arsenic and lead, which are presented as generic EILs independent of soil characteristics.

During redevelopment of the site any soil to be removed off-site shall require a waste classification in accordance with DECCW (2009) '*Waste Classification Guidelines Part 1: Classifying Waste'*. The potential presence of asbestos in fill materials must be noted in the preparation of the waste classification. The waste classification guidelines are in **Table 6.3** following:

Table 6.3 Waste Classification Guidelines based on SCC without TCLP

	Limit of Reporting	General Solid Waste	Restricted Solid Waste
METALS			
Arsenic	2.0	100	400
Cadmium	0.4	20	80
Chromium (VI)	5.0	100	400
Copper	5.0	-	-
Lead	5.0	100	400
Mercury	5.0	4	16
Nickel	1.0	40	160
Zinc	0..05	-	-
PETROLEUM HYDROCARBONS			
C6-C9 Fraction	20	650	2600
C10 – C36 Fraction	50	10000	40000
BTEX COMPOUNDS			
Benzene	0.1	10	40
Toluene	0.1	288	1152
Ethylbenzene	0.1	600	2400
Xylenes	0.3	1000	4000
POLYCYCLIC AROMATIC HYDROCARBONS			
Benzo(a)pyrene	0.5	0.8	3.2
Total PAHs	0.5	200	800
ORGANOCHLORINE PESTICIDES			
Aldrin + Dieldrin	0.1	< 50 (Scheduled waste)	< 50 (Scheduled waste)
Chlordane	0.1		
Heptachlor	0.05		
DDT + DDD + DDE	0.175		
POLYCHLORINATED BIPHENYLS			
Total PCBs	0.5	<50 (Scheduled waste)	<50 (Scheduled waste)

Note: Concentrations in Table 6.3 are contaminant threshold values (CT1 & CT2 or SCC1 & SCC2 values where CT1 & CT2 are not used) for classifying waste by chemical assessment without the leaching (TCLP) test (DECCW 2009).

7 Quality Assurance / Quality Control

7.1 QA/QC Results

The results of the QA/QC program are presented in **Table 7.1** and discussed in **Section 7.2** and **Section 7.3**. Detailed QA/QC results are included with the laboratory reports in **Appendix L.**

Table 7.1 Summary of QA/QC Results

Data Quality Indicator	Frequency	Results	DQI met?
Precision			
Soil Blind duplicates (intra laboratory)	9/155 samples	0 – 68%	Partial
Soil Spilt duplicates (inter laboratory)	7/155 samples	0 - 155%	Partial
Laboratory Duplicates	1 per batch	<50%	Yes
Accuracy			
Surrogate spikes	All organic analytes	70- 130%	Yes
Laboratory Control Samples	1 per lab batch	60-140%	Yes
Matrix spikes	1 per lab batch	60-140%	Yes
Representativeness			
Sampling appropriate for media and analytes	All media /analytes	Sampling conducted in accordance with JBS&G procedures	Yes
Storage blank	1 per sampling event	<LOR	Yes
Rinsate blank	1 per sampling event where reusable sampling equipment used	<LOR	Yes
Trip Spike	1 per sampling event when sampling for volatile or semi-volatile COPC	70-105%	Yes
Laboratory blanks	1 per lab batch	Detects	Partial
Samples extracted and analysed within holding times.	All samples	Soil: 3-7 days for organics, 3-14 days for metals, asbestos	Yes
Comparability			
Standard operating procedures for sample collection & handling	All samples	JBS&G field scientists completed all sampling works using standard operating procedures.	Yes
Standard analytical methods used for all analyses	All samples	Analytical methods as commercially available and as adopted for assessment phase activities employed for assessment	Yes
Consistent field conditions, sampling staff and laboratory analysis	All samples	All sampling and visual inspections were completed by experienced JBS&G field scientists. The primary and secondary laboratories remained the same throughout the investigation.	Yes
Limits of reporting appropriate and consistent	All samples	Limits of reporting were consistent and appropriate	Yes
Completeness			
Sample description and COCs completed and appropriate	All samples	All bore / sample logs and COCs were completed appropriately	Yes
Appropriate documentation	All samples	Appropriate field documentation included in the Appendices	Yes

Satisfactory frequency and result for QC samples	All samples	The QC results are considered adequate for the purposes of the investigation	Yes
Data from critical samples is considered valid	All samples	All	Yes
Sensitivity			
Analytical methods and limits of recovery appropriate for media and adopted site assessment criteria	All samples	Appropriate laboratory analysis methods and detection limits were considered to have been achieved during the field and laboratory phases of this investigation.	Yes

7.2 Soils QA/QC Discussion

7.2.1 Precision

Blind and Split Duplicates

Soil field blind (intra-laboratory) duplicates were collected at a rate of 9 per 155 primary samples analysed, slightly above the adopted 1/20 DQI frequency. Soil field split (inter-laboratory) triplicates were collected at a rate of 7 per 155 primary samples analysed, slightly below the adopted 1/20 DQI frequency. This was due to a laboratory error in analysis, however, due to the consistency of the analytical results it is not considered to be a major non-conformance and does not impact the outcomes of the report.

No high RPD calculations were observed between the primary, blind duplicate and triplicate soil samples, with the exception of elevated RPD calculations for some metals and PAHs results. The elevated RPD calculations for the soil blind and split duplicates may be attributed to the heterogeneous nature of the fill present at the site and the potentially increased laboratory limit of reporting (LOR).

Laboratory Duplicates

All concentrations in the primary and duplicate samples were less than the laboratory limits of reporting, or returned RPD values were within the acceptable limits of 0 – 50%.

The consistency of other laboratory duplicate RPDs indicate that these results do not affect the precision of the dataset.

7.2.2 Accuracy

Surrogate Spikes

Surrogate analyses were completed for all individual organic analyses. Surrogate samples analysed reported recoveries within the acceptable range.

Matrix Spikes

Matrix spike samples were completed at a suitable frequency. Matrix spikes analysed reported recoveries within the acceptable range.

Laboratory Control Samples

Laboratory control samples analysed reported recoveries within the acceptable range.

The DQIs for accuracy are considered to have been achieved for this assessment.

7.2.3 Representativeness

Sampling appropriate for media and analytes

All soil sampling works completed during the investigation were conducted in accordance with JBS&G standard operating procedures. Soil sampling was conducted with the advancement of hand augers, considered appropriate for the potential site contaminants.

All samples collected for asbestos analysis during the validation works were required to be 500 mL samples as per the NEPM 2013.

All sampling was completed by trained and experienced field scientists. The current soil investigation was completed by Kate Sharp. Kate has 3 ½ years' experience in the contaminated land industry, has a Bachelor of Science (Environmental Science) from the University of Wollongong and has received internal training on the appropriate sampling techniques for soil sampling. Kate was assisted by Tyler Creese. Tyler has 2 ½ years' experience in the contaminated land industry, has a Bachelor of Science (Sustainable Resource Management) and is currently completing his Master of Environmental Science.

Kate completed the field works under the guidance of Tom Harding, the project manager for the works. Tom has 6 years of experience in the contaminated land industry.

It should be noted that some primary samples were analysed twice during the assessment. This was due to initial samples being analysed, with further analysis scheduled at a later date. A laboratory error lead to re-analysis of some of the primaries. For the assessment the highest concentration was adopted and therefore does not affect the outcome of the report.

During the inspection of Parcel 3, stockpiles were observed and sampled. A subsequent survey of the Parcels reported that the stockpiles were not located within the site boundary and have been discounted from this assessment.

Trip spikes

Six trip spikes for TRH (C_6-C_9)/BTEX compounds were included with the batch of soil samples submitted for analysis. The recoveries of the trip spike samples were all within the nominated acceptance criteria.

Storage blanks

Six storage blanks were provided, one with each batch of samples and subsequent analysed for BTEX compounds. All levels of analytes in the trip blanks were below the laboratory LOR.

Laboratory blanks

At least one laboratory blank was analysed for each analyte with each batch of samples. All levels of analytes in laboratory blanks were below detection limits

Rinsate Samples

Six rinsate samples were prepared during equipment decontamination activities when reusable sampling equipment was used. Subsequent analysis of the rinsate samples indicated all levels of analytes were below the laboratory LOR.

Holding times

All analyses have been undertaken within holding times.

7.2.4 Comparability

Common and consistent JBS&G Field Personnel have been used to collect samples throughout the project. Field works have been undertaken in accordance with JBS&G field operating procedures. All required field forms and sampling logs have been appropriately completed by sampling personnel.

7.2.5 Completeness

Documentation

Samples were transported under full chain of custody (COC) documentation. The COC documentation was completed correctly and the selected analyses were correctly conducted. However, it should be noted that stockpiles located on Parcel 5 were labelled Parcel 6 in error.

All documentation was completed to the required standard. Borehole logs are provided as **Appendix K**. Chain of custody forms are provided with laboratory documentation included as **Appendix L**.

Frequency for QC Samples

The frequency of QC samples is considered to be sufficient and meets the project DQI's.

7.2.6 Sensitivity

Laboratory analysis methods for all contaminants in soil adopted during the assessment used limits of reporting significantly less than the site assessment criteria to ensure that contaminant concentrations could be confidently identified as being less than the adopted soil site assessment criteria.

7.2.7 Soil QA/QC Conclusions

The field sampling and handling procedures produced QA/QC results which indicate that the soil data are of an acceptable quality and are suitable for use in site characterisation.

The NATA certified laboratory results sheets indicate that the project laboratory was achieving levels of performance within its recommended control limits during the period when the samples from this program were analysed.

While several recoveries and RPD's fell outside the DQI limit, the non-conformances described in **Section 7.2** are considered to be acceptable due to factors such as consistency of the remaining data, many results falling within the NATA accredited range and results significantly below the adopted site assessment criteria.

On the basis of the results of the field and laboratory QA/QC program, the soil data are of an acceptable quality upon which to draw conclusions regarding the environmental condition of the site.

8 Soil Results

8.1 Field Observations

8.1.1 Observations

A total of 58 of the 65 Parcels were inspected and surface soil samples collected. One Parcel could not be inspected or sampled due to access restrictions, this was Parcel 23. The Parcels sampled are shown in **Figure 4**. The field logging records are presented in **Appendix K**.

Fill material was encountered from the ground surface at all sampling locations and generally comprised topsoil of silty clay and silty sand.

Anthropogenic materials were observed on the ground surface and in the topsoil/fill material throughout the whole site and included ACM fragments, building waste, concrete, bricks, chemical drums, household rubbish, scrap metal and vehicles. Further discussion of the extent of identified ACM materials is presented in the Hazardous Materials Assessment Report included as **Appendix J**. The surveyed extent of these materials is documented in survey plans included as **Appendix N**.

Organic odours were reported during the assessment works at within Parcel 21 only. No other odours were reported during the works. Petroleum staining was observed on the ground surface within two Parcels (Parcel 21 and 54)**.** Additionally, indications of former waste material burning activities (ash on the ground, melted plastic and ACM fragments) were identified within two Parcels (Parcels 45 and 54).

8.2 In-situ Soil Analytical Results

The soil sampling locations are shown on **Figure 4** and a summary of collected samples is provided in **Table 1.** Summarised laboratory results are presented in **Tables 2** to **4**. Detailed laboratory reports and chain of custody documentation is provided in **Appendix L**.

The results of soil sample analyses are summarised by Parcel in **Table 8.1** below:

Table 8.1: Summarised Soil Analytical Results

Parcel	Analysed	Exceedances Above Adopted Criterion	Concentrations (mg/kg)	Further Comments
Parcel 4	Metals, PAHs, TRH/BTEX, PCBs, OCPs	None	All results below adopted criteria	-
Parcel 5	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	1x copper ESL 1x nickel ESL 3x zinc ESL	Three of three samples analysed heavy metals reported an ESL exceedance for zinc (570 mg/kg, 190 & 190 mg/kg) in L01 (0.0-0.1), L02 (0.0-0.1 and L03 (0.0-0.1). One of three samples analysed heavy metals reported an ESL exceedance for copper (200 mg/kg) in L01 (0.0-0.1). One of three samples analysed heavy metals reported an ESL exceedance for nickel (30 mg/kg) in L01 (0.0-0.1)	ACM sheeting
Parcel 6	Metals, PAHs, asbestos	None	All results below adopted criteria.	ACM in fence lines of chicken coups and boundary (broken) but none in surface
Parcel 7	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	1x TRH ESL & 1x zinc ESL	One of two samples analysed for TRHs reported an ESL exceedance for TRH (>C_{16}-C_{34}) (410 mg/kg) L01 (0.0-0.1). One of three samples analysed for PAHs reported an ESL exceedance for B(a)P (1.4 mg/kg) in L01 (0.0-0.1). One of three samples analysed for heavy metals reported an ESL exceendance for zinc (260 mg/kg) in L03 (0.0-0.1)	ACM pipe observed
Parcel 8	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	None	All results below adopted criteria.	ACM in landscaped areas
Parcel 9	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	1x PAHs HIL	One of three samples analysed for PAHs reported an ESL exceedance for B(a)P (5 mg/kg) in L03 (0.0-0.1). One of three samples analysed for PAHs reported a HIL-A exceedance for B(a)P TEQ (12 mg/kg) in L03 (0.0-0.1).	-
Parcel 10	Metals, PAHs	None	All results below adopted criteria	-
Parcel 11	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	None	All results below adopted criteria	-
Parcel 12	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	2x Lead HIL, 2x, zinc ESL, 1x TRH ESL , 1 PAHs HIL	Two of two samples analysed for heavy metals reported a HIL-A exceedance for lead (380 mg/kg) in L01 (0.0-0.1) and (370 mg/kg) in L01 (0.2-0.3). One sample analysed TRH reported an ESL exceedance for TRH (>C_{16}-C_{34}) (610 mg/kg) in L01 (0.2-0.3). Two of two samples analysed heavy metals reported an ESL exceedance for zinc	-

Parcel	Analysed	Exceedances Above Adopted Criterion	Concentrations (mg/kg)	Further Comments
			(470 mg/kg & 500 mg/kg) in L01 (0.0-0.1) and (0.2-0.3). One of two samples analysed for PAHs reported an ESL exceedance for B(a)P (5 mg/kg) in L01 (0.0-0.1). One of two samples analysed for PAHs reported a HIL-A exceedance for B(a)P TEQ (12 mg/kg) in L01 (0.0-0.1)	
Parcel 13	Metals, PAHs	None	All results below adopted criteria	-
Parcel 14	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	2x zinc ESL, 1x chromium ESL	Two of two samples analysed heavy metals reported an ESL exceedance for zinc (610 mg/kg & 590 mg/kg) in L02 (0.0-0.1) & L03 (0.2-0.3). One of three samples analysed for heavy metals reported an ESL exceedance for chromium (210 mg/kg) in L03 (0.2-0.3).	ACM sheets within shed
Parcel 15	Metals, PAHs	None	All results below adopted criteria	-
Parcel 16	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	1x zinc ESL	One of three samples analysed heavy metals reported an ESL exceedance for zinc (300 mg/kg) L01 (0.0-0.1)	ACM observed in building
Parcel 17	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	None	All results below adopted criteria	-
Parcel 18	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	1x zinc ESL	One of three samples analysed heavy metals reported an ESL exceedance for zinc (1200 mg/kg) in L01 (0.0-0.1)	ACM fragments observed in surface soils
Parcel 19	Metals, PAHs, asbestos	1x Lead HIL	One of three samples analysed heavy metals reported A HIL-A exceedance for lead (560 mg/kg) in L01 (0.2-0.3).	-
Parcel 20	Metals, PAHs, TRH/BTEX, PCBs, OCPs	1x TRH HSL & 2 x ESL	One of two samples analysed for TRHs reported an ESL exceedance for TRH (>C_{16}-C_{34}) (840 mg/kg) in L01 (0.0-0.1). One of two samples analysed for TRHs reported an ESL & HSL exceedance for TRH (>C_{10} - C_{16} less Naphthalene) (305 mg/kg) in L02 (0.0-0.1).	
Parcel 21	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	1x lead HIL, 1x TRH HSL & ESL, 1x zinc ESL	One of three samples analysed heavy metals reported A HIL-A exceedance for lead (330 mg/kg) in L03 (0.0-0.1). One of three samples analysed heavy metals reported an ESL exceedance for zinc (600 mg/kg) in L03 (0.0-0.1). One of one samples analysed for TRHs reported an ESL & HSL exceedance for TRH (>C_{10} - C_{16} less Naphthalene) (295 mg/kg) in L02 (0.0-0.1).	Staining on surface soils
Parcel 22	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	1x TRH ESL	One of three samples analysed for TRHs reported an ESL exceedance for TRH (>C_{16}-C_{34}) (840 mg/kg) in L02 (0.0-0.1)	-
Parcel 23	No Access			
Parcel 24	Metals, PAHs, TRH/BTEX,	None	All results below adopted criteria	-

Parcel	Analysed	Exceedances Above Adopted Criterion	Concentrations (mg/kg)	Further Comments
	PCBs, OCPs, asbestos			
Parcel 25	Metals, PAHs	None	All results below adopted criteria	ACM in surface soils
Parcel 26	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	None	All results below adopted criteria	ACM in surface soils
Parcel 27	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	None	All results below adopted criteria	-
Parcel 28	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	2x zinc ESL	Two of three samples analysed heavy metals reported an ESL exceedance for zinc (320 mg/kg & 260 mg/kg) in L02 (0.0-0.1) and L03 (0.0-0.1). One of three samples analysed for heavy metals reported an ESL exceedance for nickel (53 mg/kg) in L02 (0.0-0.1)	ACM in building
Parcel 29	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	None	All results below adopted criteria	-
Parcel 30	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	None	All results below adopted criteria	-
Parcel 31	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	None	All results below adopted criteria	-
Parcel 32	Metals, PAHs	None	All results below adopted criteria	-
Parcel 33	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	None	All results below adopted criteria	-
Parcel 34	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	None	All results below adopted criteria	-
Parcel 35	Metals, PAHs	None	All results below adopted criteria	-
Parcel 36	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	1x TRH ESL	One of one samples analysed for TRHs reported an ESL exceedance for TRH ($>C_{16}$-C_{34}) (340 mg/kg) in L02 (0.0-0.1)	-
Parcel 37	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	1x zinc ESL	One of three samples analysed for heavy metals reported an ESL exceedance for zinc (220 mg/kg) in L03 (0.0-0.1)	-
Parcel 38	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	1x TRH ESL, 2x copper ESL, 1x zinc ESL	One of one samples analysed for TRHs reported an ESL exceedance for TRH ($>C_{16}$-C_{34}) (740 mg/kg) in L01 (0.0-0.1). One sample of three analysed for heavy metals reported an ESL exceedance for zinc (460 mg/kg) in L02 (0.0-.1)	ACM on surface soils

Parcel	Analysed	Exceedances Above Adopted Criterion	Concentrations (mg/kg)	Further Comments
			Two of three samples analysed heavy metals reported an ESL exceedance for copper (1000 mg/kg & 130 mg/kg) in L01 (0.0-0.1) & L02 (0.0-0.1)	
Parcel 39	Metals, PAHs	None	All results below adopted criteria	-
Parcel 40	Metals, PAHs	2x zinc ESL, 1x B(a)P ESL	Two of four samples analysed heavy metals reported an ESL exceedance for zinc (190 mg/kg and 500 mg/kg) in L02 (0.0-0.1) and L03 (0.0-0.1). One of four samples analysed for PAHs reported an ESL exceedance for B(a)P (1.3 mg/kg) in L02 (0.0-0.1)	-
Parcel 41	Metals, PAHs	None	All results below adopted criteria	-
Parcel 42	Metals, PAHs, asbestos	None	All results below adopted criteria	ACM with broken pipe within stockpiled material
Parcel 43	Metals, PAHs	None	All results below adopted criteria	-
Parcel 44	Metals, PAHs	None	All results below adopted criteria	-
Parcel 45	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	1x TRH HSL & 2x TRH ESL, 1x copper ESL, 1x nickel ESL, 1x zinc ESL, 1x PAHs ESL	One of two samples analysed for TRHs reported an ESL and HSL exceedance for TRH (>C_{10}-C_{16}), (>C_{16}-C_{34}) in L01 (0.0-0.1) with 160 mg/kg & 2700 mg/kg One of two samples analysed for TRHs reported an ESL exceedance for TRH (>C_{16}-C_{34}) (460 mg/kg) in L04 (0.0-0.1). One of three samples analysed heavy metals reported an ESL exceedance for zinc (1200 mg/kg) in L04 (0.0-0.1). One of three samples analysed heavy metals reported an ESL exceedance for copper (820 mg/kg) in L04 (0.0-0.1). One of three samples analysed heavy metals reported an ESL exceedance for nickel (100 mg/kg) in L04 (0.0-0.1). One of three samples analysed for PAHs reported an ESL exceedance for B(a)P (2.5 mg/kg) in L01 (0.0-0.1). One of two samples analysed for TRHs reported an ESL exceedance for TRH (>C_{10} - C_{16} less Naphthalene) (160 mg/kg) in L01 (0.0-0.1).	ACM in surface soils, evidence of burnt material
Parcel 46	Metals, PAHs, asbestos	1x zinc ESL	One of two samples analysed heavy metals reported an ESL exceedance for zinc (320 mg/kg) in L01 (0.0-0.1)	ACM in surface soils
Parcel 47	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	1X zinc ESL	One of two samples analysed heavy metals reported an ESL exceedance for zinc (220 mg/kg) in L02 (0.0-0.1)	-
Parcel 48	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	1x PAHs HIL, 1x TRH ESL	One of three samples analysed PAHs reported a HIL-A exceedance for B(a)P (22 mg/kg) in L01 (0.0-0.1). One of three samples analysed for PAHs	-

Parcel	Analysed	Exceedances Above Adopted Criterion	Concentrations (mg/kg)	Further Comments
			reported a HIL-A exceedance for B(a)P TEQ (5 mg/kg) in L01 (0.0-0.1). One of one samples analysed for TRHs reported an ESL exceedance for TRH (>C_{16}-C_{34}) (820 mg/kg) in L01 (0.0-0.1)	
Parcel 49	Metals, PAHs, asbestos	None	All results below adopted criteria	-
Parcel 50	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	1x lead HIL, 3x zinc ESL	One of four samples analysed for heavy metals reported a HIL-A exceedance for lead (790 mg/kg) in L01 (0.0-0.1). One of two samples analysed heavy metals reported an ESL exceedance for zinc in (430 mg/kg, 240 mg/kg and180 mg/kg) in L01 (0.0-0.1, 0.2-0.3) and L02 (0.0-0.1)	-
Parcel 51	Metals, PAHs, TRH/BTEX, OCPs, asbestos	None	All results below adopted criteria.	-
Parcel 52	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	None	All results below adopted criteria.	-
Parcel 53	Metals, PAHs	3x chromium, 3x zinc, 1x lead, 2x nickel	Three of three samples analysed for heavy metals reported an ESL exceedance for chromium (2000 mg/kg, 960 mg/kg and 1100 mg/kg) in L01 (0.0-0.1), L02 (0.0-0.1) and L03 (0.0-0.1). Two of three samples analysed for heavy metals reported an ESL exceedance for zinc (220 mg/kg & 180 mg/k) in L01 (0.0-0.1) and L02 (0.0-0.1). Two of three samples analysed for heavy metals reported an ESL exceedance for nickel (44 mg/kg and 88 mg/kg) in L02 (0.0-0.1) and L03 (0.0-0.1). One of three samples analysed for heavy metals reported an ESL exceedance for lead 200 mg/kg in L03 (0.0-0.1)	-
Parcel 54	Metals, PAHs, TRH/BTEX, OCPs, asbestos	1x TRH HIL & ESL & HSL, 1x zinc ESL , 1x chromium ESL , 1x nickel ESL	One of one samples analysed for TRHs reported an ESL/HIL/HSL exceedance for TRH (>C_{10}-C_{16}, >C_{10}-C_{26} & >C_{34}-C_{40}) (130 mg/kg, 27000 mg/kg and 6300 mg/kg) in L01 (0.0-0.1). One of three samples analysed for heavy metals reported an ESL exceedance for zinc (270 mg/kg) in L01 (0.0-0.1). One of three samples analysed for heavy metals reported an ESL exceedance for chromium (190 mg/kg) in L02 (0.0-0.1). One of four samples analysed for heavy metals reported an ESL exceedance for nickel (140 mg/kg) in L02 (0.0-0.1)	Staining of surface soils around chemical drums, ACM in surface soils, evidence of burnt material and melted chemical drums

Parcel	Analysed	Exceedances Above Adopted Criterion	Concentrations (mg/kg)	Further Comments
			One of one samples analysed for TRHs reported an ESL exceedance for TRH (>C_{10} - C_{16} less Naphthalene) (130 mg/kg) in L01 (0.0-0.1).	
Parcel 55	Metals, PAHs, TRH/BTEX, OCPs, asbestos	1x zinc ESL, 1x TRH ESL	One of three samples analysed for heavy metals reported an ESL exceedance for zinc (340 mg/kg) in L03 (0.0-0.1). One of two samples analysed for TRH reported an ESL exceedance for TRH (C16-C34) (340 mg/kg) in L03 (0.0-0.1)	ACM in the surface soils
Parcel 80	Metals, PAHs	None	All results below adopted criteria	ACM in the surface soils
Parcel 81	Metals, PAHs	None	All results below adopted criteria	-
Parcel 82	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	None	All results below adopted criteria	-
Parcel 83	Metals, PAHs	None	All results below adopted criteria	-
Parcel 84	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	1x Lead, 1x zinc	One of two samples analysed for heavy metals reported a HIL-A exceedance for Lead (390 mg/kg) in L02 (0.0-0.1). One of two samples analysed for heavy metals reported an ESL exceedance for zinc (550 mg/kg) in L02.	-
Parcel 85	Metals, PAHs	1x zinc ESL	One of two samples analysed for heavy metals reported an ESL exceedance for zinc (420 mg/kg) in L01 (0.0-0.1)	-
Parcel 86	Metals, PAHs, TRH/BTEX, OCPs, asbestos	None	All results below adopted criteria	-
Parcel 87	Metals, PAHs, TRH/BTEX, PCBs, OCPs	None	All results below adopted criteria	-
Parcel 88	Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	1x zinc ESL	One of three samples analysed for heavy metals reported an ESL exceedance for zinc (190 mg/kg) in L01 (0.0-0.1)	ACM within pipework stored at the site
Parcel 89	Metals, PAHs, TRH/BTEX, PCBs, OCPs	1X PAHs HIL/ESL	Two of three samples analysed for PAHs reported an ESL exceedance for B(a)P (2.5 mg/kg & 2.1 mg/kg) in L01 (0.0-0.1) and L02 (0.0-0.1). One of three samples analysed for PAHs reported a HIL-A exceedance for B(a)P TEQ (3.3 mg/kg) in L02 (0.0-0.1).	-

8.3 Stockpile Samples Analytical Results

A total of 24 stockpiles were observed across the site within 15 Parcels, with a stockpile observed along Sydney Street and the remaining stockpiles within the Parcels.

The results of stockpile soil sample analyses completed for the assessment are provided by Parcel in **Table 8.2** below:

Table 8.2: Summarised Stockpile Results

Location/Parcel	Analysed	Exceedances (HILs)	Comments
Parcel 4	1x PAHs, OCPs, PCBs	All results below adopted criteria	Vegetated Stockpile
Parcel 5	4x Metals, PAHs, TRH/BTEX, PCBs, OCPs, asbestos	One of four samples analysed for heavy metals reported HIL-A exceedance for Lead (510 mg/kg) in one of the stockpiles (SP02)	4x stockpiles, all vegetated.
Parcel 8	2x Metals, PAHs, TRH/BTEX, PCBs, OCPs	All results below adopted criteria	ACM within stockpile
Parcel 17	1x Metals, PAHs	All results below adopted criteria	Vegetated Stockpile, with gravels, ACM present within the Parcel
Parcel 35	1x Metals, PAHs	All results below adopted criteria	Gravels
Parcel 38	2x Metals, PAHs	Two of two samples analysed for heavy metals reported a HIL-A exceedance for Lead within two samples reported to have concentrations of at 430 mg/kg and 400 mg/kg	-
Parcel 42	1x Metals, PAHs, asbestos	Chrysotile detected in the samples	Asbestos reported in samples and within stockpile
Parcel 46	1x Metals, PAHs	All results below adopted criteria	ACM within stockpile
Parcel 55	2x Metals, PAHs, asbestos	All results below adopted criteria	Vegetated Stockpile, with ACM associated with building rubble and throughout stockpile
Parcel 80	2x Metals, PAHs, PAHs, TRH/BTEX	All results below adopted criteria	Vegetated Stockpile, with building material and gavels
Sydney Street Reserve	1x Metals, PAHs, PAHs, TRH/BTEX, OCP, PCBs, asbestos	One of one sample analysed for heavy metals reported a HIL-A exceedance for Lead with 3000 mg/kg. One of one samples analysed for heavy metals reported a HIL-A exceedance for zinc with 11 000 mg/kg. One of one samples analysed for PCBs reported a HIL-A exceedance for Aroclor 1260. One of one samples analysed for TRHs reported an ESL exceedance for TRH (>C_{16-34}) (770 mg/kg) Chrysotile & Crocidolite detected in the samples	Asbestos reported in samples and within stockpile

8.4 Hazardous Materials Survey

The hazardous materials survey reported 26 areas across the subdivision area that contained hazardous building materials within 17 Parcels.

These locations are shown in **Figures 5** and **6**.

The hazardous materials survey is included in **Appendix J.**

9 Site Characterisation

The results are discussed in the following section in relation to the identified decisions developed as part of the DQO process (**Section 6**). Based on the decision making process for assessing urban redevelopment sites detailed in DECC (2006), the following decisions must be made:

- Are there any unacceptable risks to likely future onsite receptors for the proposed land use scenarios?
- Are there any impacts of chemical mixtures?
- Are there any aesthetic concerns in soils present at the site?
- Is there potential for migration of contaminants from the site?
- Is a management strategy required?
- If a management strategy is required, can impacted material be retained on-site in areas of lower land use sensitivity than "residential with accessible soils" without ongoing management?
- If a management strategy is required, can identified contaminated soils remain at the site under management using a cap and containment strategy based on physical separation?
- If removal offsite is required, can current data provide waste classification under the DECCW 2009?

9.1 Are there any unacceptable risks to likely future onsite receptors for the proposed land use scenarios?

Direct comparison of the soil analytical data with the health and ecological investigation levels for 'residential with accessible soils criteria' adopted for this assessment has identified the following:

- Lead concentrations in six soil samples in four separate Parcels (5, 12, 21, 45, 50 and 84) exceed health-based criteria and ecological based criteria;
- Concentrations of carcinogenic PAHs as B(a)P equivalents were reported to exceed the adopted health criterion in soil samples collected from5 Parcels (9, 12, 40, 48 and 89);
- Fourteen sample locations exceeded the ecological criterion for TRH fractions, with these being located within ten Parcels (5, 7, 12, 20, 21, 22, 36, 38, 45, 48, 54 and 55);
- Four sample locations exceeded the health based criterion for TRH fractions, with these being located within four Parcels (20, 21, 45 and 54);
- One stockpile sample location (SS-SP01B), sourced from stockpiles within the road reserve identified PCB compounds in exceedance of the adopted HIL and ESL criteria. Stockpile SS-SP01B additionally contained concentrations of TRH (C_{16}-C_{34}) above the ESL criteria, lead and zinc concentrations above the adopted HIL criteria and friable asbestos present.

In addition to the health based exceedances for lead and equivalent Benzo(a)pyrene, individual heavy metals and Benzo(a)pyrene concentrations have also been identified as exceedances via direct comparison of individual soil concentrations with the adopted ecological thresholds. It is noted that for the heavy metals, the concentrations at the site have been reported in a range consistent with heavy metals in the Sydney region and are likely associated with runoff from galvanised zinc construction materials, lead flashing, etc. Future development of site specific ecological investigation levels (EILs) as per the methodology presented in NEPC (2013) is considered likely to confirm that specific management of these soil conditions is not necessary with respect to future/ongoing urban land use(s).

In addition, whilst a number of benzo(a)pyrene values have also been reported above the adopted ecological screening values, application of NEPC (2013) Ecological Screening Levels (ESLs) is considered to be of limited value in assessing requirements for B(a)P management given the ESLs reported are of low reliability. Plants have a limited ability to take up PAHs through the roots, especially for higher molecular weight PAHs (such as Benzo (a) pyrene). Higher molecular weight PAHs are strongly absorbed to the soil, which limits availability of PAHs to the plants (NEPC 2013). On this basis, further consideration of the potential requirements to address an unacceptable ecological risk from Benzo(a)pyrene is not necessary.

At a broader level, the results of the current investigations including the historical site use review, the site inspections and the soil analytical results as discussed above have been used to generate an inferred risk ranking for each Parcel. **Table 9.1** following provides a site contamination risk ranking based on the likelihood of site soil contamination conditions in each Parcel requiring management to address potentially unacceptable risks to sensitive human and ecological receptors.

Table 9.1 Areas of Environmental Concern and Associated Contaminants of Potential Concern

Section	Area of Environmental Concern (AEC)	Contaminants of Potential Concern (COPCs)	Risk Ranking[1]		
			High	Med	Low
Parcel 4	Illegally dumped waste materials	Heavy metals, TPH, PAHs, OCP/OPPs, PCBs, asbestos			√
Parcel 5	ACM sheeting and unknown source of fill material	Heavy metals, TPH, PAHs, OCP/OPPs, PCBs, asbestos		√	
Parcel 6	ACM sheeting and unknown source of fill material	Heavy metals, TPH, PAHs, OCP/OPPs, PCBs, asbestos			√
Parcel 7	Metal Scrap Yard, ACM on the surface soils, Above ground storage tank (disused), surface soil hydrocarbon staining	Heavy metals , TPH/BTEX, PAHs, PCBs, asbestos	√		
Parcel 8	Hazardous building materials (takeaway shop), unknown source of fill material	Heavy metals, TPH, PAHs, asbestos		√	
Parcel 9	Unknown source of fill material	Heavy metals, PAHs, asbestos			√
Parcel 10	Unknown source of fill material	Heavy metals, PAHs, asbestos			√
Parcel 11	Hazardous building materials, septic tank, unknown source of fill material, garden beds	Heavy metals, TPH/BTEX, PAHs, OCP, PCBs, asbestos			√
Parcel 12	Illegally dumped material and unknown source of fill material	Heavy metals, asbestos		√	
Parcel 13	Illegally dumped material and unknown source of fill material	asbestos			√
Parcel 14	Former agricultural use, hazardous building materials (house), ACM sheeting and drums (unknown contents), surface staining, scrap metal stockpiles	OCP/OPPs, asbestos		√	
Parcel 15	Unknown source of fill material	Heavy metals, PAHs, asbestos			√
Parcel 16	Former agricultural use, unknown source of fill material, hazardous building materials (house)	Heavy metals, TPH PAHs, OCP/OPPs, PCBs, asbestos		√	
Parcel 17	Illegally dumped material	Heavy metals, TPH, PAHs, asbestos			√
Parcel 18	Illegally dumped material, ACM observed on surface	PAHs, asbestos		√	

Section	Area of Environmental Concern (AEC)	Contaminants of Potential Concern (COPCs)	Risk Ranking[1]		
			High	Med	Low
Parcel 19	Illegally dumped material, ACM observed on surface	Heavy metals, TPH/BTEX, PAHs, OCP/OPPs, PCBs, asbestos		√	
Parcel 20	Illegally dumped material, with plastic drums	Heavy metals, PAHs, asbestos			√
Parcel 21	Unknown source of fill material	Heavy metals, PAHs, asbestos	√		
Parcel 22	Scrap metal and plant, unknown source of fill material, surface hydrocarbon staining.	Heavy metals, TPH/BTEX, PAHs, asbestos	√		
Parcel 23	No Access				
Parcel 24	Illegally dumped material, suspected ACM vinyl tiles	Heavy metals, PAHs, asbestos			√
Parcel 25	Unknown source of fill material, Car parts and burnt surface staining	Heavy metals, PAHs, , asbestos		√	
Parcel 26	Unknown source of fill material, Illegally dumped material, ACM and building waste	Heavy metals, TRHs, asbestos		√	
Parcel 27	Unknown source of fill material, Illegally dumped material	Heavy metals, TRHs, asbestos		√	
Parcel 28	Former agricultural use, hazardous building materials. Unknown source of fill material	asbestos			√
Parcel 29	Unknown source of fill material, building material waste	Heavy metals, TPH			√
Parcel 30	Unknown source of fill material, concrete curing compound drums	Heavy metals, TPH/BTEX, PAHs		√	
Parcel 31	Unknown source of fill material	Heavy metals, PAHs, asbestos			√
Parcel 32	Unknown source of fill material	Heavy metals, PAHs, asbestos			√
Parcel 33	Unknown source of fill material	Heavy metals, PAHs, asbestos			√
Parcel 34	Hazardous building materials, septic tank, unknown source of fill material	Heavy metals, TPH/BTEX, PAHs, OCP, PCBs, asbestos			√
Parcel 35	Unknown source of fill material, Illegally dumped material	Heavy metals, PAHs, asbestos			√
Parcel 36	Unknown source of fill material	Heavy metals, TRHs, asbestos		√	
Parcel 37	Hazardous building materials, chicken coups, dog kennels, unknown fill material, ACM in surface soils	Heavy metals, PAHs asbestos		√	
Parcel 38	Building waste, machinery, railway sleepers, engine oil bottles, scrap metal, motorbike circuit	Heavy metals, TPH, asbestos		√	
Parcel 39	Unknown source of fill material	Heavy metals, PAHs, asbestos			√
Parcel 40	Unknown source of fill material, concrete curing compound drums	Heavy metals, TPH/BTEX, PAHs			√
Parcel 41	Unknown source of fill material	Heavy metals, PAHs, asbestos			√
Parcel 42	Unknown source of fill material, Illegally dumped material	asbestos		√	
Parcel 43	Unknown source of fill material	Heavy metals, asbestos			√
Parcel 44	Unknown source of fill material	Heavy metals, asbestos			√
Parcel 45	Hazardous building materials, ACM in surface soils	Asbestos		√	

Section	Area of Environmental Concern (AEC)	Contaminants of Potential Concern (COPCs)	Risk Ranking[1]		
			High	Med	Low
Parcel 46	Unknown source of fill material, Illegally dumped material, ACM in surface soils	Heavy metals, asbestos		√	
Parcel 47	Unknown source of fill material	Heavy metals, PAHs, asbestos			√
Parcel 48	Former agricultural use, Unknown source of fill material	Heavy metals, TPH, PAHs	√		
Parcel 49	Unknown source of fill material	Heavy metals, PAHs, asbestos			√
Parcel 50	Hazardous building materials, ACM in surface soils	Asbestos, Heavy metals		√	
Parcel 51	Unknown source of fill material	Heavy metals, PAHs, asbestos			√
Parcel 52	Storage yard for boats and for a building company, unknown fill material	Heavy metals, TPH/BTEX, asbestos		√	
Parcel 53	Unknown source of fill material and engine oil drum	Heavy metals, PAHs, asbestos			√
Parcel 54	Storage yard for boats and for a building company, unknown fill material, fuel drums and surface staining	Heavy metals, TPH/BTEX, asbestos	√		
Parcel 55	Unknown source of fill material, Above ground storage tank, , Illegally dumped material, ACM in surface soils	Heavy metals, TPH/BTEX, PAHs, asbestos		√	
Parcel 80	Unknown fill material, ACM in surface soils	Heavy metals, PAHs, asbestos			√
Parcel 81	Unknown fill material	Heavy metals, PAHs, asbestos			√
Parcel 82	Unknown fill material	Heavy metals, PAHs, asbestos			√
Parcel 83	Unknown fill material	Heavy metals, PAHs, asbestos			√
Parcel 84	Unknown fill material	Heavy metals		√	
Parcel 85	Former agriculture, unknown fill material	Heavy metals, PAHs, OCP/OPPs asbestos			√
Parcel 86	Former agriculture, unknown fill material	Heavy metals, PAHs, OCP/OPPs asbestos		√	
Parcel 87	Former agriculture, unknown fill material	Heavy metals, PAHs, OCP/OPPs, asbestos		√	
Parcel 88	Hazardous building materials, ACM in surface soils, chlorine plastic drums	Asbestos, chlorine			√
Parcel 89	Unknown fill material	Heavy metals, TRHs, asbestos	√		
Street Reserves	Fill material stockpiles of unknown origin	Heavy metals, PAHs, OCP/PCBs, TRHs, asbestos		√	

Six Parcels have been described as High Risk. These properties are considered to currently have site activities and/or site soil conditions that will likely result in a requirement for management of broader scale soil contamination at the site.

Twenty five Parcels, plus stockpiles within one road reserve, have been described as Medium Risk. These properties have localised areas of potentially impacted soil (ie. ACM on the ground surface in minor areas, small stockpiles, etc) that will require management for the Parcels to be considered suitable for future sensitive uses.

The remaining Parcels and areas of road reserve where isolated occurrences of ACM impacts or similar may be identified during site subdivision works but which are considered to be easily managed by the implementation of site management protocols such that the site(s) would then be considered suitable for the proposed sensitive use(s).

It will be necessary to further define the extent of active soil management works within each Parcel via further site delineation assessments immediately prior the commencement of remedial activities. This will ensure that should further materials be introduced to the site and/or site activities impacting on soil conditions continue following this assessment, that such impacts are captured prior to the commencement of remedial works. These activities may include further inspection and/or sampling of stockpiles and/or near surface soils.

In general the areas of impact across all medium and low risk Parcels are anticipated to extend only to the surface soils (approximately 0.0-0.15 m bgs on average) and placed stockpiles. Impacts in the high risks sites may extend deeper, however given the shallow bedrock profile identified in areas of the site, impacts are unlikely to extend to depths of much greater than 0.5 m below ground surface.

A survey of the distribution of ACM reported during the assessment is shown in **Appendix N**. The survey located the ACM fragments identified by the field team and suggest that the distribution of ACM fragments is not widespread throughout the Parcels, but more limited to isolated Parcels and stockpiles of potential illegal dumping.

It should be noted that the survey does not include buildings that potentially contain ACM.

9.2 Are there any impacts of chemical mixtures?

There were no potential chemical mixtures identified during the investigation that may increase the risk of harm at the site or require special management.

9.3 Are there any aesthetic concerns in soils present at the site?

As discussed in **Section 9.1**, non-friable ACM was identified in the surface soils (<0.1 m bgs) within 12 of the 56 Parcels across the site and within stockpiled material in one road reserve, and a further three Parcels had ACM sheeting identified. The non-friable ACM impacts identified at the site are considered to pose an aesthetic issue with respect to future site occupant/user concerns in addition to potential health risks where present in high concentrations.

Additionally, staining of the ground surface observed within two Parcels (Parcel 21 and 54) is considered to pose an aesthetic issue.

Building materials and illegally dumped waste present as stockpiles and on the ground surface across numerous Parcels (**Section 2.2**) are considered to pose an aesthetic issue.

Organic odours were reported during the assessment works at within Parcel 21 only. No other odours were reported during the works.

9.4 Is there potential for migration of contaminants from the site?

Whilst no friable ACM was identified during implementation of this assessment, there is considered to be a low risk that ACM at the site could become weathered such that site activities and/or weather conditions may result in asbestos fibres being liberated from one or more areas of the site.

With respect to chemical contaminants identified at the site the general scale of identified areas of impacted soil are relatively low. In addition, whilst there is the potential for mass movement of impacted soils via surface water run-off, sedimentation, dust generation or other manner, the generally mulched, vegetated or compacted nature of the ground and stockpile surfaces will limit the scale of such contaminant migration during current site activities. In the event that site activities include the removal of large areas of ground cover, management controls will be required to limit the increased risk of such migration.

Benzo(a)pyrene and TRH impacts at the site have generally been limited to low solubility fractions of these contaminant groups rather than the more soluble and/or volatile contaminants within these groups. As such, the potential for vapour generation and/or migration via movement within the soil profile is sufficiently low that further consideration is not required on all but the High Risk sites. For these small number of properties, design of a future delineation assessment to evaluate the extent of impact(s) will require consideration of requirements for groundwater and/or vapour assessment in accordance with NEPC (2013) requirements.

9.5 Can impacted material be retained on-site without ongoing management?

Based on the results of the current assessment, if the soil results were compared against HIL for commercial/industrial landuse (HIL-D) (as presented in **Appendix L**), then the exceedances reported for the heavy metals and PAHs impacts within the soils would be considered suitable under a commercial/industrial landuse scenario without the need for further management. Consequently, the material identified as impacted under the adopted HIL-A land use criteria could be utilised under future road infrastructure for the development without the need for ongoing environmental management.

In regards to the TRH impacts in the soil present at the site, the majority of samples reported to exceed the ESL criterion would also be suitable to be retained beneath an future road infrastructure, with the exception of two locations (Parcels 45 and 54). The materials within Parcels 45 and 54, still exceed the adopted ESL criterion and as such, these materials would not be suitable for placement within the road reserve, unless subject to ongoing management via an Environmental Management Plan (EMP).

Based on this review, material identified as being impacted with heavy metals, Benzo(a)pyrene and/or TRH (with the exception of the TRH impacted material in Parcels 45 and 54) under a residential with accessible soils land use scenario, are considered suitable for use within future road corridors without ongoing management. Should proposed earthworks facilitate placement of this material within the proposed road corridors, it is considered this is the most straightforward and effective remedial/management strategy for these identified materials as there would be no-ongoing management legacy requirements.

9.6 Is a management strategy required?

Based on the results of the investigation and subject to the limitations presented in **Section 11**, it is considered that a site management strategy is required to address identified contamination issues in the soil, including lead, hydrocarbons and asbestos in surface and near surface fill material in various Parcels which comprise the site in addition to impacted stockpiles within the road reserve. Additionally, aesthetic issues including ACM on the ground surface, illegally dumped rubbish, surface staining and building waste will require further consideration in development of a site contamination management strategy.

Successful implementation of an appropriate site management strategy to resolve the identified unacceptable contamination conditions would result in the site being considered suitable for the proposed residential with accessible land use and associated future road reserves.

9.7 Can impacted material be retained on-site under management using a cap and containment strategy based on physical separation?

ACM fragment impacts identified within various Parcels and within with existing road corridor will require remediation for the site to be considered suitable for the proposed use(s). In addition, should movement of heavy metal, PAH and/or TRH impacted material into future road reserves (as discussed in **Section 9.5**) not be feasible, a contingency plan will be required to address remedial/management requirements for this material.

In assessing whether the identified impacted material onsite can be retained on site in a capped manner, subject to ongoing implementation of an EMP, reference has to be made to guidance including ANZECC 1999[5], in addition to the *Management of asbestos in the non-occupational environment* (enHealth 2005).

In relation to asbestos, on-site containment is identified as the preferred approach for sites impacted with asbestos (enHealth 2005). Physical separation by covering to preclude the release of airborne asbestos fibres is all that is required to control the potential risks posed by this contaminant at the site.

With respect to the identified chemical contaminant impacted soils, the TPH (>C_{10}-C_{36}), PAHs and lead compound impacts fall within Group 10, 9 and Group 5 as listed in Table 1 of the ANZECC (1999) on-site containment guidelines. For these contaminant groups, inhalation of vapours is not a primary exposure route. Therefore, implementation of a 'cap and contain' strategy comprising physical separation via capping as indicated in Table 2, ANZECC (1999), in conjunction with appropriate control measures, is appropriate.

On this basis, placement of the identified ACM and/or heavy metal, PAH and TRH impacted soil into a containment cell in an appropriate location within the site is an appropriate remedial strategy, subject to adoption of an ongoing EMP.

9.8 Can current data provide waste classification under the DECCW 2009?

Should a portion of the identified impacted material be required to be removed from the site, consideration has been given to the likely classification in accordance with DECCW 2009 waste classification guidelines. Based on the current data set, the stockpiled material and soil within the Parcels, would be classified as one of three classifications of waste, as shown below:

- General Solid Waste
- Restricted Solid Waste (PAHs)
- Hazardous Waste (Lead)
- General Solid Waste – Special Waste (Asbestos).

Further assessment, including Toxicity Characteristic Leaching Procedure (TCLP) analyses during future delineation activities would assist with the classification of specific material/areas of waste across the site that may be identified as requiring off-site disposal.

It should be noted that based on some lead concentrations, some stockpiles currently classified as hazardous waste would likely be classified as General Solid Waste with TCLP analysis.

Additionally, based on the vegetation covering Parcels and stockpiles further visual assessment should be completed for potential ACM, slag, ash or other anthropogenic materials that may influence the classification.

[5] *Guidelines for the Assessment of On-Site Containment of Contaminated Soils, ANZECC* (1999).

10 Conclusions and Recommendations

10.1 Conclusions

Based on the findings of this investigation and subject to the limitations in **Section 11**, the following conclusions are made with respect to the site:

- A total of 60 of the 66 Parcels were inspected with surface soil samples collected of representative materials from these parcels.
- One Parcel could not be inspected or sampled due to access restrictions, this was Parcel 23.
- Parcels 1, 2, 3, 56 and 79 were not included within the site boundary and are not included in this assessment.
- Fill material was encountered from the ground surface at all sampling locations and generally comprised topsoil of silty clay and silty sand to depths of less than 0.3 m bgs.
- Lead concentrations were reported in six soil samples exceeding the adopted health criterion and ecological criteria from four separate Parcels (5, 12, 21, 50 and 84).
- Concentrations of carcinogenic PAHs as B(a)P equivalents were reported to exceed the adopted health criterion in soil samples collected from 5 Parcels (9, 12, 40, 48 and 89);
- Fourteen sample locations exceeded the ecological criterion for TRH fractions, with these being located within ten Parcels (5, 7, 12, 20, 21, 22, 36, 38, 45, 48, 54 and 55);
- Four sample locations exceeded the health based criterion for TRH fractions, with these being located within four Parcels (20, 21, 45 and 54);
- One stockpile sample location (SS-SP01B), from stockpiles within the road reserve, located along Sydney Street, identified PCB compounds in exceedance of the adopted HIL and ESL criteria.
- Non-friable ACM was observed across the site in 19 Parcels. It should be noted that Parcels with vegetation may obscure the occurrence of additional potential ACM fragment impacts. Further assessment of those Parcels should be completed following the removal of the vegetation to confirm the extent of ACM impact at the site.
- Evaluation of potential remedial/management options has identified that a portion of the identified impacted material could be reused within the proposed road reserves without ongoing management. The ACM impacted material and any material not suitable for reuse within the road reserves could be the subject of a suitable cap and containment strategy with ongoing management via an EMP.
- Evaluation of the individual Parcels resulted in identification of 6 Parcels as High Risk, comprising site activities and/or site soil conditions that will likely result in a requirement for management of broader scale soil contamination at the site.
- Twenty five parcels plus the stockpiled material within the Sydney Street road reserve are considered to be Medium Risk, being properties that have localised areas of potentially impacted soil (ie. ACM on the ground surface in minor areas, small stockpiles, etc) that will require management for the Parcels to be considered suitable for future sensitive uses.
- The balance of the Parcels and areas of road reserve are considered to have a Low Risk, where isolated occurrences of ACM impacts or similar may be identified during site subdivision works but which are considered to be easily managed by the implementation of site management protocols such that the site(s) would then be considered suitable for the proposed sensitive use(s).
- Evaluation of potential remedial/management options has identified that a portion of the identified impacted material could be reused within the proposed road reserves without ongoing management. The ACM impacted material and any material not

suitable for reuse within the road reserves could be the subject of a suitable cap and containment strategy with ongoing management via an EMP.

10.2 Recommendations

It is recommended that a management strategy and/or Remedial Action Plan (RAP) be developed in accordance with the relevant regulatory requirements to address the identified contamination issues to render the site suitable for the proposed residential landuse.

The management strategy and/or RAP would include:

- A framework for delineation of the extent of impacted material(s) within Parcels prior to the commencement of site works;
- Further evaluation of the suitability of identified impacted and/or suspected impacted material(s) at the site for reuse within road reserves such that no ongoing management is required, or alternatively the suitability of the material for placement within a containment cell/capped area and the subject of an ongoing EMP;
- Appropriate waste classification methodology for soils and stockpiles, where required, to be removed and disposed of offsite;
- Development of human health and environmental management procedures to be implemented during the subdivision, infrastructure installation and containment cell design;
- Environmental management procedures to be implemented during the safe removal of asbestos containing materials from the site;
- Contingency actions to address potential unexpected finds and/or alternative management options for the asbestos, heavy metal and hydrocarbon contaminated fill, possibly including off-site disposal under an appropriate waste classification;
- Requirements for documentation of remedial works, including a quality plan for any cap and containment measures; and
- Validation of the residual soils in any resulting excavations to demonstrate suitability of remaining materials to remain on the site.

11 Limitations

This report has been prepared for use by the client who commissioned the works in accordance with the project brief only and has been based in part on information obtained from other parties. The advice herein relates only to this project and all results conclusions and recommendations made should be reviewed by a competent person with experience in environmental investigations, before being used for any other purpose.

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Sampling and chemical analysis of environmental media is based on appropriate guidance documents made and approved by the relevant regulatory authorities. Conclusions arising from the review and assessment of environmental data are based on the sampling and analysis considered appropriate based on the regulatory requirements and site history, not on sampling and analysis of all media at all locations for all potential contaminants.

Limited sampling and laboratory analyses were undertaken as part of the investigations, as described herein. Ground conditions between sampling locations may vary, and this should be considered when extrapolating between sampling points. Chemical analytes are based on the information detailed in the site history. Further chemicals or categories of chemicals may exist at the sites, which were not identified in the site history and which may not be expected at the site.

Changes to the subsurface conditions may occur subsequent to the investigations described herein, through natural processes or through the intentional or accidental addition of contaminants. The conclusions and recommendations reached in this report are based on the information obtained at the time of the investigations.

This report does not provide a complete assessment of the environmental status of the site, and it is limited to the scope defined herein. Should information become available regarding conditions at the site including previously unknown sources of contamination, JBS&G reserves the right to review the report in the context of the additional information.