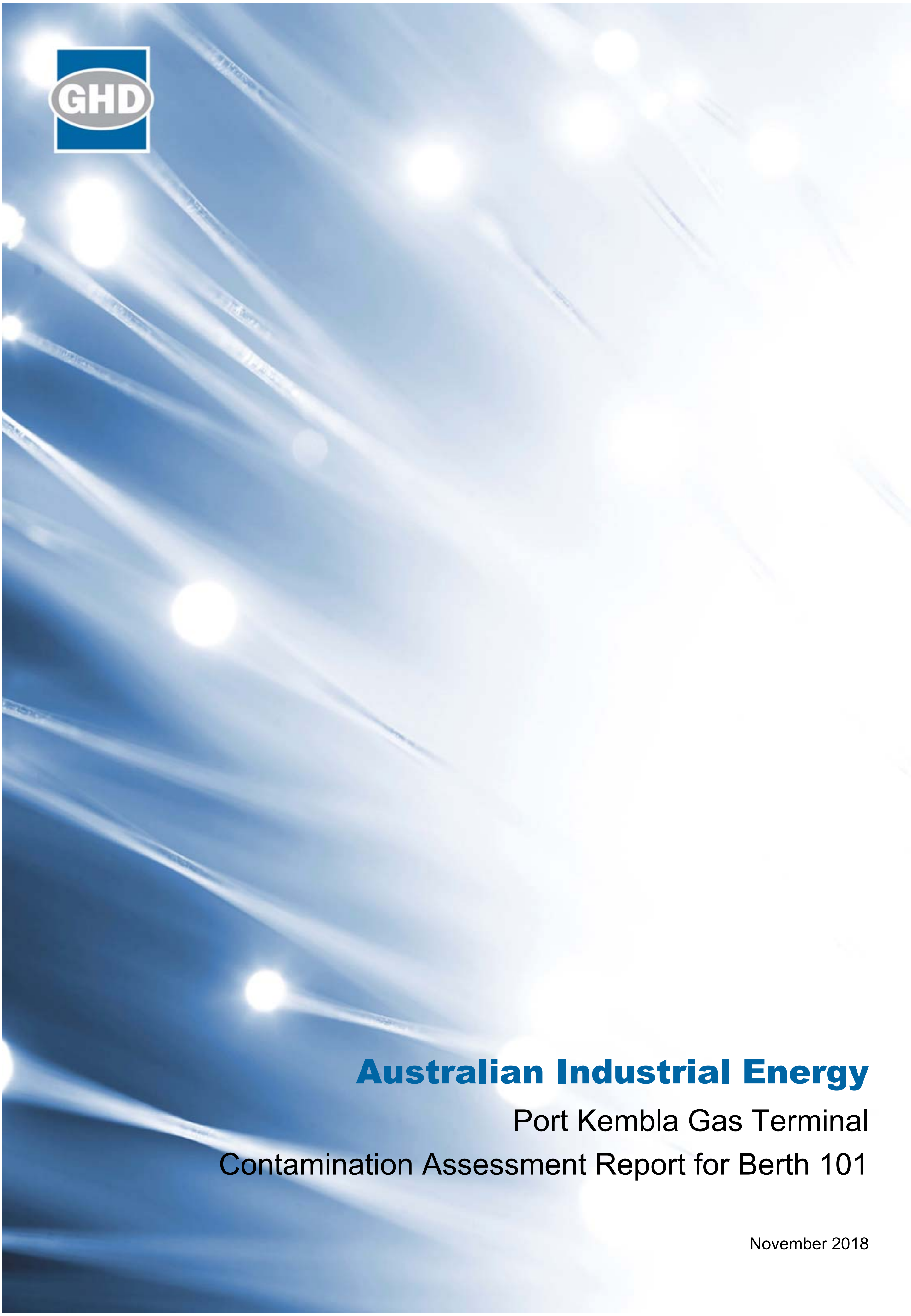
Appendix E1

Contamination - Berth 101



Australian Industrial Energy

Port Kembla Gas Terminal

Contamination Assessment Report for Berth 101

November 2018

Executive summary

Australian Industrial Energy (AIE) proposes to develop the Port Kembla Gas Terminal (the project) in Port Kembla, New South Wales (NSW). The project involves the development of a liquefied natural gas (LNG) import terminal including a Floating Storage and Regasification Unit (FSRU) moored at Berth 101 in the Inner Harbour, visiting LNG carriers, wharf offloading facilities and the installation of new pipeline to connect to the existing gas transmission network.

This report provides the results of the contamination assessment for Berth 101, which includes an area immediately east of the berth and six anchor points. The contamination assessment along the proposed pipeline route, the proposed dredge area in the waters off Berth 101 and the proposed Outer Harbour disposal area have been reported separately.

The objectives of the assessment were to:

- Assess the likelihood for contamination to exist on the site from past or present activities.
- Assess the potential presence of acid sulphate soils (ASS).
- Provide recommendations for further investigation and/or options management in relation to the proposed development (if applicable).
- Assess the preliminary waste classification of materials likely to be excavated as part of the proposed development.

The scope of work developed to meet this objective included a review of site history information, site walkover, soil sampling from 39 environmental boreholes, opportunistic observations and soil sampling from the ten geotechnical boreholes, installation of three groundwater monitoring wells, sampling and analysis of groundwater from the newly installed wells and three existing monitoring wells. Selected samples were tested for key contaminants of potential concern to inform the assessment. The results of the desk study, site walkover, field and laboratory testing were interpreted and assessed with respect to these objectives.

Based on site history information, Berth 101 (also known as the Bulk Products Berth) was constructed in 1964 and commissioned for the loading of coal, coke and slag. Dredge material from the Inner Harbour and steelworks slag may have been used in the berth's construction, although the source of fill could not be confirmed. The berth had an array of surface infrastructure including substation, conveyors and diesel underground storage tank (UST). Majority of the surface infrastructure was removed c2011 and the UST was removed in the early 1990's. No evidence of contamination was observed at the time of UST removal. Previous investigations at the site were undertaken by Douglas Partners (DP) in 2014, which assessed the former UST location, substation, fill and groundwater. DP concluded that the site was suitable for continued industrial land use. GHD notes that the assessment of the former UST was limited due to shallow refusal and collapsing ground conditions, thus limiting the depth of investigation to the upper 2.6 m of the soil profile. The base of the UST was 5 m below ground level (bgl).

Based on the scope of work undertaken, and subject to the limitations in Section 1.3 of this report, the following conclusions have been made:

Contamination

Contamination in the fill material within the area to be excavated within Berth 101 is relatively minor, and generally consistent. Only two soil samples exceeded adopted criteria; these were at GHB09 and GBH26 and were for BaP (TEQ) (health criterion) and for heavy end petroleum hydrocarbons (Management Limits) near the inferred base of fill material between 4 m to 5 m bgl. Review of potential source-pathway-linkages for this contamination indicates that it is unlikely to pose any significant constraints to the proposal, subject to further assessment of the extent of BaP TEQ hotspots and mitigation measures developed to manage potential health impacts during construction works. Potential risks to marine environmental receptors from relocation of the berth material are considered low and acceptable based on measured concentrations of contaminants.

Asbestos was identified on site in the form of fragments of asbestos containing material (ACM) on the ground surface. These are assumed to be associated with historical demolition on site. No asbestos was identified in samples below the ground surface, and it is therefore unlikely that asbestos containing materials are present in the fill, although this cannot be precluded.

Some relatively minor impacts from heavy metals and ammonia were identified in a perched fresh to brackish groundwater lens within Berth 101. The size of the lens is not well understood, however, the proposed piling and excavation works will limit the amount of perched water discharging into the marine environment, which will in any event significantly attenuate the concentrations of contaminants observed in this investigation.

Preliminary waste classification

The preliminary waste classification assessment of fill and underlying natural materials in the event that off-site disposal to land is required, is General Solid Waste (non-putrescible) based on the available data. This classification was undertaken in accordance with NSW EPA (2014) Waste Classification Guidelines, Part 1 – Classifying Waste. This preliminary classification needs to be confirmed during excavation works, and is not applicable to any material types, which differ in nature from those sampled.

Proposed excavated materials will contain some ASS and will need to be managed in accordance with the requirements of NSW EPA (2014) Classifying Waste: Part 4.

Acid sulphate soils

Based on the field screening and laboratory results, ASS occurs in natural sediments below the fill (variable and to depths between 2.5 m and 5.5 m bgl) to at least 14 m depth and probably beyond, particularly where dark grey and green clays exist. Disturbance (either excavation and or dewatering) of these natural sediments will need to be carefully managed and it is recommended that an Acid Sulphate Soil Management Plan is prepared by a consultant experienced in the identification and management of ASS.

Recommendations

Based on the results of this assessment, the following is recommended:

- One or more of the following is proposed for assessing the potential risk to human health for the two BaP (TEQ) hotspots identified at GHB09 and GBH26:
  - Development of a human health risk assessment for BaP (TEQ), to further refine the potential risk posed by these contaminants to future construction workers. Given the short duration of the works relative to the standard exposure assumptions in a commercial/industrial scenario, it is likely that derived site specific target levels for BaP (TEQ) would be higher than use adopted for this assessment.
  - Additional investigation to delineate the vertical and lateral extent of BaP (TEQ). The investigation would involve step out borehole locations which will target materials at depths between 4 m and 5 m, to assess if the contamination is isolated or widespread.
  - The source of BaP (TEQ) at GHB09 and GBH26 was not identified nor was there apparent evidence of this contamination present at the time of sampling. The contamination may be a characteristic of the fill material, meaning it could be randomly distributed throughout the fill matrix. Therefore, in addition to further investigation, bioavailability testing is also recommended so that the risk to human health is better understood and appropriate safety control measures can be adopted during construction. The laboratory is presently maintaining these samples pending further analysis.
- Removal of any remnant ACM fragments from the ground surface. The removal should be undertaken by a licenced removalist in accordance with relevant SafeWork NSW codes of practice. Following removal, a licenced asbestos assessor should inspect the site and provide a clearance certificate confirming removal of asbestos.
- Inclusion of an unexpected finds protocol for contamination in the Construction Environmental Management Plan (CEMP) for the work associated with construction activities.
- Preparation of an ASS Management Plan (ASSMP) be prepared so that excavated material containing ASS is appropriately managed. This will also include appropriate treatment for offsite disposal whether that be to an onshore landfill or Outer Harbour disposal cell.

This report is subject to, and must be read in conjunction with, the limitations set out in Section 1.3 and the assumptions and qualifications contained throughout the Report.

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1. Introduction

1.1 Background

Australian Industrial Energy (AIE) proposes to develop the Port Kembla Gas Terminal (the project) in Port Kembla, New South Wales (NSW) (the Site). The site location is shown on Figure 1). The project involves the development of a liquefied natural gas (LNG) import terminal, which would be the first such import terminal in NSW and provide a simple, flexible solution to the State's gas supply challenges.

NSW currently imports more than 95% of its natural gas requirements from Victoria, South Australia and Queensland. An import terminal would enable NSW to control and secure its own direct supplies. The project has the capacity to deliver in excess of 100 petajoules of natural gas per annum to NSW. This is equivalent to more than 70% of the State's annual needs. Supply could be increased further to around 140–150 petajoules per annum through a slight increase in scheduled deliveries and pipeline upgrades.

The project consists of four key components:

- LNG carrier vessels — there are hundreds of these in operation worldwide transporting LNG from production facilities all around the world to demand centres;
- Floating Storage and Regasification Unit (FSRU) — a cape-class ocean-going vessel which would be moored at Berth 101 in Port Kembla. There are around 30 such vessels currently in operation around the world;
- Berth and wharf facilities – including landside offloading facilities to transfer natural gas from the FSRU into a natural gas pipeline located on shore; and
- Gas pipeline – a Class 900 carbon steel high-pressure pipeline connection from the berth to the existing gas transmission network.

The project has been declared critical state significant infrastructure in accordance with section 5.13 of the *Environmental Planning and Assessment Act, 1979* (EP&A Act) and Schedule 5 of the *State Environmental Planning Policy* (SEPP) *State and Regional Development*. An Environmental Impact Statement (EIS) is required to support the application for approval for determination by the NSW Minister for Planning.

This report provides the results of the contamination assessment for Berth 101, which includes an area immediately east of the berth and six anchor points, as shown by the red outline in Figure A. The contamination assessment along the proposed pipeline route, the proposed dredge area in the waters off Berth 101 and the proposed Outer Harbour reclamation area have been reported separately.

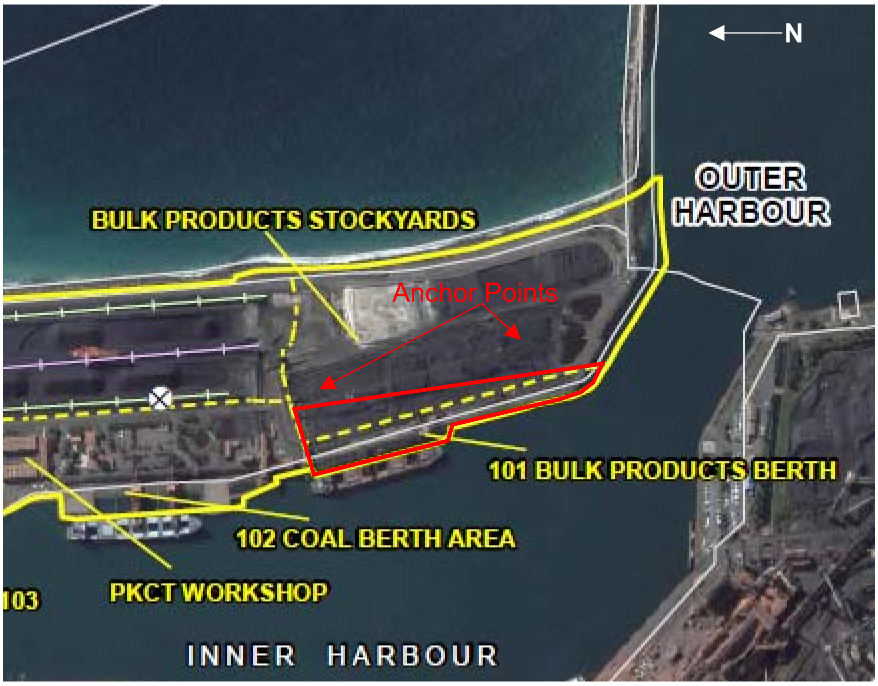


Figure A – Site definition (Cardno Forbes Rigby 2008, p. 152)

1.2 Project objectives

The objectives of the assessment were to:

- Assess the likelihood for contamination to exist on the site from past or present activities.
- Assess the potential presence of acid sulphate soils (ASS).
- Provide recommendations for further investigation and/or options management in relation to the proposed development (if applicable).
- Assess the preliminary waste classification of materials likely to be excavated as part of the proposed development.

1.3 Limitations

This report: has been prepared by GHD for Australian Industrial Energy and may only be used and relied on by Australian Industrial Energy for the purpose agreed between GHD and the Australian Industrial Energy as set out in Section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Australian Industrial Energy arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Australian Industrial Energy and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report, which were caused by errors, or omissions in that information.

Limited information is available on the early history of the site and therefore, some site activities may not have been identified. In addition, aerial photographs are up to 16 years apart and other site history information available prior to 1950 is limited. We cannot preclude that potentially contaminating activities took place during these periods. Allowances for uncertainties and potential unexpected finds should be made during planning and development phases.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

In preparing this report, current guidelines for assessment and management of contaminated land were followed. This work has been conducted in good faith in accordance with GHD understanding of the client's brief and general accepted practice for environmental consulting.

This report was prepared for Australian Industrial Energy based on the objectives and scope of work list in Sections 1.2 and 2. No warranty, expressed or implied, is made as to the information and professional advice included in this report. Anyone using this document does so at their own risk and should satisfy themselves concerning its applicability and, where necessary, should seek expert advice in relation to the particular situation.

2. Scope of work

The work carried out by GHD to meet the above objectives included:

- Review of publically available information (e.g. topographic, geological, soil landscape, acid sulphate soil maps).
- Specific information reviewed for assessing the likelihood of potential contamination to exist at the site included: aerial photographs and council planning records; historical title search, holding interviews with persons familiar with the history of the site; and search of NSW Environmental Protection Authority (EPA) databases.
- A site walkover to visually assess potential sources of contamination, observe surrounding land uses, topography, drainage, nearby sensitive receptors, and assess details of the site history and desk study to further assess potential areas of environmental concern (AEC) and contaminants of potential concern (COPC).
- Subsurface investigation comprising:
  - Thirty-nine (39) boreholes drilled by trailer and truck mounted drilling rigs within the planned location excavation area to between 5.0 m and 10.0 m below ground level (bgl).
  - Installation and development of three groundwater monitoring wells designated MW2, MW3 and MW6. GHD also developed three existing groundwater monitoring wells installed by Douglas Partners in 2011 and designated 201, 204 and 205.
  - Gauging, purging and sampling groundwater from the above mentioned wells. Field water quality parameters were also measured at the time of purging and sampling.
  - Ten geotechnical boreholes, undertaken by Worley Parsons, and drilled using truck mounted drilling rigs within Berth 101 to between 22.15 m and 33.3 m bgl.
- Laboratory analysis included:
  - Eighty-five (85) samples for heavy metals
  - Eighty-three (83) samples for total recoverable hydrocarbons (TRH), benzene, toluene, ethylbenzene, xylenes (BTEX) and polycyclic aromatic hydrocarbons (PAH).
  - Twenty-six (26) samples for asbestos (absence/presence) in soil.
  - Twenty-four (24) samples for tributyltin (TBT), cyanide and ammonia.
  - Two samples for asbestos (absence / presence) of suspected ACM material.
  - One sample for dioxins.
- ASS laboratory testing included:
  - One hundred and seventy (170) samples for pH screening.
  - Sixty-seven (67) samples for chromium reducible sulphur suite.
- Quality control sampling included duplicate and triplicate samples, and trip spikes and trip blank samples.
- Preparation of this report summarising the site history, results of fieldwork, presenting and interpreting analytical results and findings, comparing chemical concentrations to applicable guidelines, and making recommendations with respect to the objectives outlined in Section 1.2. The contamination aspects of the report were prepared with reference to NSW EPA made or approved guidelines.

3. Site setting

3.1 Current land use and proposed development

Berth 101 is currently operated Port Kembla Coal Terminal (PKCT) and historically handled small bulk products such as coal, coke and slag (Port Authority of NSW 2015, p. 20). The Berth 101 infrastructure, previously included *'road receival area, road hopper, coke screener, stockyard, conveyors transfer station, ship loader, front end loaders, wharf and berthing basin'*, which were removed in circa 2013 (Cardno 2008, p. 59). Utilisation of Berth 101 has declined in recent years.

3.1.1 Proposed development

The proposed development will require berthing and unloading infrastructure for two vessels and a pipeline connection to transfer the gas to the local market and will include:

- Construction of a new berth pocket and associated mooring infrastructure south-east of the existing Berth 101 to accommodate an approximate 300 metre FSRU unit, berthed alongside an LNG vessel to allow unloading of LNG to the FSRU. Refer to Figure B.
- The new berth would be cut into the existing shoreline at Berth 101 so as not to impede the navigation of vessels travelling to and from the Eastern Basin (Berths 102, 103 and 104). This would involve demolition of the existing Berth 101 infrastructure and excavation and dredging of approximately 600,000 m^3 of dredge material; with an estimated bulking factor of 1.2 increasing volume to about 720,000 m^3. Refer to Figure C.
- Subject to geochemical testing and analysis, the material removed would likely be transported for disposal within the footprint of the proposed Outer Harbour reclamation area. Refer to Figure D.
- Installation of topside port infrastructure, including high pressure gas loading arms and a new 12.7 km 18" gas transmission pipeline commencing at the terminal and connecting to the existing gas transmission network at Cringila.

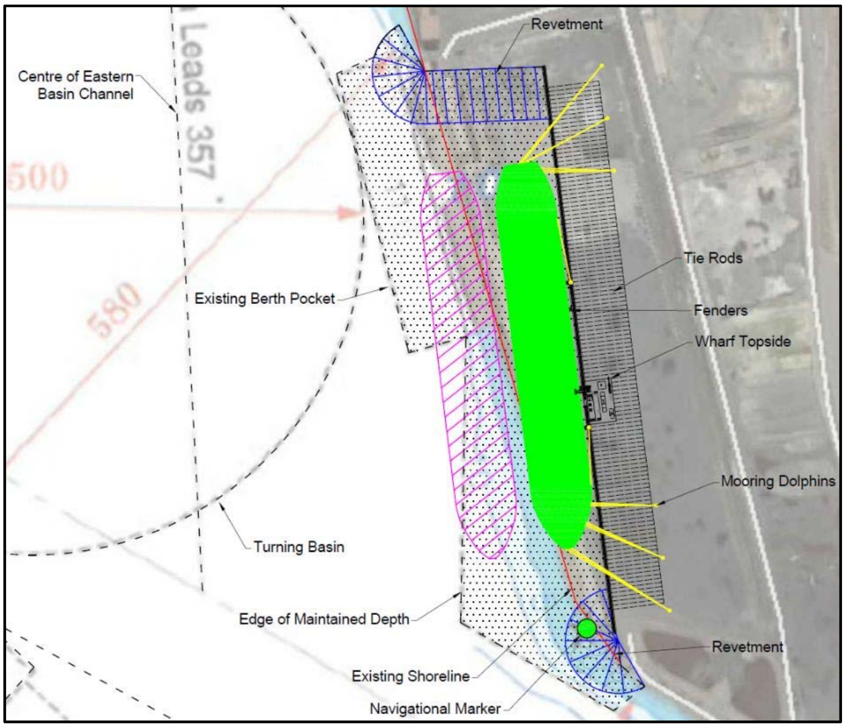


Figure B – LNG Gas Terminal at Berth 101

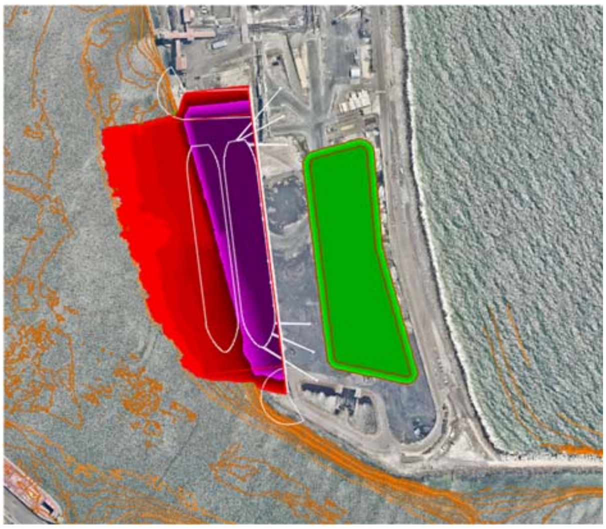


Figure C – Excavation of Berth 101

Purple area is the current berth and the red is the proposed dredging area. Green is the proposed stockpiling area.

Figure D – Proposed disposal area

The blue-green area southeast of the berth is the proposed disposal area.

It should be noted that the contamination assessment has been undertaken concurrently with the detailed design process and was based on the original proposed development which is shown in Figure B. Since undertaking fieldwork, the development has been refined to include the location of the proposed anchor points (Figure 2).

3.1.2 Earthworks and reclamation

Excavation and stockpiling

The WorleyParsons *Technical Note – Dredge and Disposal Methodology* (24 September 2018) indicates that excavation of Berth 101 will likely proceed as follows.

Preliminary land based activities will include the following:

- Demolish existing Berth 101
- Remove and stockpile existing rock revetment
- Excavate fill layer across site to remove existing slabs, foundations and services

Once these enabling works are complete the excavation of the in-situ material beyond the new quay wall could proceed using a Long Reach Excavator. Due to the limitation on reach of such excavators currently in use in the area, it is possible that excavation of deeper material may need to be dredged. The backhoe dredger would be situated in the Inner Harbour adjacent to Berth 101 and would primarily be used to excavate the deeper sediments at Berth 101.

Material will be excavated into heavy haul trucks which will relocate the material into an area at the rear of the Berth 101 site (current Coal Terminal East Stockyard). The area potentially available for stockpiling is around 400 m long by 50 m wide. The stockpile will be up to 10 m high ready for truck transportation.

Material disposal

WorleyParsons (2018) indicates that stockpiled material from the Berth 101 excavation will be relocated to a disposal site within the Outer Harbour. A perimeter bund will be constructed to ensure the stability of the disposal site. This bund will need to be constructed on relatively stiff material which will necessitate the removal of existing soft sediments that have previously been placed across the disposal site. Trucks will transport Berth 101 materials to the Outer Harbour site and place material close to the shore line to be pushed out by bulldozers. Material dredged by the backhoe dredger would be put in barges for transport to the Outer Harbour for disposal. The volume of material to be excavated by long reach excavator and transported by haul truck versus the volume of material to be dredged by backhoe dredger and transported by barge may vary depending on the preference and capacity of the construction contractor.

3.2 Site identification

Site identification details and surrounding land uses are summarised in Table 1. The site layout and surrounding areas are shown on Figure 1.

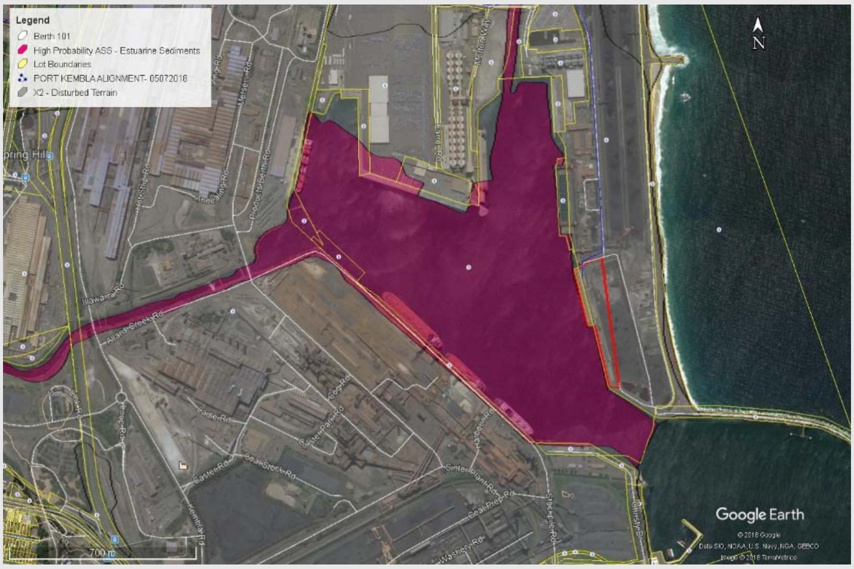
Table 1: Site identification details

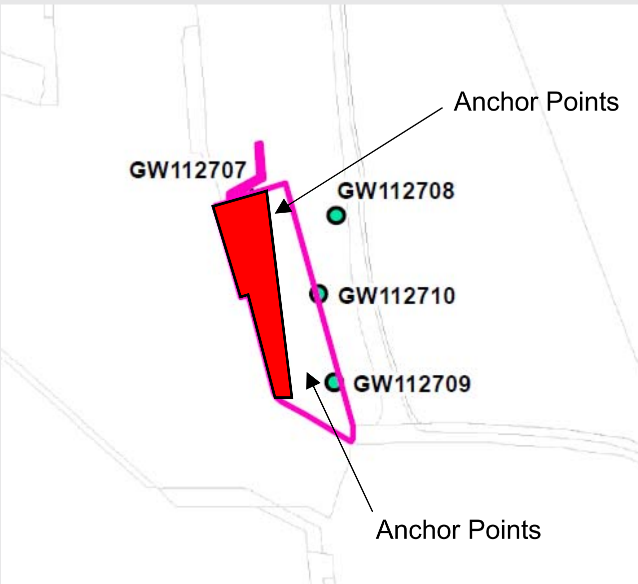
Address:	Berth 101, Port Kembla
Title identification:	Part Lot 22 DP 1128396
Zoning:	SP1 – Special Activities SEPP (Three Ports) 2013
Area approximate:	3 ha (excavation area)
Local government area:	Wollongong
County:	Camden
Parish:	Wollongong
Current land use:	Industrial Ports
Adjoining land uses:	Industrial and coal terminal
Site coordinates: (Zone 56 H)	307013 m E; 6184616 m N (southern point of excavation area)

3.3 Topography, drainage, soil, geology & hydrogeology

Table 2 summarises topography, drainage, soil, geology and hydrogeology associated with the site. Topography, drainage, soil and geology information was obtained from the Lotsearch report included in Appendix A.

Table 2: Topography, drainage, geology and hydrogeology

Elevation:	Between 3 m and 5 m above Australian Height Datum (AHD) (from Google Earth Pro).
General slope direction:	Information obtained from Google Earth Pro indicates that the berth gently slopes down towards the south and west.
Closest surface water body:	Berth 101 is adjacent to the Inner Harbour (Tom Thumb Lagoon) and Port Kembla Harbour. Tom Thumb Lagoon, a remnant saline coastal lagoon, has been progressively reclaimed by the Port Kembla Steelworks; originally 500 ha in area, the lagoon is now 50 ha (BES 2010, p. 15).
Drainage:	Surface water is generally directed to the PKCT stormwater system, which includes a number of settlement ponds; one of which is located immediately south-east of Berth 101. It is expected in high rainfall events that surface water will flow directly into the harbour.
Regional geology:	The 1:100,000 Geological Series Sheet of Wollongong-Port Hacking indicates that the regional underlying geology is Quaternary sediments described as quartz and lithic fluvial sand, silt, and clay.
Site specific geology: (DP, 2014)	Refer to Table 5.
Acid Sulphate Soils:	The ASS Risk Map indicates that the Berth (in red outline) is situated in an area mapped as disturbed terrain at an elevation >4 m (shown in grey shading). Estuarine sediments exist within the harbour and are mapped as high probability of ASS.  **Figure E – ASS Risk Map**
Soil landscape:	Disturbed Terrain

Groundwater bore search:	The four closest registered bores are located within or adjacent to the Berth's eastern boundary, as shown in Figure F. These are groundwater monitoring wells installed by Douglas Partners (DP, 2014), which is further discussed in Section 4.4.  **Figure F – Registered groundwater bores near Berth 101** Work summary sheets are located in Appendix A as part of the Lotsearch report.
Depth to groundwater:	Based on previous reports, standing groundwater levels were measured between 3.87 m and 6.6 m below ground surface (DP 2014, p. 25)
Inferred groundwater flow direction:	Groundwater is expected to be tidally influenced, with a general flow towards the south-west (DP 2014, p. 24). An Aurecon Hatch report (2010) indicated that groundwater was not tidally influenced yet affected by heavy rainfall events (DP 2011, p. 12). The basis of this conclusion is unknown as GHD did not have a copy of the original report.

4. Site history review

Information on the site history was obtained from:

- Review of selected aerial photographs (1951 to 2016).
- Interviews with PKCT staff who have worked at the site for at least four to five years.
- A search of NSW EPA register for listings of the site and nearby sites. The registers searched include the Contaminated Land Record of Notices and Notified Sites under the *Contaminated Land Management Act 1997* (CLM Act), and environmental protection licenses under the *Protection of the Environment Operations Act 1997* (POEO Act).
- A review of Wollongong City Council Section 10.7 planning certificate.
- Previous reports provided by PKCT.

The site history information is presented in Appendices A and B and a summary is provided below. Relevant historical details are shown on Figure 2.

4.1 Site history search results

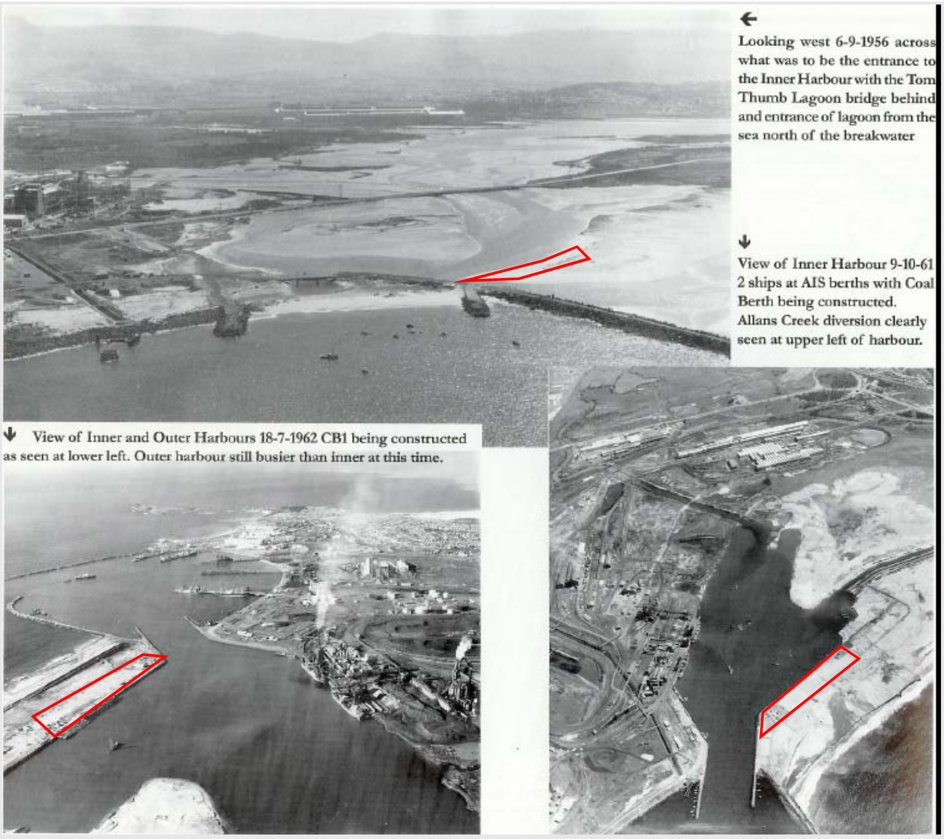
Site history searches undertaken for this site and their results are summarised in the table below. Relevant results from the site history searches are shown on Figure 2.

Table 3: Summary of site history search results

Search type	Search result
Land owner	NSW Government leased to PKCT (BES 2010, p 21)
NSW EPA Registers (Appendix A)	There was one current listing for Contaminated Sites Record of Notices[1] within 500 m of the site: • Four notices have been issued in relation to the No. 2 Steelworks (Five Islands Road, Port Kembla NSW Bluescope Steel, No. 2 Steelworks, Lot 1 in DP606434) • The most recent notice for the No 2 Steelworks site, dated 27 March 2018, notes that the EPA is satisfied that ongoing regulation under the under the *Contaminated Land Management Act 1997* (CLM Act) is no longer warranted, and that the ongoing monitoring and management of the contamination will be captured under the environment protection licence for the site. • A copy of the Voluntary Management Proposal for No 2 Steelworks has not been made publically available on the NSW EPA web site, and the nature of the contamination which was formerly regulated is not known. There was one current record for List of NSW Contaminated Sites Notified to EPA[2] within 500 m of the site, which also related to the No 2 Steelworks site. The NSW EPA website lists the status as "Regulation under the CLM Act not required".

[1] A site will be on the Contaminated Land: Record of Notices only if the EPA has issued a regulatory notice in relation to the site under the Contaminated Land Management Act 1997. The notice is issued by the EPA to the party responsible for cleaning up contamination.

[2] NSW contaminated sites notified to the EPA indicate that the notifiers consider that the sites are contaminated and warrant reporting to EPA. However, the contamination may or may not be significant enough to warrant regulation by the EPA.

Search type	Search result
	<u>Records for current Environment Protection Licences under the POEO Act located on or adjacent to the site include:</u> • PKCT for cokeworks and bulk shipping. Includes discharge of water within collection ponds to harbour during storm conditions or water quality criteria set by EPA are achieved (BES 2010, p. 10). • Australian Amalgamated Terminals for bulk shipping • Quattro P RE Services Pty Ltd for 'other activities'. • Across the harbour and south and west of Berth 101: – Several licences for BlueScope Steel – Bulk shipping – Cement handling – Petroleum storage <u>Records for surrendered licences under the POEO Act located within 500 m of the site, include:</u> • Water based extractive activities • Water discharge • Herbicide application along waterways.
Section 10.7 Planning Certificate (Appendix B)	Council's records show that because of previous uses the land may be contaminated. Land not subject to any notifications under the *Contaminated Land Management Act 1997*.
Historical photographs (BES 2010, p. 16)	 Historical photographs circa 1956 to 1962. Approx. Berth 101 area in red.

Search type	Search result
	 Historical photograph circa 1962. Approx. Berth 101 area in red.

4.2 Aerial photographs

Aerial photographs are included in Appendix A.

Table 4: Summary of aerial photography review

Image Date	Onsite Observations	Off-site Observations
1951 (black & white)	The area where Berth 101 is presently located appears to be a sand bar. The western portion of Berth 101 appears to be ocean.	Except for a road located west of the site (across the harbour), the surrounding areas appear undeveloped.
1961 (black & white)	Berth 101 is evident but does not yet appear to be completed.	Tom Thumb Lagoon has been dredged. The road noted in the previous aerial photograph is no longer evident. The steelworks is evident south of Berth 101 along with the breakwater located to the east.

Image Date	Onsite Observations	Off-site Observations
1977 (black & white)	The construction of Berth 101 appears to be complete and resembles the current configuration. The berth appears operational with stockpiles of dark material, possible coal, which is being loaded into a docked ship. Infrastructure is evident and likely to be associated with the distribution and loading of coal. Three relatively small buildings are located near the berth's central western boundary. Another possible building is located near the central northern boundary.	The area north of Berth 101 has continued to develop, with several buildings evident. Berth 102 is also evident. East of Berth 101, a railway line and train is evident. Some development observed within the steelworks area.
1984 (colour)	Berth 101 appears similar to the previous aerial photograph. Several relatively small rectangular objectives, possibly trucks, are evident in the south eastern portion of the berth. At least four additional buildings are evident along the central western boundary of the berth. Several small objects occupy the southern tip of the proposed berth excavation area.	The railway line located east of the berth is no longer evident. The area appears unpaved with vegetation growing within the northern half of this area. Areas north-east of Berth 101 also appear to be used for the storage of coal. Large structures, possibly associated with a conveyor system are evident and located immediately north of Berth 101.
1994 (colour)	The Berth 101 configuration appears similar to the previous aerial photograph. Less coal appears to be stockpiled. An 'L' shaped building is located within the western portion of the berth but within the southern half. Several small features, possibly vehicles, are evident in the near the northern boundary of the berth. An 'S' shaped road bisects the berth from east to west. A rectangular feature, possibly a settlement pond, is located in the north-western portion of the berth, adjacent to the ship docking area. Some of the buildings previously occupying the northern portion of the berth, near the central northern boundary, appear to have been removed.	A settlement pond has been constructed within the southern portion of Berth 101 and immediately south east of the proposed excavation area. Two settlement ponds have also been constructed north of Berth 101 and east of Berth 102. Coal appears to be stockpiled in the area east of Berth 101.

Image Date	Onsite Observations	Off-site Observations
2002 (colour)	Berth 101 appears similar to the previous aerial photograph. Approximately five small structures, possibly buildings, occupy the northern portion of the berth, adjacent to the northern boundary.	Surrounding areas appear similar to those in the previous aerial photograph. The area north-east of Berth 101 appears to have been filled. Less coal appears to have been stored in areas east of Berth 101.
2008 (colour)	Berth 101 appears similar to the previous aerial photograph. Two relatively small settlement ponds are evident in the southern half, near the western boundary of the berth.	The area previously filled appears to have undergone further development with possible retaining walls evident.
2013 (colour)	The majority of the coal loading and distribution infrastructure has been removed. A series of small rectangular objects are positioned in a row adjacent the western conveyor. Several small objects are evident near the central north boundary of the berth. Some of the objects could be vehicles.	Coal no longer appears to be stockpiled east of Berth 101. Stockpiles, possibly coke or slag are noted in the northern half of this area.
2016 (colour)	The buildings previously occupying the area adjacent to the central northern boundary of Berth 101 have been removed. The series of small rectangular structures previously observed, have also been removed; however similar structures appear have been used in the northern half of the berth. The objects appear to be configured to designate areas. Relatively small stockpiles of coal are stored within the eastern area of the berth. Several small objects, possibly trucks, are also present within the coal stockpiling area. A stockpile of coke/slag is evident in the south tip of the berth, west of the southern settlement pond.	The area east of Berth 101 has two large stockpiles of coal and several stockpiles of coke/slag stored.

4.3 Interviews

Two PKCT personnel, Bob Black (Project Coordinator) who has been with PCKT since 2014 and Luke Pascot (Environmental Specialist) who has been with PKCT since 2013, were interviewed on 14 and 16 August 2018. A summary of the information obtained from the interviews follows:

- The terminal, in some form, has existed for over 100 years. Activities have included coal and coke loading into ships. The ships were loaded with mobile loaders.
- The terminal was constructed using fill of unknown origin but expected to be largely slag. There are reported to be no early records available concerning filling activities.
- Fill material used to construct Berth 101 may have contained potential acid sulphate soils (ASS).
- An underground storage tank (UST) existed north of Berth 101 (off-site) and was reportedly removed 2013/2014. Another UST may have existed somewhere east of Berth 101.
- No significant chemical spills or releases have occurred in last six years; only minor hydraulic leaks.
- Numerous underground services exist at the site. A low pressure oil pipeline owned and managed by Manildra exists along the western edge of Berth 101 and continues out to the breakwater (brown line on Figure 2). A water service (green line on Figure 2), constructed of asbestos containing materials (ACM) also exists within Berth 101.
- The yard layout was designed by GHD.

4.4 Summary of previous land contamination reports

Several investigations have been undertaken at Berth 101. The key findings of the investigation reports reviewed are summarised in Table 5.

Table 5: Summary of previous reports

Reference	Objective	Scope of work	Site history, areas of potential contamination and key findings	Conclusions and recommendations
Illawarra Coal, 2008 (prepared by Basix Environmental Solutions; (BES))	Qualitative risk assessment for potential contamination.	N/A	Filling of coal loader occurred between 1950s and 1960s. Blast furnace slag was commonly used under roadways, hardstand and stockyard areas. Since 1990, *'very little land filling has occurred'*. Base of terminal is likely to be harbour fill (assuming harbour sediments) and *'basalt from local quarries'*. Alkaline pH reported, suggesting impacts from slag use across the terminal. The southern settlement pond was constructed in 1992 and lined with blast furnace slag. An underground storage tank (UST) which was used to store diesel, was removed in the early 1990s. The UST dimensions were 5 m by 30 m and was observed to be in good condition at the time of removal. The UST was located east of the proposed excavation area at Berth 101 and in the vicinity of the proposed anchor points (Refer to Figure 2). Accumulation of potentially contaminated sediment in settlement ponds was periodically cleaned out. Coal fines recycled however no comment was made about disposal of potentially contaminated sediments. Hydrocarbon/chemical storage was bunded indicating the potential for contamination from these features would be reduced. No above ground storage tanks (ASTs) present at the terminal. No known flocculent overdose reported in the southern settlement pond. No major spill events reported. Coal contaminated water generated during a ship washout entered the harbour in 2007. Additional control measures were implemented to prevent a similar future incident. Oil spill occurred (date unknown) during ship bunkering which is inferred to have damaged the oil pipeline. The pipeline was repaired, and additional control measures implemented.	N/A
Cardno, 2008 (Environmental Assessment)	To discuss the extent of environmental impacts from existing PKCT operations and assess any increase from proposed development.	N/A	Waste management practices involved removal of waste from site such as waste oils/lubricants, general rubbish and scrap metal.	N/A
BES, 2010, (DRAFT) (Preliminary Contamination Assessment)	Assess if there is a 'Duty to Report' under Section 60 of the CLM Act.	• Review of activities, infrastructure and site history. • Interviews with site personnel. • Review previous reports, EMPs, closure plans, chemical registers, product loss monitoring of USTs. • Identify potential contamination types. • Site walkover to observe potential contamination. • Review groundwater and surface water monitoring records.	Berth 101 (also known as the Bulk Products Berth) was commissioned in 1964 for the loading of coal, coke and slag. Two settlement ponds exist on-site and a third pond located immediately east of the site, which may discharge to the harbour during storm events or if water quality criteria are achieved for suspended solids, pH and oil/grease. Water from the truck washing facilities (north of Berth 101) is directed to the PKCT water collection and treatment system, treated then reused. The BES review of data indicated several exceedances for total suspended solids (TSS) were reported between 2001 and 2008. Exceeding concentrations were '*only slight in magnitude'* (BES 2010, p. 36). Coal fines may contain trace amounts of arsenic and zinc, which have not been assessed. Use of recycled water from Sydney Water's sewage treatment plant for dust suppression was identified as viable with the key concern being additional nutrient loads impacting onsite water collection system. The report included the 2008 Illawarra Coal risk assessment summarised above. Other potentially contaminating activities / areas identified included a substation (located in the western portion of Berth 101), former UST that was removed in the early 1990s, leaching of zinc from building materials used across the site and filling activities as previously described. COPC included TPH, BTEX, PAH, PCB and/or metals. No significant physical indicators of contamination were observed; some minor	Low risk of petroleum hydrocarbon and heavy metal contamination. No Duty to Report, as concentrations of COPC not exceed adopted criteria. It is noted that BES compared sediment concentrations to the Duty to Report criteria to form this conclusion. Further investigation was recommended to gain a better understanding of fill placed at PKCT and implementation of action plans to manage identified risks.

Reference	Objective	Scope of work	Site history, areas of potential contamination and key findings	Conclusions and recommendations
		• No sampling and analysis undertaken. The work was commissioned by BHP Billiton Illawarra Coal.	staining was noted but this was outside Berth 101. Paved surfaces and adsorption on to coal products was considered to reduce the likelihood of hydrocarbons entering the groundwater. The sediments excavated from the inner harbour north of Berth 101 and general dredging comprised very soft dark grey to black estuarine clay. BES review of existing data identified heavy metals and TBT exceeded either the low or high Interim Sediment Quality Guidelines (ISQG). This material was disposed of at the Outer Harbour reclamation area. Some of these sediments may have been historically used in the construction of the Berth in 1958-1962.	
Douglas Partners (DP, 2011) (Phase 1 (desktop) Contamination Assessment)	• Identify past and present potentially contaminating activities. • Identify potential contamination types. • Discuss the site condition. • Provide a preliminary (desktop) assessment of site contamination. • Assess the need for further investigations.	• Review of aerial photographs, NSW EPA records, WorkCover records, Council records and previous reports prepared by DP and other consultants. • Site inspection • No sampling and analysis undertaken. *The assessment included a larger area of 17 ha, which also includes the current Berth 101 site. The findings included in this summary only pertain to the Berth 101 site.*	Based on site history information, there was *'no discernible use was applied to the site'* prior to 1955 (DP 2011, p. 18). Between 1956 and 1960, the Inner Harbour was dredged and the construction of Berth 101 was completed in 1964. Inner Harbour sediments may have been used in the construction of Berth 101. Since construction of Berth 101, it has been used as a coal and bulk product loader. The southern settlement ponds were constructed in the early 1990's and lined with slag. Based on the results of the assessment, DP assessed the site to have a low to moderate potential for contamination from: • Long term use of the site as a coal and bulk products loader. Modern standards of environmental practices may not have been observed historically and on-site refuelling was carried out. • Fill used in the construction of the site. Some fill is thought to have been derived from dredging activities from the Inner Harbour, which could be contaminated. • Contamination in the vicinity of a former diesel UST located north-east of Berth 101 (and general vicinity of the proposed anchors). • Potential oil (containing PCBs) from on-site transformer within the electrical substation located in the southern portion of the Berth 101. Previous geotechnical site investigations undertaken by DP indicated a variable fill depth between 7.0 m and 14.1 m overlying estuarine deposits then siltstone / sandstone rock. Fill within the upper 0.5 m was described as a gravel / coal waste layer which was overlying a more uniform gravel and sand fill layer. However, Aurecon Hatch (2010, referred to in DP, 2011 but not available for GHD to review) reported thinner fill layers, approximately 2 m thick, comprising sand and gravels and possibly sourced from the Inner Harbour during dredging activities in 1959/1960. Groundwater was measured at 2 m to 2.5 m above Port Kembla Height Datum (PKHD). DP (2011) also referred to an earlier (2002) sediment investigation carried out by DP within the Inner Harbour comprising 74 sediment cores (six immediately west of the site) analysed for BTEX, PAH, TBT, PCB, pesticides, dioxins, heavy metals, cyanide, phenols and nutrients. Zinc concentrations in elutriate exceeded were the only contaminant reported to exceed the adopted guidelines (not stated), but were assessed by DP to have a negligible environmental impact and suitable for offshore disposal. It is noted that DP (2002) did not evaluate the concentrations of dioxins detected as this required site specific risk assessment which was beyond the scope of that investigation. Circa 2011, a transfer house and conveyor north of Berth 101 were removed and asbestos containing material (ACM) was removed from site. Douglas Partners reported that PD Envirotech had removed and lawfully disposed 8.5 m^3 of hazardous building materials including ACM, floor tiles, asbestos brake shoes, lead paint and electrical cabinets. Historically, refuelling of mobile plant occurred immediately north-east of Berth 101. Diesel was stored in a UST, which was later removed in the early 1990s. The UST was a steel tank (5 m x 30 m), in good condition, and at the time of removal, no leaks were observed. A substation exists within the southern portion of Berth 101. DP reported that the oils within the transformers had been tested and did not contain PCBs (testing assumed to have been arranged by PKCT). However, it cannot be precluded that PCB containing oils were historically used. An oil pipeline (brown line	Low to moderate potential for contamination. Recommended that a targeted Phase 2 contamination assessment be carried out to assess the identified potential for contamination. The targeted Phase 2 contamination assessment would include soil and groundwater sampling. The assessment would be undertaken in accordance with a sampling analysis and quality plan (SAQP). The targeted Phase 2 contamination assessment would also include further investigative works to determine the acid sulphate soil potential of fill at the site.

Reference	Objective	Scope of work	Site history, areas of potential contamination and key findings	Conclusions and recommendations
			on Figure 2), owned and managed by Manildra also exists near the western edge of Berth 101. DP (2011) did not report any incidents associated with this pipeline.	
DP, 2012 (SAQP)	N/A	N/A	The SAQP was developed to further assess the areas of potential contamination identified in the Phase 1 Contamination Assessment (DP, 2011). A summary of the sampling and analysis plan pertaining to the current site area is listed below: • Substation: four surface samples, adjacent to the walls of the substation. • UST: eight test pit locations excavated to 3 m, refusal or collapse: – Two locations along each 'long side' of UST, total of four locations; – One location along each 'short side' of UST, total of two locations; – Two locations positioned within the footprint of the former UST. • Fill / general coverage: two test pits excavated to 3 m, refusal or collapse. • Groundwater: three monitoring wells (two adjacent to the settlement pond and one near the northern boundary of the site). The wells were nominated to be drilled to a maximum depth of 10 m, 2 m below observed groundwater inflow or refusal. The boreholes were to be advanced using auger drilling or air hammer. With the exception of the substation, the proposed analytical schedule was not specific to each area that would be targeted by sampling locations. The SAQP stated selected soil samples, approximately 1.5 samples from each test pit would be analysed for TRH, BTEX, PAH, PCB, tin, phenols and/or heavy metals. Soil samples targeting the substation would be analysed for TRH and PCBs. Groundwater was to be analysed for TRH, BTEX, PAH (low level), PCB (trace level), pH, electrical conductivity (EC) and hardness. *A copy of DP's proposed sample location plan from the SAQP, Figure 1, is included in Appendix C.*	N/A
DP, 2014 (Targeted Phase 2 Contamination Assessment)	• Assessment of: – Soil contamination – Groundwater – Acid sulphate soil potential • Conceptual groundwater modelling • Assess whether the site is suitable for the continued industrial use • Identify requirements (if any) to render the site suitable for the continued industrial use.	DP stated the scope of work undertaken was in accordance with the SAQP (DP 2012). However GHD notes several departures from the SAQP's. The scope of work undertaken is discussed in cell on right. *The assessment included a larger area of 17 ha, which also includes the current Berth 101 site. The findings included in this summary only pertain to the Berth 101 site.*	The following sampling and analysis is listed below. Soil samples were compared to commercial / industrial assessment criteria (NEPM 1999). Groundwater samples were compared to ANZECC 2000 guidelines for marine water: • UST: – Ten test pits excavated to depths between 0.3 m and 2.6 m where refusal or pit collapse occurred. Headspace screening measured by photo-ionisation detector (PID) was <1 ppm. Fill was encountered at each location and described as coalwash, slag and/or sand. – Two boreholes were drilled to 6 m below ground level (bgl) within the eastern portion of the former UST footprint. Fill was encountered at both locations and extend beyond 6 m depth. The fill was described as coalwash, slag, orange-brown sand. No PID measurements were recorded for samples collected from boreholes. Samples appear to have been collected directly off the auger. Groundwater inflow was observed at 4 m and 4.5 m bgl. These boreholes were converted into groundwater monitoring wells, where the lower 6 m of the well were screened. – No evidence of petroleum hydrocarbons were observed during sampling activities. – Laboratory analysis included – 17 soil samples for TRH, BTEX, PAH, PCB, heavy metals, phenolics and/or tin. – Sample were analysed for tin as a screening mechanism for TBT. – Eight samples selected for analysis were between 2.5 m and 5.1 m and only two samples targeting the base of the UST at 4.9 m and 5.1 m.	Based on the site history, field observations and laboratory results, the site is considered to be compatible with a continued industrial use. *GHD notes that there was insufficient information from the former UST footprint to reach this conclusion. Only two locations within the eastern portion of this area extended to base of former UST.* Potential ASS may be present within sandy clay materials encountered at some locations below 1.7 m. *Although not encountered at the one test pit location within the Berth 101 site, it cannot be precluded to exist.*

Reference	Objective	Scope of work	Site history, areas of potential contamination and key findings	Conclusions and recommendations
			– TRH concentrations exceeded the adopted assessment criterion of 1,000 mg/kg in three samples representing depths between 0.2 m and 2.6 m bgl. TPH speciation was undertaken to further assess the significance of TRH concentrations reported in the three samples. These samples did not exceed aliphatic/aromatic assessment criteria. Three samples reported zinc concentrations exceeded the adopted environmental investigation levels (EILs). No other exceeding concentrations were reported. – For groundwater, TRH, BTEX, PAH, PCB and phenolics concentrations were below the laboratory reporting limit. Copper and zinc concentrations exceeded groundwater investigation levels (GILs). • Substation: – Four surface soil samples were collected from the upper 0.1 m of the soil profile. Fill was encountered at each location and described as coarse gravel (slay, road base, coalwash). PID results were <1 ppm. – These samples were analysed for TRH and PCBs. – Detectable concentrations of PCBs were reported for each sample, but below adopted assessment criteria. • General site area: – One test pit was excavated within the site to a depth of 1.7 m, at which point collapse occurred. Fill was encountered to at least 1.7 m and described as coalwash, slag and yellow-brown sand. The remaining test pits providing general site coverage were outside the current Berth 101 site. PID results were <1 ppm. – One sample was selected for analysis of TRH, BTEX, PAH, heavy metals, phenolics and tin. Reported concentrations did not exceed the adopted assessment criteria. – Acid sulphate soil (ASS) sampling and analysis was only undertaken from test pits targeting the general site area. Samples were collected every metre and tested for pH field and pHfox. One sample (213/0.0-0.2m) was selected for chromium reducible sulphur suite testing. No exceedances of the ASSMAC 1998 guidelines were reported. *A copy of DP's sample location plan for the Phase 2 Contamination Assessment, Figure 2, is included in Appendix C.*	Recommendations: • Implementation of an ASS management plan. • Waste classification for any spoil requiring offsite disposal. • Unexpected finds procedure.

4.5 Summary of site history

Based on available site history information, the current understanding of chronological historical land use is summarised below:

- 1873 to 1955 the area of Berth 101 was used as a public reserve, with the exception of the area located adjacent to Berth 102, which between the years 1908 to 1955 was reserved for a night soil depot (DP 2011). The nightsoil depot was located off-site but along the proposed pipeline alignment.
- The 1951 historical aerial imagery shows the site was a sand bar with no anthropogenic influence at that time
- Between 1956 and 1960, the Inner Harbour was dredged and the construction of Berth 101 was completed in 1964 (DP 2011). Inner Harbour sediments may have been used in the construction of Berth 101
- 1964: Berth 101 (also known as the Bulk Products Berth) was commissioned for the loading of coal, coke and slag (BES 2010). Since construction of Berth 101, it has been used as a coal and bulk product loader based on the historical aerial images.
- 1990s: Diesel UST removed and the southern settlement ponds were constructed and lined with slag.
- 2011: Transfer house, conveyor and other associated infrastructure was removed. Some of this infrastructure was identified to contain hazardous building materials (i.e. Lead based paints and ACM).
- 2013 to present day: Largely unchanged landscape use within the site boundary, based on historical aerial photographs and present day Google Earth imagery.

4.6 Gaps in the site history

The following gaps in the site history were identified:

- Some of the anecdotal information from the interviews was inconsistent with previous reports. In particular, the location of USTs and when Berth 101 was constructed.
- The site history generally infers that sediment dredged from the Inner Harbour between 1956 and 1960, and slag from the Steelworks were used in the construction of Berth 101. There were no records available which confirms the actual source of fill material used in berth's construction.
- Substation built at some time between 1964 and 1975. Given the age of the substation and detectable concentrations of PCBs (DP, 2014) in surface samples adjacent to the substation, it is likely that transformer oil contained PCBs. Anecdotal information indicates transformers do not currently use oils training PCBs, however there were no records available to confirming historical oil types used, removal and disposal activities.

5. Site observations

Fieldwork was undertaken between 19 August and 25 September 2018. The investigation area comprised Berth 101 and immediately surrounding area to the east as shown on Figure 2. The investigation area largely comprised of near level open concrete surfaces or gravel surfaces. Coal stockpiling was taking place at the time of fieldwork towards the southern end of the investigation area, this area is slightly raised due to the stockpiling activities. Photographs 1 to 4 show the typical landscape and features of the investigation area and relevant features are also shown on Figure 2.

A decommissioned coal conveyor belt is positioned to the east of the investigation area, aligned in a north-south direction, located behind a concrete wall that broadly separates the greater area into two halves. Concrete panels were present from structures now partly demolished near location GBH04, and to east of GBH15. Steel frames and elevated walking platforms were seen in several areas around the site. An electrical substation was seen on the western side of the site, at the southern end of the berth, this area was largely fenced off with brick structures built around some areas. The substation was in relatively good condition with no leaks or damage observed. Anthropogenic material was observed generally scattered across the whole site, including slag, steel, plastic and wood.

Several services are present on-site including an above ground water pipe which was observed on the western side of the site positioned in a north-south direction. A buried low pressure oil pipeline was also present along a similar alignment running to the west of the water pipe. An asbestos water pipe is located east of the substation and shown as a green line of Figure 2. Near the substation, two fragments of suspected asbestos containing material (ACM) were noted. No suspected ACM was observed within other areas of the site.

Two large stockpiles, approximately 700 m^3 to 800 m^3 of mixed sandy gravel material were observed in the south-western section of site, slag gravel, cobbles and boulders were seen mixed with this stockpiled material. Water was found to be largely captured by internal site drainage except in areas where the coal was stockpiled, and ponding was found to occur due to inadequate drainage in these areas. A partitioned pond was observed in the southern portion of Berth 101 and outside the proposed excavation area and anchor points.

Large industrial equipment and plant including coal loaders were observed on paved areas around the site. The site is actively used by light and heavy vehicles at most times of the day. There is no permanent vegetation or trees in the investigation area, only small patches of grasses and weeds.

Photograph 1: Panoramic view looking south towards the proposed northern anchor points and Berth 101 (right) (5/7/2018)

Photograph 2: Looking west towards the steelworks, GBH04 in the foreground (12/9/2018)

Photograph 3: Looking south towards the paved area of the site, near sample location GBH32 (13/8/2018)

Photograph 4: Looking south at Berth 101 and proposed excavation area. GHD borehole locations GBH33 and GBH37 were drilled in the area shown (13/8/2018)

6. Data quality objectives

6.1 Overview

Data Quality Objectives (DQOs) have been established for this assessment to assist the design and implementation of data collection activities, to ensure the type, quantity and quality of data obtained are appropriate and address the project objectives. The DQO process described in the Guidelines for the NSW Site Auditor Scheme, 3rd edition (EPA, 2017) was adopted for this project. The DQO process involves seven steps:

- Step 1: State the problem
- Step 2: Identify the decision
- Step 3: Identify inputs to the decision
- Step 4: Define the study boundaries
- Step 5: Develop a decision rule
- Step 6: Specify limits on decision errors
- Step 7: Optimise the design for obtaining data

Description of each DQO step developed for this project is provided below.

6.2 Step 1: State the problem

AIE intend to redevelop Berth 101 of Port Kembla Coal Terminal with the construction of facilities to allow the importation and management of LNG. GHD has performed a review of the previous investigations and conducted a desktop review of information available for the Berth 101 redevelopment area with consideration towards the plans outlined in Section 3.1.1 and identified the following potential contamination issues:

- Moderate to high potential for contamination to be present in soil and groundwater onsite.
- Moderate to high potential for acid sulphate soils to be present onsite
- Site soils and fill materials were not assessed against NSW EPA Waste Classification guidelines.
- The potential presence of as yet unidentified on-site or off-site contaminating sources.

The problem as it stands is that the site is proposed for redevelopment and the degree to which contamination may pose a risk to human health and/or the environment as a result of the change in site condition is unknown.

6.3 Step 2: Identify the decisions

The decisions to be made at the end of this assessment are:

- Does soil and groundwater contamination at the site present a potential risk to identified human health and ecological receptors associated with the proposed redevelopment of the site, listed in Section 3?
- Is there a need for further assessment, remediation and/or management of contamination (if identified)?
- What is the waste classification of material to be managed as part of the redevelopment?
- Are acid sulphate soils present on site and is there need for further management?

6.4 Step 3: Identify inputs to the decision

The information considered in the decision making process comprised:

- Review of historical land uses and potential sources of contamination identified at the site and on surrounding properties.
- The proposed redevelopment extent and scope.
- Published environmental information for the site, including geological and hydrogeological maps.
- The conceptual site model (CSM) developed for the site.
- Information obtained from previous investigations, listed in Section 4.4.
- Soil and groundwater analytical data obtained during the investigation, and comparison to applicable criteria for the proposed land use.
- Applicable guidelines, made or approved by NSW EPA under Section 60 of the *Contaminated Land Management Act 1997* (CLM Act).

6.5 Step 4: Define the study boundaries

The lateral investigation extent is the investigation area illustrated in Figure 2 (Site Layout Plan Showing Approximate Sampling Locations).

The maximum vertical extent for the investigation was 33.3 m bgl and for groundwater to 9.30 m bgl (i.e. as the maximum depth of the investigation and the maximum measured depth of the installed monitoring wells).

The temporal extent of the investigation was between 20 August to 12 September 2018 for soil sampling and 25 September 2018 for groundwater sampling.

6.6 Step 5: Develop a decision rule

The decision rules adopted in this detailed site investigation were:

- The concentrations of contaminants of potential concern are to be assessed against adopted site investigation levels, which are sourced from NSW EPA made or approved guidelines with reference to site-specific exposure scenarios for permissible and proposed land use.
  - If concentrations of contaminants in soils and groundwater are below the adopted investigation levels, then contamination at the site will be considered unlikely to pose an unacceptable risk to identified receptors. In such case, no further investigation, remediation or management will be considered warranted.
  - Conversely, when concentration(s) of contaminants of potential concern exceed the adopted site investigation levels, further assessment may be required to evaluate the need for additional investigation and / or remediation / management activities.

6.7 Step 6: Specify limits on decision errors

Two primary decision error-types may occur due to uncertainties or limitations in the project data set:

- A sample/area may be deemed to pass the nominated criteria, when in fact it does not. This may occur if contamination is 'missed' due to limitations in the sampling plan, or if the project analytical data set is unreliable.

- A sample/area may be deemed to fail the nominated criteria, when in fact it does not. This may occur if the project analytical data set is unreliable, due to inappropriate sampling, sample handling, or analytical procedures.

The following aspects were considered when establishing the acceptable limits on decision errors:

- The null hypothesis for the project is: the sample / investigation area is deemed to be contaminated. Sufficient weight of evidence, via the uses of statistical analysis (e.g. 95% upper confidence limit of the mean (UCL)) and/or gathering of multiple lines of evidence (e.g. desktop review and laboratory analytical data), would be required to reject / disapprove the null hypothesis.
- A quality assurance / quality control (QA/QC) assessment evaluating the reliability and useability of data, which are expressed as five data quality indicators (DQI) discussed in Section 6.7.1.

6.7.1 Data quality indicators (DQIs)

The DQIs for sampling techniques and laboratory analysis of collected samples identifies the acceptable level of error for this investigation. The DQIs adopted in this investigation comprise five components, being precision, accuracy, representativeness, comparability and completeness. Detailed discussion of each component is provided below:

- Precision – measures the reproducibility of measurements under a given set of conditions. The precision of the data is assessed by calculating the Relative Percent Difference (RPD) between duplicate sample pairs.

$$RPD(\%) = \frac{|C_o - C_d|}{C_o + C_d} \times 200$$

Where Co = Analyte concentration of the primary sample
Cd = Analyte concentration of the duplicate sample

- GHD adopts a nominal acceptance criterion of < 50% RPD for field duplicates and splits for organics and an acceptance criterion of < 30% RPD for inorganics. However, it is noted that this will not always be achieved, particularly at low analyte concentrations and in heterogeneous media.
- Accuracy – measures the bias in a measurement system. Accuracy can be undermined by such factors as field contamination of samples, poor preservation of samples, poor sample preparation techniques and poor selection of analytical techniques by the analysing laboratory. Accuracy is assessed by reference to the analytical results of laboratory control samples, laboratory spikes, laboratory blanks and analyses against reference standards. The nominal “acceptance limits” on laboratory control samples are defined as follows:

  – Laboratory spikes – 75-125% recovery for metals / inorganics and 70-130% for organics.

  – Laboratory duplicates – Nominal RPD values of 30% or lower. Higher RPD values are generally considered acceptable when the result is close to the LOR.

  – Laboratory Surrogates (Organics only) – 50% - 150% recovery.

  – Laboratory blanks - <LOR.

- Representativeness – expresses the degree which sample data accurately and precisely represents a characteristic of a population or an environmental condition. Representativeness is achieved by collecting samples in appropriate locations across the investigation area, and by using an adequate number of sample locations to characterise soil and groundwater at the investigation area. Consistent and repeatable sampling techniques and methods are utilised throughout the sampling.
- Completeness – defined as the percentage of measurements made which are judged valid measurements. The completeness goal is set at there being sufficient valid data generated during the study. If there is insufficient valid data, then additional data are required to be collected.
- Comparability – is a qualitative parameter expressing the confidence whether one data set can be compared with others. This is achieved through maintaining a level of consistency in techniques used to collect samples and ensuring analysing laboratories use consistent analysis techniques and reporting methods.

6.8 Step 7: Optimise the design for obtaining data

With due consideration given to the DQO steps described above, a sampling and analytical quality plan (SAQP) was developed for the intrusive investigation programme to obtain information to address the decision questions set out in Section 6.3. The SAQP comprises the following:

- Soil investigation and sampling at locations targeting previously identified area of environmental concern.
  - The sampling density within the site areas was developed with reference to recommended minimum sampling densities (NSW EPA, 1995) and previous investigations.
  - The sampling pattern across the site was completed on an approximate grid based system (as far as practicable).
- Gauging and sampling of previously installed groundwater monitoring wells.
- Laboratory analysis of selected soil samples and groundwater samples for identified contaminants of potential concern. Samples were selected on the basis of:
  - The likelihood of contamination presence in surficial and shallow soils in the unsaturated zone.
  - Visual and olfactory indications of potential contamination presence observed during investigation, as well as PID screening results
- Assessment of data quality with reference to the specified DQIs to evaluate the reliability and useability of the obtained data.
- Assessment of laboratory analytical results against adopted criteria.

7. Sampling, analysis and quality plan

7.1 Overview

The proposed excavation and anchor points occupy an approximate area of 3 ha. To assess a site with an area of about 3 ha with respect to contamination, a minimum of 40 sampling locations are recommended by the NSW EPA (1995) (subject to results of the site history and identified areas of environmental concern). The DP 2014 targeted investigation included:

- Twelve sampling locations were used to assess the former UST footprint, which included two groundwater monitoring wells within its eastern part.
- Four sample locations targeting the electrical substation
- One sample location for general coverage.

For this investigation, 38 environmental boreholes and 10 geotechnical boreholes were used to assess the site. The boreholes were spatially positioned on grid, to achieve a minimum of a 95% confidence of detecting a hotspot of 32.4 m. It is noted that the western 15 m to 20 m of Berth 101 was a suspended concrete slab over water. Therefore, no drilling was undertaken within this portion of the berth. GHD borehole locations GBH01 to GBH06, were positioned at the original anchor point locations, which have since been relocated (Refer to Section 3.1.1). Environmental borehole depths were between 5 m and 10 m bgl, whereas the geotechnical boreholes extended to depths of 22.15 m and 33.3 m bgl. Opportunistic sampling was undertaken from geotechnical boreholes and was biased to depths below 10 m, which was the limit of investigation for environmental boreholes.

Borehole GBH02/MW2 positioned in vicinity of an anchor point was the closest location (i.e. 6 m south) to the former UST footprint. Borehole GBH27 was positioned approximately 4 m west of the substation compound. The oil and ACM pipelines were not targeted as part of this investigation.

Two samples of suspected ACM were collected in an area approximately 7 m east of the substation compound. These samples were tested for asbestos.

The soil samples selected for analysis targeted layers/horizons associated with the likely mode of contaminant deposition and/or visual evidence of potential contamination. Samples for TRH and BTEX analysis were selected based on field screening and field evidence of potential contamination (if present).

Selected soil samples were analysed for TRH, BTEX, PAH, TBT, cyanide, ammonia, heavy metals and/or asbestos. One sample from borehole BH11 was inadvertently selected for dioxin analysis. PCBs were not analysed as part of this investigation as PCBs concentrations reported in surface samples collected adjacent to the substation were below the adopted assessment criteria for industrial / commercial land use (NEPM 1999). The vertical and spatial distribution of samples analysed is presented in Table 6.

Three boreholes GBH02, GBH03, GBH06 were converted to groundwater monitoring wells (MW2, MW3, MW6) to allow assessment of groundwater quality in the vicinity of the anchor points. Groundwater quality was not assessed in the proposed excavation area. Three existing groundwater monitoring wells (201, 204, 205) installed by DP in 2014, were also sampled. Groundwater monitoring wells installed within the former footprint could not be located at the time of fieldwork. Groundwater was analysed for TRH, BTEX, PAH (ultratrace), cyanide and ammonia. TBT was not analysed as part of this groundwater monitoring event, due to concentrations in soil being below LOR.

ASS samples, where possible were collected at 1 m or 2 m intervals for environmental boreholes, for field screening purposes. Samples typically targeted fill (possible dredged sediments) and natural soils. Based on field screening results, selected samples were analysed for chromium reducible sulphur suite.

7.2 Quality assurance / quality control plan

The QA/QC plan is designed to achieve predetermined data quality indicators (DQIs) that will demonstrate accuracy, precision, comparability, representativeness and completeness of the data generated. Refer to Section 6.7.1.

Samples will be transported to the following laboratories under chain of custody conditions for analysis:

- Eurofins|MGT laboratory, Lane Cove, NSW – Primary soil samples and intra-laboratory duplicates.
- ALS Environmental Services Pty Ltd, Sydney, NSW – Inter-laboratory duplicates.

These laboratories are NATA accredited for the analyses to be undertaken.

Table 6: Sampling and analysis plan

Depth Range (m)		Berth 101				Anchor Points						Berth 101																																	
Upper	Lower	BH05	BH08	BH09	BH11	GBH01	GBH02	GBH03	GBH04	GBH05	GBH06	GBH07	GBH08	GBH09	GBH10	GBH11	GBH12	GBH13	GBH14	GBH15	GBH16	GBH17	GBH18	GBH19	GBH20	GBH21	GBH22	GBH23	GBH24	GBH25	GBH26	GBH27	GBH28	GBH29	GBH30	GBH31	GBH32	GBH33	GBH34	GBH35	GBH37	GBH38	GBH39	Soil Unit*	Total Analysed
0	1				E		A/D	D			A		D	A/E	B, E	A	E						D	D		D	D	A	A		B/D			D	D			B/D	A		E	D		Fill 1	26
1	2				D	A										E	A	D	A			A				A						E	D		A		B, E				B, E				13
2	3							B	A	A								B		A										D				B					B	A			B	Fill 2	10
3	4																					B					B		B				A			A						B	B		7
4	5					A	B				A			A									A								A						A				A				8
5	6															B		F			A						F					B												Alluvial / Estuarine / Possible Alluvium	5
6	7									A		A													A																				3
7	8					A					A																																		2
8	9									A	A	A													B			A				A													6
9	10				C																A							B																	3
10	11		A																																										1
11	12																																												0
12	13																																												0
13	14																																												0
14	15																																												0
15	16	B																																											1
16	17		A	B																																									2
17	18																																												0
18	19																																												0
19	20				B																																								1
20	21	A																																											1
29	30																																												0
32	34																																												0

Legend

Testing Suite:

- A TRH, BTEX, PAH, HM
- B TRH, BTEX, PAH, HM, TBT, Cyanide, Ammonia
- C TRH, BTEX, PAH, HM, TBT, Dioxins, Cyanide, Ammonia
- D TRH, BTEX, PAH, HM, Asbestos
- E Asbestos
- F Metals

B/D Two samples analysed from depth interval

Depth of borehole

* Generalised soil unit

Fill 1: Sandy gravel / gravelly sand (coal, road base) trace slag

Fill 2: Reclaimed Sand

8. Assessment criteria

8.1 Contamination

The soil and groundwater assessment criteria that have been adopted are shown in Tables LR1 and LR2 (soil) and Table LR3 (groundwater) in Appendix D. Exceedances of these criteria do not necessarily mean that remediation is required, however they should be regarded as triggers for further assessment, (e.g. a site specific risk assessment), and/or management.

8.1.1 Soil

The assessment criteria proposed for this project were sourced from the following references:

- NEPC (1999) National Environment Protection (Assessment of Site Contamination) Amendment Measure (No. 1) 2013 (NEPM)
- Friebel and Nadebaum (2011) CRC Care Technical Report No. 10 – Health Screening Levels for Petroleum Hydrocarbons in Soil and Groundwater

The ASC NEPC (2013) presents health based investigation levels for different land uses (e.g. industrial / commercial, residential, recreational, etc.) as well as ecological investigation levels.

The site is situated within a heavy industrial area of Port Kembla. The site land use has been and will continue to be industrial.

The potential receptors include commercial/industrial site users / visitors and intrusive maintenance workers. It is expected during construction workers may be in direct contact with soil for short periods (Refer to Section 12.3).

In addition to human health risks, ecological risks also need consideration for the above land uses. The ecological risks consider contaminant impacts to vegetation and transitory wildlife. The risk to those receptors is dependent on the exposure pathway and site activities, which may degrade ecological values (e.g. a railway corridor). The majority of soils will be excavated for the berth box or be covered with structures and/or pavements, thereby eliminating the exposure pathway. The site and surrounding areas have been used for heavy industrial activities for over 50 years. As discussed in Section 12.3, site and surrounding activities have significantly reduced the potential habitat value for ecological receptors. Therefore, terrestrial ecological values are considered to be significantly degraded and are not considered to require further assessment.

Based on the likely receptors identified for this site, the following assessment criteria will be adopted for soil assessment purposes:

- Health screening level (HSL) for hydrocarbons (TRH, BTEX and naphthalene) via vapour intrusion (Table 1A(3) of NEPM HSL D) (sand)
- Health investigation level (HIL) for remaining contaminants of potential concern (Table 1A(1) of NEPM HIL D)
- Direct contact and intrusive maintenance workers screening values for petroleum hydrocarbons listed in Tables B3 and B4 (CRC Care, 2011)
- Management Limits for TRH fractions in soil (Table 1B(7) of the NEPM)

It is noted that no Australian human health criteria are available for dioxins or TBT in soils. This is discussed further in Section 10.4.2.

The assessment criteria selected are listed in Table LR1.

8.1.2 Groundwater

For any particular site, there can be a number of potential groundwater receptors. The receptors may be exposed to groundwater directly or via groundwater discharging into a nearby surface water body, which for this site is the Inner Harbour (west) and Tasman Sea (east). Table 1 discusses potential receptors and assesses the likelihood of beneficial use of groundwater based on available information. Where a receptor with beneficial use has been identified, guidelines have been adopted to afford this receptor protection and are discussed in more detail in the following sections.

Table 7: Assessment of beneficial uses of groundwater

Potential beneficial use	Plausible use	Potential beneficial use
Ecosystems / Ecological	Yes	Refer to Section 12.3
Land use	Yes	Direct contact on-site with groundwater is unlikely in day-to-day operations; however with any deep excavations that are left open for extended periods of time, groundwater may be encountered potentially creating a direct contact situation. Vapour migration from groundwater is also possible.
Drinking water	No	Based on the NSW DEC (2007) guidelines (Appendix 2, page 44), the NSW EPA regards aquatic ecosystems and drinking water as default environmental values in assessment of groundwater contamination, unless environmental values are identified in a Water Sharing Plan (WSP). The site falls outside the Greater Metropolitan Regional Groundwater WSP. TDS was not measured during this groundwater monitoring event. Electrical conductivity was measured during sampling and was between 929 µS/cm and 3,128 µS/cm. While this is not indicative of sea water, it is likely a small lens of fresh to brackish water which is perched on tidal seawater, and is not considered to be a groundwater resource. Groundwater is unlikely to be considered as a suitable drinking resource because: • Fresh water lens is likely to be highly localised and of low yield. • Town water is available. • TDS may exceed potable thresholds. • Potential risk of seawater intrusion caused by groundwater extraction.

Potential beneficial use	Plausible use	Potential beneficial use
Recreation	No	Because of ship movements and heavy industrialisation of the Inner Harbour, it is implausible that recreational activities will occur. The Tasman Sea is located east of the site, but access to these areas is restricted thus limiting the potential for recreational activities to occur in this area. However, anecdotal evidence indicates fishing activities do occur from the sea wall. Incidental exposure to sea water may occur during land-based fishing activities but this exposure would be much lower than primary recreational contact such as swimming, which is not understood to be permitted in the harbour.
Agricultural (e.g. irrigation, stockwater, etc.)	No	Other than groundwater monitoring wells installed by DP in 2014, no other groundwater bores were registered within 500 m of the site. No agricultural land use is located within 500 m of the site.

Laboratory results for groundwater samples will be compared to guidelines which afford protection to the identified receptors (human direct contact and marine water) and contained within the following references:

- ANZECC/ARMCANZ (2000)[3] Australian Water Quality Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra, October 2000. For a working harbour, 80% species protection level criteria are considered to be applicable for this highly modified environment and have been adopted.
- National Environment Protection (Assessment of Site Contamination) Measure 1999 (as amended in 2013), (NEPC 2013), National Environment Protection Council, Canberra (this document references ANZECC 2000)Verbruggen, E.M.J. (2004) Environmental Risk Limits for Mineral Oil (Total Petroleum Hydrocarbons) for the National Institute for Public Health and the Environment, Netherlands, Report Ref: RIVM report 601501021/2004.
- Friebel and Nadebaum (2011) CRC Care Technical Report No. 10 – Health Screening Levels for Petroleum Hydrocarbons in Soil and Groundwater, listed in Table 1A(4).

The assessment criteria selected are listed in Table LR3.

[3] ANZG (2018) criteria were endorsed by NSW EPA under S105 of the CLM Act on 4 September 2018. At the same time the ANZECC (2000) water quality guidelines were revoked. While the ANZG (2018) have been endorsed, AZNG (2018) authors have stated that there were not intended to be any new criteria to ANZECC 2000 at the time of publishing. However, a preliminary review of the AZNG guidelines by GHD and others has identified a number of discrepancies with ANZECC (2000) which have yet to be clarified. As such, ANZECC (2000) criteria have still been adopted for the purposes of this report until the issues with ANZG (2018) have been resolved.

8.2 Waste classification

Waste classification of site soils is undertaken in general accordance with the six step procedure for classifying waste as detailed in the Waste Classification Guidelines - Part 1: Classifying Waste (NSW EPA (2014)). Because excavated material may contain potential or actual ASS, the waste classification has also been carried out in accordance with Waste Classification Guidelines - Part 4: Acid Sulfate Soils.

Waste classification criteria adopted for this assessment are listed in Table LR4.

It is noted that no waste classification criteria are available for TBT and dioxins. Dioxin contaminated waste is subject to the Chemical Control Order in Relation to Dioxin-Contaminated Waste Materials (1986) (The Dioxin Waste CCO). This document defines dioxin contaminated waste as waste materials containing more than one part in 100 million (by weight; equivalent to 0.01 ppm, or 10 ug/kg) of dioxin. Dioxin is in turn defined as 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD).

For TBT, it is understood that the TBT waste management framework is currently under review by NSW EPA, and consequently EPA advice should be sought for TBT remediation projects or where TBT waste requires disposal.

8.3 Acid sulphate soils

The assessment and management of coastal acid sulphate soils has been based on the following:

- Acid Sulfate Soil Manual (1998) prepared by the Acid Sulfate Soil Management Advisory Committee (ASSMAC 1998).
- Dear, S-E., Ahern, C. R., O'Brien, L. E., Dobos, S. K., McElnea, A. E., Moore, N. G. & Watling, K. M., 2014. Queensland Acid Sulfate Soil Technical Manual (QASSTM): Soil Management Guidelines. Brisbane: Department of Science, Information Technology, Innovation and the Arts, Queensland Government (Dear et al 2014).

It is generally accepted that the 1998 ASSMAC Guidelines, whilst still useful as a reference document, have been superseded in terms of up to date scientific research and management practices. For this reason the Queensland guidance has been relied upon as a more definitive reference when dealing with management of coastal acid sulphate Soils (CASS) on the east coast of Australia. ASS action criteria adopted for this assessment are listed in Table 8.

Table 8: QASSTM (2014) acid sulphate soil action criteria

Soil Texture Category	Approximate Clay Content (%)	Action Criteria (>1000 tonnes)	
		Sulphur Trail Net Acidity	Acid Trail Net Acidity
		(SPOS or SCR) (%)	TAA, TPA or TSA (mol H^+/tonne)
Coarse	<5%	0.03	18
Medium	5% to 40%	0.03	18
Fine	>40%	0.03	18

Notes:

Net Acidity calculated using acid base accounting

SPOS Peroxide oxidisable sulphur

SCR Chromium reducible sulphur

TAA Total Actual Acidity

TPA Total Potential Acidity

TSA Total Sulphidic Acidity

9. Field investigations

9.1 Fieldwork

The subsurface investigations were carried out between 20 August and 25 September 2018 and site works were managed by an appropriately experienced GHD Environmental Engineer, in accordance with GHD Standard Operating Procedures.

The sampling locations were initially cleared used a suitably qualified service locator prior to excavation. Sampling locations and elevation were measured by a registered surveyor, sampling locations are shown in Figure 2. Environmental investigation borehole logs by GHD are included in Appendix E. The results of soil headspace screening are also presented on the logs. A copy of the geotechnical logs by WorleyParsons is included in Appendix H.

Thirty nine (39) boreholes, designated GBH01 to GBH39, were drilled using either a truck mounted Scout rig or trailer mounted custom Honda drilling rig.

Table 9: Summary of field investigations

Date of Fieldwork	Sampling Method	Number of Locations and Location Identification	Depth of Investigation (m)
20/08/2018 to 12/09/2018	Contamination Boreholes	38 locations – GBH01 to GBH35, GBH37, GBH38 were drilled to the intended target depth, however borehole GBH36 refused on a concrete subslab.	5.0 to 10.0
13/08/2018 to 29/09/2018	Geotechnical Boreholes	10 locations – BH01 to BH06 and BH08 to BH11 Note: Boreholes BH01 to BH06 and BH08 to BH11 were undertaken by Worley Parsons. Worley Parsons carried out opportunistic environmental sampling on behalf of GHD.	22.15 to 33.3
29/08/2018 to 07/09/2018	Well installation	Three locations – GBH02/MW2, GBH03/MW3 and GBH06/MW6	6.07 to 9.30
21/09/2018	Grab sample	PACM1 and PACM2 (fibre cement samples)	At surface
25/09/2018	Groundwater sampling	Six locations – MW2, MW3, MW6, 201, 204 and 205 Note: Boreholes 201,204 and 205 were installed by Douglas Partners in 2011	5.65 to 6.60

9.2 Soil sampling

Drilling was advanced using 100 mm solid flight augers to get through pavement or gravel hardstand. Continuous push tube sampling was used to recover samples above the groundwater table, which was between 4 m and 5 m below ground level. Thereafter, wash boring and push tube were used to recover samples. Casing was advanced for boreholes that extended below water table due to saturated sands causing the borehole to otherwise collapse.

Drilling mud, Pac L Ultra, was required to stabilise sands within the borehole once below the water level and reduce collapse. The mud was introduced into all boreholes at an approximate product to water ratio of 0.5 to 1,000 L. The boreholes were advanced using a wash boring technique to the target sample depth. A disposable push tube was then inserted into the borehole to recover an undisturbed sample. A sample of the mud in neat and mixed form were sampled and submitted to the laboratory for analysis. The purpose of sampling the product was to assess if the mud contained chemicals which would either interfere or contribute to concentrations of chemicals of potential concern. Worley Parsons used the same technique to recover opportunistic environmental samples from the geotechnical boreholes.

All environmental samples were collected with a new pair of nitrile gloves, directly from the push tube sleeve or by direct grab either directly from the side wall of borehole. A small number of samples were collected directly from the auger. Between sampling locations the augers were washed with a high pressure hose followed by brush scrubbing with a phosphate free detergent and finally rinsed with potable water. The push tube sampler was lined with a single-use polycarbonate sampling sleeve to retain the undisturbed soil sample.

Soil samples were generally collected at 1 m intervals, at major changes in stratigraphy or where evidence of odours or staining was noted (if observed). Clean, laboratory supplied 250 mL glass jars were filled with soil to the brim and immediately sealed with Teflon lined caps to lower the potential for loss of volatile contaminants. Samples were then labelled and placed directly into ice filled cooler boxes. A minimum of 50 g of soil was placed in zip lock bags for asbestos testing. A minimum sample of 100 g of soil was placed in zip lock bags for Acid Sulphate Soil testing.

The test reports, chain-of-custody (COC), and Sample Receipts are provided in Appendix F.

Soil samples for chemical analyses were collected in duplicate into zip-lock bags. The headspace above each sample was measured using a PhotoCheck Tiger PID fitted with a 10.6eV lamp and calibrated with isobutylene gas at a concentration of 100 ppm. A copy of the instrument's calibration certificate is included in Appendix G. This instrument allows rapid, semi-quantitative analysis of ionisable volatile organic compounds (VOCs) in the soil. Headspace screening results are presented on borehole logs (Appendix E).

Additional environmental samples were collected by Worley Parsons field staff who were conducting a geotechnical investigation for the same project at the time of our investigation. Worley Parsons field staff were briefed on the appropriate procedure to collect and adequately preserve samples, they were also supplied with all the necessary cleaning equipment and containers necessary to perform the task. Because Worley Parsons had geotechnical samples to collect, sometimes there was insufficient sample volume for contamination assessment. For example, ziplock bags for asbestos or PID samples could not be collected. Worleyparsons borehole logs are included in Appendix H.

9.3 Groundwater well installation and sampling

Three existing groundwater monitoring wells (201,204 and 205) identified on site had been installed at the site by Douglas Partners in 2011. For the current investigation GHD installed three additional groundwater monitoring wells (MW2, MW3 and MW6) using a trailer mounted rig; wash boring was necessary to reach the target installation depth.

For the groundwater monitoring wells installed by Douglas Partners, the lower 3 m section of the well was screened with 50 mm machine slotted, threaded PVC. Blank (unslotted) Class 18 PVC was used to case the well to ground surface. Coarse sand was placed within the well annulus to a level of between 1.0 m and 2.0 m above the top of the slotted screen, followed by an annular seal of granular bentonite pellets. Backfill was then placed to the surface. The top of the well was completed with a steel protective well monument.

For the groundwater monitoring wells installed by GHD, the lower 3 m section of the well for MW2 and MW3 and the lower 6 m for MW6 was screened with 50 mm machine slotted, Class 18, threaded PVC. Blank (unslotted) Class 18 PVC was used to case the well to ground surface. Washed coarse sand was placed within the well annulus to approximately 0.5 m above the top of the slotted screen, followed by an annular seal of granular bentonite pellets. A mixture of cuttings and sand from drilling were used to fill to within 0.3 m bgl of the surface, concrete was used to from 0.3 to 0.05 m bgl. The well was plugged using a well cap and a gatic cover was installed to make the well flush with the ground surface and to provide protection.

The location of all the wells is shown on Figure 2. The log of the well, along with well completion details, is included in Appendix E. Table 10 presents the monitoring well completion details.

Table 10: Monitoring well completion details

Location	Date Completed	Total Well Depth (m BGL)	Screen Interval From – To (m BGL)	Diameter and Type of Casing
GBH02/MW2	07/09/2018	6.07	3.07 to 6.07	50 mm Class 18
GBH03/MW3	06/09/2018	6.85	3.85 to 6.85	50 mm Class 18
GBH06/MW6	29/08/2018	9.30	3.3 to 9.30	50 mm Class 18
201	22/11/2011	6.5	3.5 to 6.50	50 mm Class 18
204	23/11/2011	6.0	3.0 to 6.0	50 mm Class 18
205	23/11/2011	7.0	4.0 to 7.0	50 mm Class 18

The groundwater monitoring wells were developed within a few days of installation. For monitoring wells MW2, MW3 and MW6 approximately 50 L, 100 L and 50 L, respectively were removed using a dedicated bailer with rapid recharge observed. For the existing wells 201 and 204, approximately 20 L was removed from each. Monitoring well 205 had approximately 15 L removed, and was observed to poor recharge during purging.

Groundwater at MW2 and MW3 was observed to have high concentrations of drilling mud present (i.e. evident by high viscosity of the purge water). Additional groundwater was purged to remove the drilling mud present at these locations. A 12 V submersible pump was used to remove an additional 950 L of water from MW3 and 450 L from MW2, at which point the groundwater viscosity reduced to normal, indicating drilling muds had been sufficiently removed. Purged groundwater was pumped into sealed tanks and taken off-site for disposal.

All wells were allowed to stabilise at least seven days prior to sampling. Standing water levels were measured and then groundwater was sampled on 25 September 2018. The potential presence of non-aqueous phase liquids (NAPL) was also checked using an oil/water interface probe prior to sampling. Typically three well volumes were removed from the wells during purging where practicable. Field water quality parameters, including temperature, pH, electrical conductivity (EC), dissolved oxygen (DO) and oxidation-reduction potential (ORP), were measured during the well purging and sampling using a calibrated water quality meter. The water quality parameters achieved stabilisation as per Table 11. A copy of the calibration certificate for the water quality meter is included in Appendix G.

The monitoring wells were developed, purged and sampled with a dedicated disposable plastic bailer. The groundwater sample was placed into appropriately preserved containers supplied by the contract laboratory. The groundwater samples for heavy metals analysis was filtered in the field with a 0.45 µm filter. The groundwater samples were immediately stored in a chest cooled with ice.

Table 11: Water quality stabilisation criteria

Parameter	Stabilisation Criteria
pH	+/- 0.05 pH Units
Electrical Conductivity	+/- 3%
Oxidation/Reduction Potential	+/- 10 millivolts
Dissolved Oxygen	+/- 10%

9.4 Field quality control sampling

Field quality control samples included:

- Collection and analysis of ten duplicate and seven triplicate soil samples. The corresponding primary samples are listed in Table 12. It is noted that duplicate and triplicate samples are not required for ASS testing, however some were collected to provide a general understanding of potential viability that may exist in materials sampled.
- Collection and analysis of one duplicate (QC1) groundwater sample, which corresponded to primary sample 201. A triplicate sample was not collected as less than ten samples were collected and analysed.
- Three laboratory prepared soil trip spikes and trip blanks were transported with the samples. A water trip spike or trip blank were not transported with groundwater samples, as volatile contaminants were not detected in soil samples or observed at groundwater well locations.
- The available water on-site was from recycled and hydrant sources. GHD was advised that the water being used for drilling was from the hydrant water supply and not the recycled water. To assess the quality of water used during drilling and, a sample from the source water was collected and designated BWS01. This sample was analysed for a broad suite of COPC including TRH, BTEX, PAH, OCP, OPP, PCB, VOCs, heavy metals and pH.Drilling mud was introduced into the borehole to stabilise the hole and facilitate sampling. The use of drilling muds was unavoidable, as sampling was required below the water table in largely non-cohesive soils. The product data sheet had limited detail in respect of drilling mud composition, therefore, samples of drilling mud, in solution (DW01) and neat (DS01) were collected and analysed for TRH, BTEX, PAH and heavy metals. A copy of the Product Data Sheet is included in Appendix I.
- A rinsate sample was not collected as the majority of samples were collected using disposable or dedicated sampling equipment to recovery soil samples. As discussed in Section 9.2, a small number of samples (i.e. less than five) were collected directly from the auger.

Table 12: Summary of duplicate and triplicate samples analysed

Sample date	Primary sample ID	Depth (m)	Duplicate	Triplicate	TRH, BTEX, PAH	Metals	Dioxin	TBT, cyanide, ammonia	ASS Field
21/08/2018	GBH28	3.8-4.0	QC4	-	✓	✓	-	-	✓
20/08/2018	GBH33	0.2-0.4	QC2	QC2a	✓	✓	-	✓	✓
20/08/2018	GBH34	0.1-0.4	QC1	-	✓	✓	-	-	-
23/08/2018	GBH32	4.1-4.2	QC7	QC7a	✓	✓	-	-	-
24/08/2018	GBH10	0.1-0.3	QC8	QC8a	✓	✓	✓	✓*	-
31/08/2018	GBH05	6.7-7.0	QC11	QC11a	✓	✓	-	-	✓
31/08/2018	GBH05	8.7-9.0	QC12	-	✓	✓	-	-	✓
7/09/2018	GBH01	1.7-2.0	QC14	QC14a	✓	✓	-	-	✓
6/09/2018	GBH04	2.7-3.0	QC13	QC13a	✓	✓	-	-	✓
11/09/2018	GBH23	9.7-10.0	QC18	QC18a	✓	✓	✓	✓	✓
Total duplicate / triplicate samples analysed					10/7	10/7	2/2	3/3	7/6
Total primary samples analysed					83	85	1	24	181

Table notes: * Insufficient sample available to perform ammonia analysis

10. Results

10.1 Subsurface conditions

Fill was encountered at all locations up to 5.5 m depth, typically comprising gravelly sand and sandy gravel (Fill Unit 1) overlying sand (probable reclaimed sand – Fill Unit 2). Natural sands, assumed to be likely alluvium, were encountered from 3.2 m, graduating to finer alluvial deposits (silts and clays) to the maximum depth of investigation. The generalised subsurface conditions encountered at the site from GHD boreholes are summarised in Table 13.

The Worley Parsons logs showed similar sub-surface conditions to those noted in the GHD boreholes. Fill was encountered at all locations up to 5.5 m depth, typically sandy gravel to gravelly sand (Fill Unit 1) overlying sand (probable reclaimed san – Fill Unit 2). Natural sands, logged as alluvial deposits, were observed from 4.1 m, graduating to finer alluvial deposits (silts and clays). Residual deposits of sandy clay and clay were logged from 12 m to 29.7 m. Bedrock is understood to have been encountered at the geotechnical boreholes from a depth of 17.6 m to 29.5 m.

Groundwater inflows were very similar between both investigations, with Worley Parsons recording groundwater inflows between 4.2 m to 5.5 m bgl. Some minor differences in colour and grain size were noted between the GHD logs and Worley Parsons logs, although this can be attributed to localised differences between the boreholes. As a whole, the site subsurface conditions are similar. A copy of the WorleyParson's geotechnical borehole logs are presented in Appendix H.

Table 13: Summary of generalised subsurface conditions

Unit	Unit Description	Borehole(s) encountered (GBH)	Depth range to base of unit (m)	Thickness of the unit (m)
Pavement	Concrete	01, 02, 03, 05, 09, 16, 19, 31	0.0 to 0.15	0.05 to 0.15
	Concrete	04[2]	0.9 to 1.0	0.1
	Asphalt	08, 10, 11, 12, 13, 26, 28, 29, 30, 32, 33, 34, 35, 37, 39	0.0 to 0.1	0.05 to 0.10
Fill **(Fill unit 1)**	Gravelly SAND, dark grey, grey, black, brown, dark brown, fine to coarse sand, fine to coarse sub-angular to angular gravel, trace to some silt, trace to some coal, trace clay, cobbles Foreign materials: slag, coal, steel, concrete and wood	01, 04, 06, 17, 18, 19, 22, 23, 25, 36	0.0 to 2.5	0.15 to 2.50
	Sandy GRAVEL, dark brown, grey, black, pale brown, pale grey, pale green, brown, fine to coarse grained angular to sub-angular gravel, fine to coarse grained sand, trace clay, silt Foreign materials: slag and coal	02, 03, 07, 08, 09, 10, 11, 12, 13, 14, 15, 16, 20, 21, 26, 28, 29, 30, 31, 32, 33, 34, 35, 37, 38	0.0 to 1.4	0.15 to 1.4
	SAND, pale green, fine to medium grained, trace silt	02, 03	0.1 to 0.4	0.25 to 0.30
	SILT, black, some fine to coarse sand, trace of fine to coarse sub-angular to sub-rounded gravel, trace of medium plasticity clay, coal reject	24, 35, 39	0.0 to 1.65	1.65
Fill (probable reclaimed sand) **(Fill unit 2)**	SAND, brown, pale brown, yellow, orange, fine to coarse grained, trace amounts of shell fragments, fine to coarse gravel, silt bands and layers, clayey sand layers, trace iron stained sand, fine black sand layers (probable heavy mineral sands), rounded to sub-rounded gravel, clay lenses and layers. Foreign materials: charcoal, wood and coal.	All boreholes except 36	0.0 to 5.5[1]	3.7 to 5.5[1]
	Clayey SAND, black, dark grey, grey, fine to coarse grained sand, medium to high plasticity clay, trace silt, shell fragments, gravel	02, 29	4.20 to 4.45	0.25
	Gravelly CLAY, black, dark grey, grey, low to medium plasticity, fine to coarse grained angular to sub-angular gravel, trace of fine to coarse grained sand	32	0.8 to 1.2	0.4
Possible Alluvium	SAND, brown, pale brown, yellow, orange, fine to coarse grained, trace amounts of shell fragments, fine to coarse gravel, silt bands and layers, clayey sand layers, trace iron stained sand, fine black sand layers (probable heavy mineral sands), rounded to sub-rounded gravel, clay lenses and layers	01, 02, 03, 05, 06, 07, 08, 09, 10, 11, 13, 15, 16, 17, 19, 20, 21, 23, 24, 26, 27, 28, 29, 30, 32, 35, 37, 39,	3.2 to 10.0	0.3 to 5.5
Alluvium / Estuarine	CLAY, brown, grey, high plasticity, trace of fine coarse grained, trace of gravel, rounded cobbles	06	9.0 to 10.0[1]	1.0[1]
	Silty SAND , dark brown, grey, brown, fine to coarse sand, trace of fine gravel, shell fragments	01, 05, 27	7.0 to 10.0[1]	0.5 to 3.0 [1]

Table Notes:

[1] Terminated in the same material/strata, true thickness unknown.

[2] Drilling occurred on construction pad comprising coal of 0.9 m to 1.0 m thick. It was constructed due to accumulation of surface runoff following a heavy rainfall, which precluded access to that area of the site. The original concrete pavement was below this constructed pad.

Foreign materials not always present in each sample

No obvious evidence of contamination such as unusual odours, oil staining or suspected asbestos containing materials (ACM) were observed during sampling.

Apart from the fill, the subsurface conditions encountered are consistent with the published geological information.

10.2 Groundwater

For this investigation groundwater inflows were encountered in all boreholes except GBH34 and GBH36 at depths between about 3.7 m and 5.0 m. GBH36 refused at 0.15 m. Where groundwater monitoring wells were not installed, boreholes were immediately backfilled on completion of the drilling. Table 14 summarises the standing water level measurement of existing wells installed by Douglas Partners in 2011, and wells installed by GHD in 2018.

Table 14: Summary of groundwater levels

Well ID	Surface Level	Groundwater Levels									
		5-Dec-11		17-Jul-12		30-Aug-18		25-Sep-18		16-Oct-18	
	m PKHD	m bgl	m PKHD	m bgl	m PKHD	m bgl	m PKHD	m bgl	m PKHD	m bgl	m PKHD
MW2	5.70	-	-	-	-	-	-	4.72	0.98	4.67	1.03
MW3	5.80	-	-	-	-	-	-	4.86	0.94	4.90	0.90
MW6	6.70	-	-	-	-	-	-	4.50	2.20	4.45	2.25
201	5.2*0	4.13*	1.07*	4.65*	0.55*	4.22	0.98	4.27	0.93	4.18	1.02
204	4.90*	3.87*	1.03*	4.35*	0.55*	3.97	0.93	4.07	0.83	4.01	0.89
205	5.40*	4.55*	0.85*	5.15*	0.25*	4.88	0.52	4.71	0.69	4.69	0.71

Table notes:

m bgl: metres below ground level

m PKHD relative level, metres Port Kembla Height Datum. PKHD is equivalent to Australian Height Datum (AHD) + 0.872 m

* Information obtained from Douglas Partners (2014)

No hydrocarbon odours were noted in groundwater during drilling or sampling at any of the wells. No evidence of NAPL was observed during groundwater sampling. No odours or sheens were noted on the surface of the groundwater from monitoring wells during purging and sampling for the remaining locations.

An inconsistency in groundwater elevation was noted at MW6 relative to other groundwater monitoring wells at the site. A GHD environmental geologist carried out another gauging event on 16 October 2018 to further assess this inconsistency. Given that depth to water below ground level was similar to other monitoring well locations and the berth was near level, it was likely that the error has occurred in survey data.

10.3 Headspace screening results

Results of the soil vapour headspace measurements are presented on the borehole logs. All soil samples screened recorded negligible readings ranging between 0.3 ppm and 3.8 ppm. This is generally consistent with field observations and the laboratory tested soil samples. This indicates that significant volatile ionisable contamination was unlikely to be present in the samples screened.

10.4 Laboratory testing

10.4.1 Data validation

Laboratory analysis

Soil samples were transported in ice-cooled chests to the following contract laboratories under chain of custody:

- Eurofins|MGT laboratory, Lane Cove, NSW – Primary soil samples and intra-laboratory duplicates.
- ALS Environmental Services Pty Ltd, Sydney, NSW – Inter-laboratory duplicates.

A copy of the chain of custody for all batches is attached. The laboratories selected to carry out analysis are NATA accredited for the analysis performed. Test methods are listed on the attached laboratory reports.

Samples were selected for analysis mainly based on geological origin of the sample material, sample location, results of the PID screening, visual and olfactory evidence of potential contamination, in order to obtain representative data for material to be excavated, as far as practicable.

Field and laboratory quality control assessment

In order to validate the accuracy and validity of soil sampling results, a range of field and laboratory quality control (QC) samples were collected and assessed during the investigation.

Based on our assessment, the following comments can be made:

- The following laboratory non-conformances that pertained to GHD samples were reported:
  - Laboratory control spikes: PAH recoveries were outside the laboratory upper control limit for sample QC8A (Batch ES1821425).
  - Laboratory duplicates: RPDs and/or inconsistencies exceeded laboratory control for several soil samples for copper, arsenic, zinc and/or nickel. This result indicates some variability in heavy metal concentrations can be expected. Heavy metal concentrations in soil were well below the assessment criteria and therefore, variability observed is unlikely to affect the conclusions of this report.
  - Matrix spikes: Cyanide recorded a recovery of 14%, which corresponded to primary soil sample GBH23/9.7-10.0 m was outside the lower control limit of 70% (batch 618151). The laboratory indicated that the low recovery was due to matrix interference, as an acceptable laboratory control spike recovery was recorded for this sample. Cyanide concentrations were below the laboratory reporting limits for all samples analysed, indicating concentrations reported in this sample appears to be generally representative of subsurface conditions.
  - Missing quality control samples: blanks, laboratory duplicates, matrix spikes and/or laboratory control spikes were not carried out for ammonia in Eurofins batches 618151,

612790, 614911 and 614912. The laboratory has been contacted regarding the omission, and has reissued with relevant quality control information.

– Raised LORs: the LORs were raised for QC8 due to matrix interference. LORs were still below adopted assessment criteria.

- Sample QC2a and some samples from batch 614911 were analysed outside the recommended holding time for TRH, BTEX, PAH and cyanide, despite having been received by the laboratory with sufficient time for analysis. Results were generally consistent with field observations and other samples analysed within holding time and not considered to materially affect report conclusions.
- Insufficient sample was available for TCLP lead and cyanide GBH39/2.2-2.4 m and QC8A, respectively. Waste classification may potentially classify as restricted solid waste due to lead concentrations exceed CT1 criterion and could not be reassessed based on TCLP results. However, based on 95% UCL results, the soil is likely to classify as general solid waste and insufficient samples have not materially affected the conclusions of this assessment. Sample QC8A was a triplicate and therefore, cyanide results are available from the corresponding primary and duplicate samples.
- Temperatures: some sample batches were received at the laboratory slightly warmer than the recommended preservation temperature of 6°C. Sample temperatures were generally less than 10°C. Eurofins indicated that ice bricks rather than ice were used in eskies to despatch samples to ALS, which resulted in warmer sample temperatures for triplicate samples. Triplicate sample temperatures were less than 13.6°C. None of the received temperature are considered to have had a material impact on the findings, noting that trip spike samples were within recovery limits.
- Field duplicates: An RPD of 64% was recorded for total PAH, which exceeded the adopted control limit (i.e. < 50% or no limit if result is less than ten times the limit of reporting). Inconsistencies were also recorded for three samples where the primary sample had PAH concentrations above the LOR whilst the duplicate did not (or vice versa) for zinc and total PAH. This result may indicate some variability in contaminant concentrations, particularly heavy metals and total PAHs, which can be expected in heterogeneous fill and depositional environments such as alluvium. This is not considered to affect the conclusions of the report as concentrations of paired samples are either well above or below the adopted assessment criteria. Field duplicate results are presented in Tables QAQC1 and QAQC2 in Appendix D.
- PID and water quality meter calibration passed and was within manufacturer’s specifications. A copy of calibration certificates are presented in Appendix G.
- Trip spike and blank results were within adopted control limits and presented in Table QAQC3 in Appendix D.

- Water and mud used during drilling:
  - – Water: TRH, BTEX, PAH, OCP, OPP, PCB were below laboratory reporting limit. For heavy metals, with the exception of copper and zinc, concentrations were close to or below the laboratory reporting limit. Higher copper and zinc concentrations may be associated with the pipework used to distribute water. Some VOC concentrations were detected by generally close to the laboratory reporting limit; and email VOCs were below the laboratory reporting limits. The source of the detectable concentrations of VOC's in tap water is unknown.
  - – Drilling muds: concentrations of copper, chromium and zinc were generally higher than those reported in fill samples and tap water. Detectable concentrations, close to the LOR, for TRH were reported. Elevated concentrations of copper and zinc, exceeding GILs, were reported in groundwater samples from both newly installed and existing monitoring wells. Additionally, chromium and TRH concentrations were below the LOR.
  - – These results suggests that the introduction of drilling mud product during sampling has not influenced groundwater or soil results.

GHD considers that the laboratory QC results are representative of the soil and groundwater conditions encountered at the locations sampled and therefore acceptable for the purposes of interpreting and verifying the analytical results of this assessment.

10.4.2 Contamination – soil analytical results

The laboratory analytical results for soil are summarised in Tables LR1 and LR2 (Appendix D). Original laboratory reports are included in Appendix F. All results were below adopted criteria with the exception of the following:

- Samples GBH09/4.2-4.4 and GBH26/4.75-4.90 m had benzo(a)pyrene (TEQ) concentrations of 150 mg/kg and 110 mg/kg, respectively, which exceed the HIL-D assessment criterion of 40 mg/kg.
- Samples GBH09/4.2-4.4 and GBH26/4.75-4.90 m had TRH F3 (>C_{16}-C_{34}) concentrations of 5,400 mg/kg and 4,100 mg/kg, respectively, which exceeds the Management Limit for this fraction of 3,500 mg/kg.
- Fibre cement samples PACM 1 and PACM 2 collected from the ground surface east of the substation were identified to contain chrysotile, amosite and/or crocidolite. Asbestos was also tested in selected soils samples. No asbestos was detected in soil samples.

Exceeding concentrations are also shown on Figure 4. Remaining COPC were either below the reporting limit or adopted assessment criteria where available.

For dioxins, there are no assessment criteria available in the NEPM. Only one sample was tested, which indicated all congeners below the limit of reporting (LOR) with the exception of OctaCDD (octachlorodibenzo p dioxin) at a concentration of 37.3 ng/kg. According to WHO (2005), the toxicity equivalency (TEQ) of OctaCDD is 0.0001 (or one ten thousandth) of TCDD, the most toxic and studied dioxin. Given that the USEPA Regional Screening Level (RSL; Region 9) for TCDD (industrial soils) is 22 ng/kg, the OctaCDD result is not considered to merit further assessment from a human health perspective.

Organotin results indicated no detectable tributyltin (TBT) with all results below LOR. Dibutyltin (DBT) and monobutyltin (MBT), which are degradation products of TBT, were up to 2.4 ug/kg and 17 ug/kg respectively. The USEPA RSLs for both DBT and TBT are orders or magnitude higher than the observed concentrations of butyltins, and as such these COPC are considered highly unlikely to represent an unacceptable health risk to identified receptors.

10.4.3 Contamination – groundwater analytical results

The laboratory analytical results for groundwater are summarised in Table LR3 (Appendix D). Original laboratory reports are included in Appendix F. The following is noted and also shown on Figure 3:

- Groundwater from each monitoring well had arsenic concentrations between 3 µg/L and 7 µg/L, which marginally exceeds ANZECC (2000) trigger value (low reliability interim working level – assuming As III) of 2.3 µg/L for marine water.
- Groundwater from each monitoring well had copper concentrations of between 2 µg/L and 100 µg/L. Concentrations exceeded the ANZECC (2000) trigger value of 8 µg/L for marine water in all wells except 201. Notably higher copper concentrations of 97 µg/L and 100 µg/L were reported in groundwater from monitoring wells 204 and MW3, respectively.
- Groundwater from monitoring wells 204 and MW3 had lead concentrations of 4 µg/L and 6 µg/L, which are below the adopted ANZECC (2000) trigger value of 12 µg/L for marine water. It is noted that concentrations are also below the 90% species protection level (6.6 ug/L) for lead.
- Groundwater from monitoring wells 204, MW2, MW3 and MW6 had nickel concentrations between 11 µg/L and 29 µg/L, which were all below the adopted ANZECC (2000) trigger value of 560 µg/L for marine water. It is noted that concentrations of nickel were also below the 90% species protection level (200 ug/L).
- Groundwater from each monitoring well had zinc concentrations between 27 µg/L and 190 µg/L. Exceedances of the adopted ANZECC (2000) trigger value of 43 µg/L for marine water were recorded in all wells except 201. The highest zinc concentrations were reported in groundwater from 204 and MW3.
- Groundwater from monitoring wells MW2 and MW3 indicated ammonia concentrations of 1,800 µg/L and 1,500 µg/L, respectively. MW2 marginally exceeds the adopted ANZECC (2000) trigger value of 1700 µg/L for marine water. Ammonia concentrations at these locations were notably higher than reported in groundwater from other monitoring wells.
- Electrical conductivity (EC) of 3,128 µS/cm was recorded during sampling groundwater from MW6, which is outside the trigger value range of 125 to 2,200 µS/cm for marine water. However, this is likely to be due to the presence of a lens of fresh water perched above marine water within the berth.
- pH values were between 7.47 and 8.48 which is outside the trigger value range of 8.0 and 8.4 pH units for marine water. As noted above, this is likely to be due to the presence of a lens of fresh water perched above marine water within the berth
- The cyanide limit of reporting was 5 µg/L, is slightly above the assessment criterion of 4 µg/L (ANZECC 2000). However, it should be noted that no soil samples contained detectable concentrations of cyanide.

Concentrations of TRH, BTEX, PAH and remaining heavy metals were either close to or below the laboratory limit, which was also below adopted assessment criteria.

10.4.4 Acid sulphate soil laboratory testing

Field Screening

The ASS field screening results are included in Appendix D and summarised in Table LR5 (Appendix D). One hundred and seventy (170) samples were tested using the ASS analysed for pH field screening test. The results are summarised below:

- Samples in a 1:5 mixture with distilled water generally indicated a pH of between 6.2 and 12 pH Units, ranging from slightly acidic to strongly alkaline. A pH less than or equal to 4.5 is likely to indicate the presence of actual acid sulphate soils (AASS).
- A final pH ranging between 2.1 and 11 pH Units following digestion with hydrogen peroxide (pH_{FOX}). Moderate to extreme effervescence was observed for 163 out of 170 samples from. No reaction was recorded for seven samples. A final pH of less than 3.5 can be indicative of potential acid sulphate soils (PASS). A pH_{FOX} of less than 3.5 was indicated in three of the 170 samples screened;
- A decrease or no change in pH was observed in 157 out of 170 samples between 0.0 and 6.1 pH units following oxidation.
- An increase in pH was observed in 23 out of 170 samples between 0.1 and 1.9 pH units following oxidation.

Further discussion of the field screening results is given in Section 11.3.

Acid sulphate soils – chromium reducible sulphur method

In order to supplement the ASS field screening results, 67 samples were submitted to the NATA accredited laboratory, for laboratory analysis using the chromium reducible sulphur method (Scr). The results were compared to the action criteria provided in the QLD (2014*) Acid Sulfate Soils Technical Manual – Soil management Guidelines* (V4.0) based on greater than 1,000 tonnes of coarse texture soils to be disturbed.

The laboratory report is included in Appendix F. The results have been summarised in Table 15.

The results are summarised below:

- Eight samples recorded a Scr result above the adopted action criteria (0.3%). The pH KCL in these samples was between 4.6 and 12.0 indicating moderately acidic to strongly alkaline conditions.
- One sample recorded a net acidity above the action criteria (0.3%). The pH KCL in these samples was between 4.6 and 6.5 indicating acidic conditions.
- The majority of the samples recorded elevated acid neutralising capacity (ANC) resulting in net acidity below the action criteria.
- Liming rates, calculated by the laboratory, in the four samples that exceeded net acidity were between 7.1 kg and 220 kg $CaCO_3$ per tonne.
- Liming rates in the remaining samples was less than 1 kg $CaCO_3$ per tonne.

Table 15: Summary of Chromium Reducible Sulphur (Scr) results

Sample ID	pH KCL	TAA (%)	Scr (%)	Net Acidity (%)	Liming Rate (kg $CaCO_3$ per tonne)
BH05 20.0-20.45	7.2	<0.02	0.012	<0.02	<1
BH09 15.15-15.25	5.5	<0.02	0.6	0.6	28
BH11 4.5-5.0	9.7	<0.02	<0.005	<0.02	<1
BH11 12.0-12.25	6.9	<0.02	0.065	<0.02	<1
BH11 18.1-18.5	6.5	<0.02	<0.005	<0.02	<1
BH11 19.6-20.0	6.0	<0.02	<0.005	<0.02	<1
GBH01 2.7-3.0	9.5	<0.02	0.007	<0.02	<1
GBH01 7.7-8.0	8.4	<0.02	<0.005	<0.02	<1
GBH02 0.4-0.6	12.0	<0.02	0.42	<0.02	<1
GBH02 4.2-4.45	8.4	<0.02	1.1	<0.02	<1
GBH02 4.8-5.0	9.7	<0.02	<0.005	<0.02	<1
GBH03 2.3-2.5	9.6	<0.02	0.007	<0.02	<1
GBH04 2.7-3.0	8.1	<0.02	<0.005	<0.02	<1
GBH05 1.7-2.7	9.4	<0.02	<0.005	<0.02	<1
GBH05 4.7-5.0	9.7	<0.02	0.008	<0.02	<1
GBH05 7.7-8.0	9.7	<0.02	0.009	<0.02	<1
GBH06 0.5-0.7	9.6	<0.02	0.008	<0.02	<1
GBH06 3.7-4.0	9.7	<0.02	<0.005	<0.02	<1
GBH06 7.7-8.0	9.8	<0.02	0.018	<0.02	<1
GBH06 9.7-10.0	7.3	<0.02	<0.005	<0.02	<1
GBH07 1.7-2.0	9.5	<0.02	0.006	<0.02	<1
GBH07 4.7-5.0	9.7	<0.02	<0.005	<0.02	<1
GBH07 8.7-9.0	8.4	<0.02	0.33	<0.02	<1
GBH08 2.2-2.4	9.6	<0.02	<0.005	<0.02	<1
GBH09 2.2-2.4	9.5	<0.02	<0.005	<0.02	<1
GBH10 4.4-4.6	10.0	<0.02	0.049	<0.02	<1
GBH11 2.1-2.3	9.5	<0.02	0.009	<0.02	<1

Sample ID	pH KCL	TAA (%)	Scr (%)	Net Acidity (%)	Liming Rate (kg $CaCO_3$ per tonne)
GBH12 1.7-2.0	9.0	<0.02	0.02	<0.02	<1
GBH13 2.7-3.0	9.6	<0.02	<0.005	<0.02	<1
GBH13 5.7-6.0	9.7	<0.02	<0.005	<0.02	<1
GBH14 2.7-3.0	9.6	<0.02	<0.005	<0.02	<1
GBH15 3.7-4.0	9.7	<0.02	<0.005	<0.02	<1
GBH16 3.7-4.0	9.8	<0.02	<0.005	<0.02	<1
GBH16 9.7-10.0	9.0	<0.02	0.041	<0.02	<1
GBH17 3.7-4.0	9.8	<0.02	0.014	<0.02	<1
GBH18 2.7-3.0	9.8	<0.02	0.012	<0.02	<1
GBH18 4.7-5.0	9.8	<0.02	0.009	<0.02	<1
GBH19 2.7-3.0	9.8	<0.02	0.008	<0.02	<1
GBH19 3.7-4.0	9.8	<0.02	0.008	<0.02	<1
GBH20 1.7-2.0	9.8	<0.02	0.010	<0.02	<1
GBH20 4.7-5.0	9.8	<0.02	0.014	<0.02	<1
GBH20 8.7-9.0	9.4	<0.02	0.017	<0.02	<1
GBH21 3.7-4.0	9.8	<0.02	0.011	<0.02	<1
GBH22 4.2-4.5	9.7	<0.02	0.015	<0.02	<1
GBH23 2.7-3.0	9.8	<0.02	0.013	<0.02	<1
GBH23 9.7-10.0	9.3	<0.02	0.066	<0.02	<1
GBH24 4.7-4.9	9.6	<0.02	0.042	<0.02	<1
GBH25 3.5-3.7	9.8	<0.02	0.013	<0.02	<1
GBH26 1.8-2.0	9.7	<0.02	0.013	<0.02	<1
GBH26 2.8-3.0	9.7	<0.02	0.011	<0.02	<1
GBH27 1.7-2.0	9.7	<0.02	<0.005	<0.02	<1
GBH27 4.7-5.0	9.8	<0.02	<0.005	<0.02	<1
GBH27 9.7-10.0	7.9	<0.02	0.011	<0.02	<1
GBH28 2.3-2.5	9.6	<0.02	0.007	<0.02	<1
GBH29 2.4-2.6	9.7	<0.02	<0.005	<0.02	<1

Sample ID	pH KCL	TAA (%)	Scr (%)	Net Acidity (%)	Liming Rate (kg $CaCO_3$ per tonne)
GBH30 3.8-4.0	9.7	<0.02	<0.005	<0.02	<1
GBH31 1.7-2.0	9.5	<0.02	0.008	<0.02	<1
GBH31 2.7-3.0	9.7	<0.02	0.006	<0.02	<1
GBH32 4.1-4.2	9.8	<0.02	<0.005	<0.02	<1
GBH33 3.8-4.0	9.8	<0.02	<0.005	<0.02	<1
GBH33 4.8-5.0	9.8	<0.02	<0.005	<0.02	<1
GBH34 0.6-0.8	9.5	<0.02	0.011	<0.02	<1
GBH34 4.8-5.0	9.7	<0.02	<0.005	<0.02	<1
GBH35 4.5-4.7	9.7	<0.02	<0.005	<0.02	<1
GBH37 2.4-2.6	9.8	<0.02	<0.005	<0.02	<1
GBH38 2.7-3.0	9.4	<0.02	0.011	<0.02	<1
GBH39 4.5-4.7	9.7	<0.02	<0.005	<0.02	<1
ACTION CRITERIA		**0.03**	**0.03**	**0.03**	

Table notes: exceeding concentrations highlighted in orange.

10.4.5 Preliminary waste classification

The laboratory results for this assessment are summarised in Table LR4 (Appendix D) and laboratory reports are included in Appendix F. GHD followed the six-step process described in Part 1 of the guidelines for assessing the classification of the soil to be excavated as part of the berth box construction. It should be noted that this classification is only for the purposed of off-site disposal, if required. According to the waste classification procedure:

- **Step 1 – Is the waste special waste?** Fragments of ACM on the ground surface classify as asbestos, and these are inferred to be from previous demolition activities. However, no asbestos was identified in any soil samples, therefore, soil is not considered to be special waste.
- **Step 2 – Is the waste liquid waste?** The material assessed is not a ‘liquid waste’ in its current form. The material should it require off-site disposal will be soil and capable of being picked up by a spade or shovel. This may need to be reassessed at the time of excavation, particularly following significant rainfall events.
- **Step 3 – Is the waste pre-classified?** The material is not pre-classified.
- **Step 4 – Does the waste possess hazardous characteristics?** The material does not possess hazardous characteristics based on the site history, observations and chemical testing as defined under the Australian Code for the Transport of Dangerous Goods by Road and Rail.
- **Step 5 - Determining a waste’s classification using chemical assessment:** The waste has been assessed using chemical analysis. The laboratory analytical results for soil are summarised in Table LR4. The following comments are made with respect to the waste classification criteria for both fill and natural materials:
  - Specific contaminant concentrations were generally below the CT1 criteria, with the exception of chromium, lead, benzo(a)pyrene and PAHs. Benzo(a)pyrene and PAHs exceeded CT2 criteria at GBH09/4.2-4.4 m and GBH26/4.75-4.9 m. With the exception of benzo(a)pyrene and PAHs at GBH09 and GBH26, all COPC concentrations were below the SCC1 criteria (with leaching). Further assessment using the toxicity characteristic leachability procedure (TCLP) confirmed that leachable concentrations of chromium and benzo(a)pyrene were below the TCLP1 criteria. However, insufficient sample remained for GBH39/2.2-2.4 m to further assess the waste classification of lead at this location.
  - Remaining COPC concentrations did not exceed CT1 criteria.
- **Step 6 - Is the waste putrescible or non-putrescible?** The material consisted predominantly of soil and thus is deemed to be non-putrescible. NSW EPA (2014) notes that materials that are generally not classified as putrescible include soils, timber, garden trimmings, agricultural, forestry and crop materials, and natural fibrous organic and vegetative materials. Based on observations by GHD, the material is considered to be non-putrescible.

Because proposed excavated material contains ASS (see Section 10.4.4, handling, treatment and disposal of ASS must be carried out in accordance with Part 4 of the waste classification guidelines (EPA 2014). ASS results are further discussed in Section 11.3.

11. Discussion

11.1 Contamination assessment

11.1.1 Soil

No observations of gross contamination in the form of strong odours, non-aqueous phase liquids, or other visual indicators were made during the investigation, suggesting that the potential for widespread gross contamination is low. The results are generally consistent with previous investigations in the Berth 101 area.

The potential constraints which have been identified are discussed in the following sections.

Carcinogenic PAHs

The only contamination detected above adopted health criteria was BaP TEQ at GBH09/4.2-4.4 (150 mg kg) and GBH26/4.75-4.9 m. (110 mg/kg).

GBH09 is in the north-eastern corner of the area to be excavated, while GBH26 is in the southern third of the site, with no obvious spatial relationship. However both exceedances were between 4 and 5 m bgl, with GBH09 labelled as "Fill" and GBH26 labelled as "Possible Alluvium". There is an overlap of approximately up to 2.5 m thickness where the interface of reclaimed sand fill and natural sands is difficult to interpret in-situ due to the similarity of the materials, and as such it is likely that the GBH26 BaP TEQ exceedance is related to fill material impacts.

No other BaP TEQ concentrations were within an order of magnitude of these two results, with the majority of results at LOR. As such it may be that these two results represent hotspots that require further investigation, noting that both concentrations are greater than 2.5 times the adopted criterion.

The potential risk posed by BaP TEQ to human health is considered to be low; at present the identified contamination is at depth and inaccessible. There will be opportunity for direct contact with the materials during excavation, stockpiling and relocation to the outer harbour for construction workers. This could be managed by:

- Adopting appropriate controls during construction (e.g. minimum personal protective equipment (PPE) requirements) documented in a construction and environmental management plan; and/or
- Carrying out bioavailability testing to test the assumptions inherent in the derivation of the BaP TEQ HIL, which are quite conservative; and/or
- Preparation of a site specific risk assessment. As construction works will be of short duration in nature it is expected that a site specific target level for BaP TEQ would be less conservative than the default HIL.

In terms of potential environmental impacts in the marine environment, BaP and the other carcinogenic PAHs are typically of very low solubility and hence environmental mobility. This is supported by the low concentrations of BaP obtained from leachability testing by TCLP, which is a much more aggressive test than environmental conditions.

Petroleum hydrocarbons

Two exceedances of NEPM Management Limits were detected during the investigation. These were co-located with the BaP TEQ exceedances noted above, and support a potential hotspot of hydrocarbon material at this locations associated with historical fill. Both exceedances were for TRH F3 (C_{16}- C_{34}) which is a heavier end hydrocarbon band often associated with oil products.

The NEPM management limits are applicable to petroleum hydrocarbon compounds only. They are applicable as screening levels following evaluation of human health and ecological risks and risks to groundwater resources. They are relevant for operating sites where significant sub-surface leakage of petroleum compounds has occurred and when decommissioning industrial and commercial sites. They have been developed to consider the following:

- formation of observable light non-aqueous phase liquids (LNAPL);
- fire and explosive hazards; and
- effects on buried infrastructure e.g. penetration of, or damage to, in-ground services by hydrocarbons.

The margin of exceedance on both results was less than two, and no visual observations of staining or NAPL were made which indicates the potential for NAPL formation is minimal. No utilities are intended to be placed within the material, and given the non-volatile nature of this fraction, the risk of fire or explosive hazard associated with these exceedances is also considered minimal.

From an environmental perspective, the TRH F3 fraction is effectively insoluble in water. The absence of any sheen at the sampled interval indicates that these exceedances are unlikely to impact the environment though any physical generation of LNAPL.

Asbestos

The ACM fragments observed are considered likely to have been remnants of the demolition of former buildings on site. No fragments or fibres were identified in the fill or underlying soils, and it is considered unlikely that asbestos is present in the fill soils, although this cannot be ruled out.

11.1.2 Groundwater

Groundwater sampling was limited to areas of the berth which will not be excavated. These locations are close to the centreline of the filled area and are likely to be less affected by tidal flux than the area to be excavated, although the entire area will be tidally influenced.

Based on electrical conductivity and pH characteristics, the installed wells appear to be intersecting a lens of fresh to brackish groundwater which is perched above the denser, saline marine water. This fresh water lens is likely to be recharged by infiltration from surface run-off, and as a result will likely be impacted by contaminants from the ground surface. The volume of perched water will be dependent on rainfall to recharge, and may not be permanently present. It is assumed that the perched water encountered outside of the excavation area will also be found in the excavation, although the lens will be thinner towards the edges.

Heavy metal concentrations in the perched water exceeded the adopted criteria for arsenic (marginally), copper (by up to an order of magnitude) and zinc (by up to five times). Ammonia concentrations also marginally exceeded the adopted criterion in one of the wells (MW2).

The excavation of Berth 101 will involve the installation of piles between the monitored groundwater wells and the excavation area. These piles will effectively act as a retaining wall which will limit the flow of perched groundwater into the maritime environment. The excavation of saturated sands from Berth 101 would also result in removal of perched groundwater in this area. As a result, the net impact of any perched groundwater discharge into the local marine environment is likely to be lessened, and will be further attenuated within the larger marine environment.

11.2 Preliminary waste classification

Based on laboratory results, we assessed the following waste classification in accordance with the NSW EPA (2014) Waste Classification Guidelines, Part 1 – Classifying Waste:

- Potential Hazardous Waste:
  - Soils in the vicinity of GBH09/4.2-4.4 m and GBH26/4.75-4.9 m exceeded CT2 and SCC2 following TCLP testing for PAH and benzo(a)pyrene, which would be indicative of hazardous waste. Concentrations of PAH and benzo(a)pyrene were much higher (by an order of magnitude) at these locations than any other. The source of PAH and benzo(a)pyrene was not apparent at the time of sampling and these samples, which are inferred to be within the base of the fill at both locations, did not appear distinctly different from soils at other borehole locations. Statistical analysis of the fill layer (UCL95) indicates that the UCL95 concentration of BaP is 9.02 mg/kg, which is below SCC1. This suggests that the fill unit could be classified as General Solid Waste with respect to benzo(a)pyrene. Statistical outputs are included in Appendix J.
  - Further investigation may be required to delineate the extent of elevated PAH and benzo(a)pyrene for health risk, at which time this classification would need to be re-assessed.
- Potential Restricted Solid Waste:
  - Lead concentrations exceeded the CT1 criterion at GBH39/2.2-2.4 m (fill unit) which would indicate a Restricted Solid Waste classification. The laboratory had insufficient sample to test this sample for TCLP lead. However, statistical assessment of the fill layer indicates that the UCL95 concentration of lead in fill is 40.59 mg/kg, which is well below CT1.
- Special Waste (Asbestos Waste):
  - The two fibre cement samples PACM1 and PACM2 contained asbestos and will therefore classify as Special Waste (Asbestos Waste). Any ACM fragments will need to be removed off-site by an appropriately licenced removalist and disposed of at a waste facility licenced to accept this waste. No ACM or fibrous asbestos was identified within soil samples. This suggests that the fill unit could be classified as General Solid Waste.
- General Solid Waste (non-putrescible):
  - Laboratory results for remaining samples indicate the samples would classify as General Solid Waste (non-putrescible).

Based on that assessment above, the preliminary waste classification assessment of fill and underlying natural materials in the event that off-site disposal to land is required, is **General Solid Waste (non-putrescible)** based on the available data.

Proposed excavated materials will contain some ASS and will need to be managed in accordance with the requirements of NSW EPA (2014) Classifying Waste: Part 4. The laboratory results indicate that the amount of ASS present within site soils and the buffering capacity, means that most of the fill and the tidal sands to at least 10 m bgl would probably be suitable for a site specific resource recovery exemption, providing contaminant concentrations do not exceed relevant criteria adopted for the exemption.

The client and nominated contractors should also note the following:

- Waste classification must be confirmed on materials excavated during the development. The preliminary waste classification does not apply to any materials not represented by the samples tested in this report. Different material types will require additional testing.
- All waste disposed off-site must be to an appropriately licenced waste facility and prior approval sought from this facility before transporting offsite. Depending on the facility, the client should allow up to seven days for this approval process.
- All waste disposal dockets must be retained.

11.3 Acid sulphate soil

The subsurface conditions indicate that there is approximately 4 m to 5 m of fill material overlying alluvial/estuarine sands and silty sands with occasional sandy clays to at least 8 m depth. Below the estuarine sands are varying layers of estuarine and alluvial clays and sands and gravels overlying residual soils and weathered rock.

11.3.1 Fill

The fill material comprises placed sands, fine coal washery reject and foreign materials such as slag, steel and concrete. The logs indicate the presence of shells and shell grit within the fill and this is shown in the laboratory results, where elevated ANC has been recorded. The water table was located generally at the base of the fill (between 4 m and 5 m depth).

The majority of the samples in the fill recorded net acidity below the action criteria (0.3%). There was one anomaly, GBH02/0.4-0.6 m, which recorded a Scr result of 0.42%. A review of the logs at this depth showed that the sample was collected in material immediately below a concrete pavement, well above the water table. It is unlikely that this material is ASS. The risk that acidic conditions will develop, should the fill be disturbed (excavated), is considered very low based on the low SCr results and the high ANC.

11.3.2 Alluvial materials

It appears that at some locations, silty sands and clays occur immediately below the fill and contain ASS (e.g. GBH02/4.2-4.45 m, GBH10/4.4-4.6m and GBH24/4.7-4.9 m). This layer does not appear to be uniform across the site.

The majority of the natural sandy material below the fill is probably tidal sands which are usually non ASS. There appears to be a large proportion of shells within these sands meaning they have some natural buffering capacity.

Lenses and pockets of finer grained silty sands can also occur within the tidal sands and these layers usually contain ASS (e.g. GBH07/8.7-9.0 m and GBH23/9.7-10.0 m). The samples collected within the finer grained silty sands had sufficient natural buffering capacity (elevated ANC) to account for the potential acidity. It is considered that the tidal sands represent a low risk of acidic conditions developing should these sediments be disturbed (e.g. excavated or dewatered).

Samples collected below about 10 m depth in BH11 indicate that some stratigraphic units below the tidal sands contain ASS with little natural buffering. These layers are typically dark grey to black, soft to firm sandy clays and loose to medium dense silty sands. Stiff to hard, dark grey and green clays have also been logged at depth and experience has shown that these layers can also contain ASS. These layers represent a high risk of acidic conditions developing should they be disturbed (e.g. excavated or dewatered).

12. Conceptual site model

A conceptual site model (CSM) is a representation of site-related information regarding contamination sources, receptors and exposure pathways between those sources and receptors. The CSM is developed using information obtained from previous investigations, site history, site observations, proposed land use and expected ground conditions. Once the contamination status is understood through the sampling and analysis process, the CSM then allows the assessor to evaluate the risk posed by the contamination to the identified receptor, and whether remediation is required to manage that risk.

12.1 Potential contamination sources and associated contaminants of potential concern

Site history information and site observations indicate a number of potentially contaminating activities have occurred at the site in Areas of Environmental Concern (AECs). These activities and potential sources of contamination include:

- On-site sources:
  - Fill used in the construction of Berth 101 and adjoining areas: Between 1956 and 1960, the Inner Harbour was dredged and the construction of Berth 101 was completed in 1964. Inner Harbour sediments may have been used in the construction of Berth 101. Previous investigations have described fill as sands, clays, gravels which include coalwash and slag. Slag is likely to have been sourced from the steelworks.
  - Electrical substation: Historically transformer oil contained PCBs. If spills occurred, soils and potentially groundwater within the substation may be impacted with TRH and PCBs. Testing undertaken by PKCT indicated that transformer oil currently used does not contain PCB and no spills have been reported. Soil sampling undertaken adjacent to the substation reported detectable concentrations of PCBs, but were below the assessment criteria for commercial/industrial sites (DP 2014).
  - Hazardous building materials: previous reports indicated that hazardous building materials including lead based paints and ACM were removed during the demolition of the transfer house and conveyors. GHD observed two fragments of ACM on the ground surface. Based on the 2008 aerial photographs, these fragments were in the vicinity of former infrastructure, which has since been removed. It is likely that the ACM fragments were associated with former buildings and infrastructure removed in 2011.
  - Underground services: numerous underground services bisect the site. A low pressure oil pipeline (Figure 2) is owned and operated by Manildra. No spills or releases have reported to have occurred within Berth 101. An ACM water pipe (Figure 2) is also located within Berth 101.

- Off-site sources:
  – UST: a former diesel UST (5 m x 30 m) was located approximately 20 m east of Berth 101 and 5 m north of the northern most anchor point. The UST is understood to have been removed in the early 1990s and at the time of removal, the tank was observed to be in good condition and there was no evidence of contamination. Soil and groundwater assessment were undertaken by DP in 2014. Concentrations of COPC were below assessment criteria and DP assessed the area as suitable for ongoing industrial land use. It is noted that the majority of soil samples did not target the base of the tank, particularly in the western half.

Associated contaminants of potential concern (COPC) were assessed to be:

- Fill material within Berth 101 and surrounding areas: TRH, BTEX, PAH, TBT, cyanide, ammonia, heavy metals and asbestos.
- Electrical substation: TRH and PCBs.
- Hazardous building materials: lead, zinc and asbestos.
- Oil and ACM pipeline: TRH, PAH and asbestos.
- UST: TRH, BTEX and PAH.

12.2 Potential exposure pathways

The primary pathways by which potential receptors could be exposed to the COPC outlined above are considered to be:

- Direct contact with contaminated soil or groundwater
- Inhalation of dust from contaminated soils
- Inhalation of vapours/gases generated by soil / groundwater contaminated by volatile and semi-volatile contaminants

12.3 Potential receptors

Based on GHD's understanding of the project, fill material from the berth is proposed to be excavated, stockpiled and then relocated to the Outer Harbour disposal site. Accordingly, the key receptors of interest include:

- Future workers: individuals involved in potential future construction and maintenance of the site and landside offloading facilities.
- Future site users: including workers and site visitors. Although the majority of Berth 101 will be excavated, the same potential for contamination will still exist, in particular fill as it extends north and east of Berth 101 and the former UST.
- Intrusive maintenance workers: carrying out repairs or installation on subsurface utilities. It is expected that minor excavation activity could occur in the future (e.g. for installation of additional services).
- Terrestrial ecological receptors: as noted above, the site and surrounding areas have been used for heavy industrial purposes for 50 to 100 years. Constructed sediment ponds could provide limited habitat for threatened species such as the Green and Golden Bell Frog, however it is likely that the species would only use these resources temporarily whilst moving between areas of better quality habitat. Detailed analysis of biodiversity values is included in Chapter 14 and Appendix H of this EIS.

- Marine ecological receptors: The relocation of the material to the Outer Harbour could facilitate the release of contaminants into the marine water column via leaching. It is noted that the tidal nature of groundwater in the Berth 101 fill materials means that existing contamination has subject to potential leaching and discharge into the Inner Harbour for decades. Detailed analysis of potential risks to marine ecology values are included in Chapter 13 and Appendix G of this EIS.

12.4 Source-pathway-receptor linkages

Based on the above and as identified in the CSM, Table 16 lists the potential Source-Pathway-Receptor (SPR) contaminant linkages that have been identified for the site.

Table 16: Source-Pathway-Receptor Linkages

Sources (Primary and secondary)	Pathway	Receptor	Potentially Complete?
Contaminated fill impacted by volatile /semi-volatile compounds (impacted by either historic or current leaks or spills from former underground infrastructure)	Volatilisation and lateral migration to outdoor air and subsequent inhalation.	Construction workers / Intrusive Maintenance Workers	No – no volatile contaminants were detected above adopted criteria.
	Direct contact (during material handling)	Construction workers / Intrusive Maintenance Workers	No – no volatile contaminants were detected above adopted criteria.
	Direct contact/ leaching	Marine environment (disposal area)	Unlikely, volatile contaminant concentrations were low in soil, and below detection in groundwater.
Contaminated fill impacted by non-volatile compounds	Direct contact (during material handling)	Construction workers / Intrusive Maintenance Workers	**Possible** – concentrations of BaP TEQ exceeded HIL-D at two locations within the fill between 4 – 5 bgl. However, material handling is likely to be of short duration, and further assessment / mitigation should address this risk.
	Direct contact/ leaching	Marine environment (disposal area)	Unlikely, contaminant concentrations in soil were generally low. While two locations indicated concentrations of BaP and PAH well above background, leachability testing of BaP was < LOR as were groundwater results.

Sources (Primary and secondary)	Pathway	Receptor	Potentially Complete?
Asbestos	Dust inhalation	Construction workers / Intrusive Maintenance Workers	Unlikely – while two fragments of asbestos were confirmed at ground surface, this is likely from historical above ground demolition. No asbestos was detected in the fill, however its potential presence cannot be discounted.
Dissolved phase volatile contaminants in groundwater	Volatilisation and lateral migration to outdoor air and subsequent inhalation.	Construction workers / Intrusive Maintenance Workers	No – no volatile contaminants were detected above adopted criteria.
Dissolved phase volatile and non-volatile contaminants in groundwater	Direct contact / incidental ingestion	Construction workers / Intrusive Maintenance Workers	Unlikely – contact with groundwater is unlikely in the deep excavation, and would be expected to be controlled by mitigation measures in a construction and environmental management plan.
	Lateral migration in groundwater.	Ecological receptor (marine environment)	Unlikely – while concentrations of some contaminants are above adopted criteria in the lens of groundwater sampled, the volume of impacted perched fresh water is likely to be small, and any discharges would be rapidly attenuated within the marine environment.

Based on review of the potential SPR linkages, it is considered that the only potentially complete linkage for the proposed redevelopment is exposure to carcinogenic PAHs in fill material by construction workers. This should be further assessed to confirm whether management will be required during redevelopment.

13. Conclusions and recommendations

Based on the scope of work undertaken, and subject to the limitations in Section 1.3, the following conclusions have been made:

13.1 Contamination

Contamination in the fill material within the area to be excavated within Berth 101 is relatively minor, and generally consistent. Only two soil samples exceeded adopted criteria; these were at GHB09 and GBH26 and were for BaP (TEQ) (health criterion) and for heavy end petroleum hydrocarbons (Management Limits) near the inferred base of fill material between 4 m to 5 m bgl. Review of potential source-pathway-linkages for this contamination indicates that it is unlikely to pose any significant constraints to the proposal, subject to further assessment of the extent of BaP TEQ hotspots and mitigation measures developed to manage potential health impacts during construction works. Potential risks to marine environmental receptors from relocation of the berth material are considered low and acceptable based on measured concentrations of contaminants.

Asbestos was identified on site in the form of fragments of ACM on the ground surface. These are assumed to be associated with historical demolition on site. No asbestos was identified in samples below the ground surface, and it is therefore unlikely that asbestos containing materials are present in the fill, although this cannot be precluded.

Some relatively minor impacts from heavy metals and ammonia were identified in a perched fresh to brackish groundwater lens within Berth 101. The size of the lens is not well understood, however, the proposed piling and excavation works will limit the amount of perched water discharging into the marine environment, which will in any event significantly attenuate the concentrations of contaminants observed in this investigation.

13.2 Preliminary waste classification

The preliminary waste classification assessment of fill and underlying natural materials in the event that off-site disposal to land is required, is General Solid Waste (non-putrescible) based on the available data. This classification was undertaken in accordance with NSW EPA (2014) Waste Classification Guidelines, Part 1 – Classifying Waste. This preliminary classification needs to be confirmed during excavation works, and is not applicable to any material types, which differ in nature from those sampled.

Proposed excavated materials will contain some ASS and will need to be managed in accordance with the requirements of NSW EPA (2014) Classifying Waste: Part 4.

13.3 Acid sulphate soils

Based on the field screening and laboratory results, ASS occurs in natural sediments below the fill (variable and to depths between 2.5 m and 5.5 m bgl) to at least 14 m depth and probably beyond, particularly where dark grey and green clays exist. Disturbance (either excavation and or dewatering) of these natural sediments will need to be carefully managed and it is recommended that an Acid Sulphate Soil Management Plan is prepared by a consultant experienced in the identification and management of ASS.

13.4 Recommendations

Based on the results of this assessment, the following is recommended:

- One or more of the following is proposed for assessing the potential risk to human health the two BaP (TEQ) hotspots identified at GHB09 and GBH26:
  - Development of a human health risk assessment for BaP (TEQ), to further refine the potential risk posed by these contaminants to future construction workers. Given the short duration of the works relative to the standard exposure assumptions in a commercial/industrial scenario, it is likely that derived site specific target levels for BaP (TEQ) would be higher than use adopted for this assessment.
  - Additional investigation to delineate the vertical and lateral extent of BaP (TEQ). The investigation would involve step out borehole locations which will target materials at depths between 4 m and 5 m, to assess if the contamination is isolated or widespread.
  - The source of BaP (TEQ) at GHB09 and GBH26 was not identified nor was there apparent evidence of this contamination present at the time of sampling. The contamination may be a characteristic of the fill material, meaning it could be randomly distributed throughout the fill matrix. Therefore, in addition to further investigation, bioavailability testing is also recommended so that the risk to human health is better understood and appropriate safety control measures can be adopted during construction. The laboratory is presently maintaining these samples pending further analysis.
- Removal of any remnant ACM fragments from the ground surface. The removal should be undertaken by a licenced removalist in accordance with relevant SafeWork NSW codes of practice. Following removal, a licenced asbestos assessor should inspect the site and provide a clearance certificate confirming removal of asbestos.
- Inclusion of an unexpected finds protocol for contamination in the Construction Environmental Management Plan (CEMP) for the work associated with construction activities.
- Preparation of an ASS Management Plan (ASSMP) be prepared so that excavated material containing ASS is appropriately managed. This will also include appropriate treatment for offsite disposal whether that be to an onshore landfill or offshore ocean disposal cell.

14. References

ANZECC/ARMCANZ (2000) Australian Water Quality Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra, October 2000.

Acid Sulfate Soil Manual (1998) prepared by the Acid Sulfate Soil Management Advisory Committee (ASSMAC 1998).

Basix Environmental Solutions (BES) (2010) Draft - Preliminary Contamination Assessment of PKCT (Report Ref: 1003 Rev D3, dated 15 February 2010). *Report incomplete with appendices and some figures missing.*

Cardno Forbes Rigby (2008) Environmental Assessment – Existing Operations & Increased Road Receival Hours for PKCT (Report Ref: 108004-02/Report 001 Rev 1, dated September 2008).

Dear, S-E., Ahern, C. R., O'Brien, L. E., Dobos, S. K., McElnea, A. E., Moore, N. G. & Watling, K. M., 2014. Queensland Acid Sulfate Soil Technical Manual (QASSTM): Soil Management Guidelines. Brisbane: Department of Science, Information Technology, Innovation and the Arts, Queensland Government (Dear et al 2014).

Department of Mineral Resources (1985) Wollongong-Port Hacking Geological Series Sheet 9029-9129, first edition.

Douglas Partners Pty Ltd (DP) Phase 1 (Desktop) Contamination Assessment, Proposed upgrade of the PKCT, Port Kembla (Report Ref: 48573.05, dated 1 December 2011).

Douglas Partners Pty Ltd (DP) (2012) Draft – Phase 1 Contamination Assessment – North, PKCT, Port Kembla, NSW (Report Ref: 48573.13, dated 28 August 2012).

Douglas Partners Pty Ltd (DP) (2012) Sampling, Analysis and Quality Plan, Proposed Upgrade PKCT, Port Kembla (Report Ref: 48573.05-2, dated January 2012).

Douglas Partners Pty Ltd (DP) (2014) Targeted Phase 2 Contamination Report, Proposed upgrade of PKCT, Port Kembla, NSW (Report Ref: 48573.06, dated 11 February 2014).

Friebel and Nadebaum (2011) CRC Care Technical Report No. 10 – Health Screening Levels for Petroleum Hydrocarbons in Soil and Groundwater, listed in Table 1A(4).

Illawarra Coal (2008) Qualitative Risk Assessment for Potential Contamination at PKCT (Ref: ICTMP0002, V. 2, dated 28/10/2008).

NEPC (1999), National Environment Protection (Assessment of Site Contamination) Measure (NEPM).

NEPC (2013) National Environmental Protection (Assessment of Site Contamination) Measure 1999, as amended in 2013, National Environment Protection Council (ASC NEPC).

NSW EPA (1995) Sampling Design Guidelines.

NSW EPA (2017) Contaminated Land Management: Guidelines for the NSW Auditor Scheme, 3rd Ed.

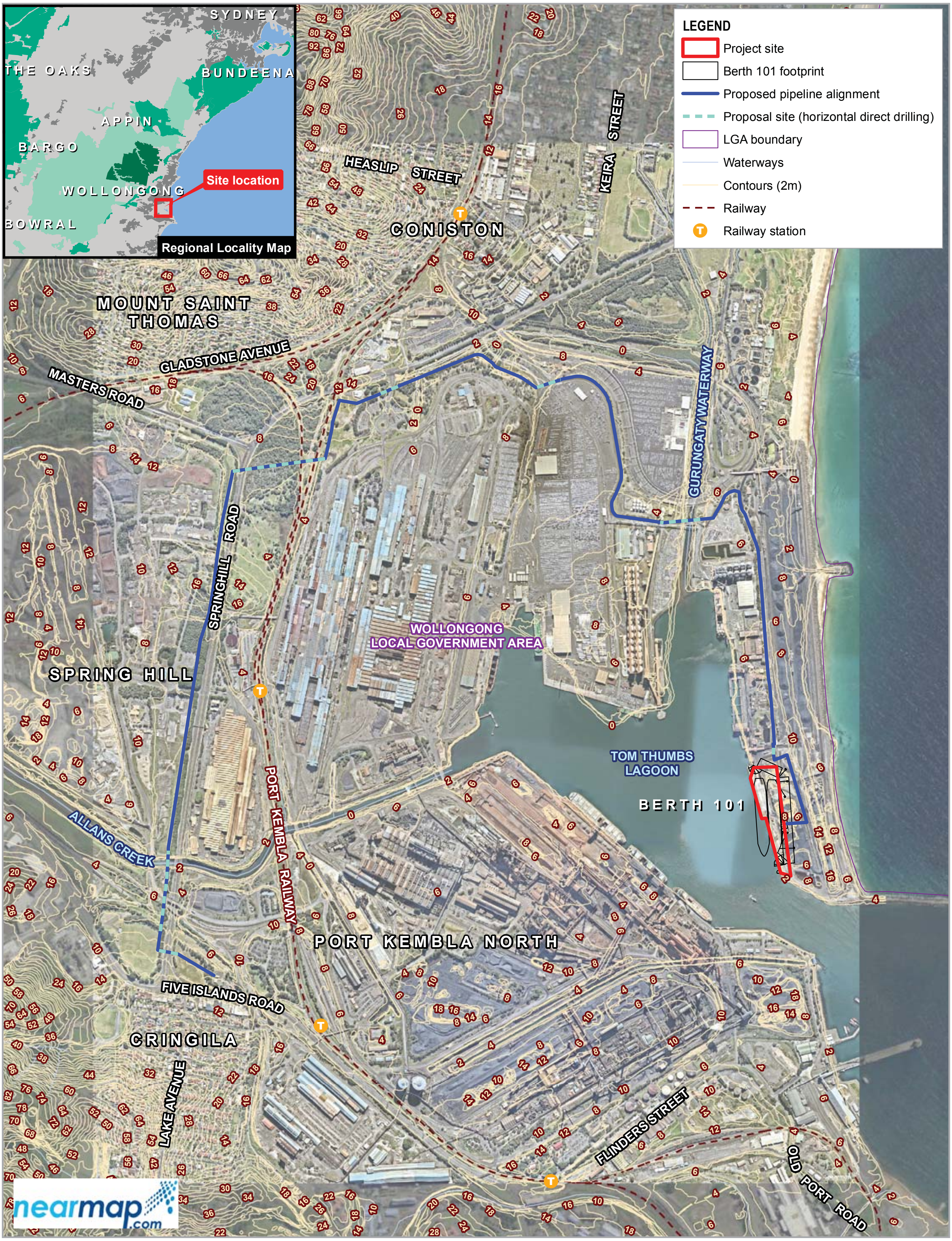
NSW EPA (2014) Waste Classification Guidelines - Part 1: Classifying Waste.

NSW EPA (2014) Waste Classification Guidelines - Part 4: Acid Sulfate Soils.

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

Port Authority of NSW (2015) Port of Port Kembla – Port Instructions, dated 4/9/2015.

Figures



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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Australian Industrial Energy
Port Kembla Gas Terminal
Preliminary Contamination Assessment
Berth 101, Port Kembla, NSW, 2505

Project No. 21-27477
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Date 29/10/2018

Site Location

FIGURE 1

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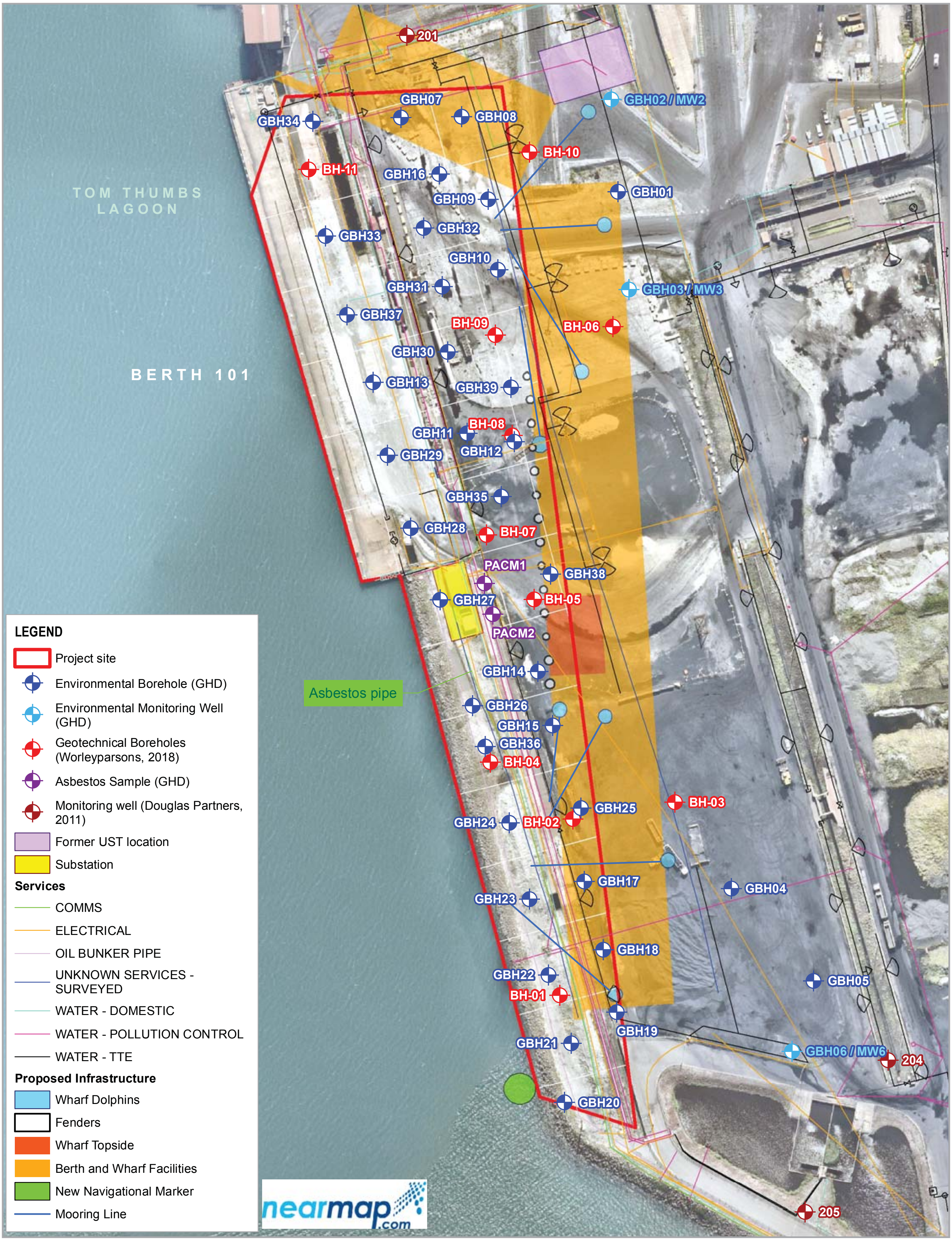
Data source: Aerial imagery - nearmap 2018 (image date 16/04/2018, date extracted 01/08/2018) & sixmaps © Department of Finance, Services & Innovation 2017; General topo - NSW LPI DTDB 2017, 2015 & 2015; Inset map - Geoscience Australia; IBRA, IBRA subregion, BioNet NSW Landscapes, wetlands, vegetation - OEH; Berth footprint - Australian Industrial Energy. Created by: jrprice



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Berth 101, Port Kembla, NSW, 2505

Site Layout Plan Showing Approximate Sampling Locations

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FIGURE 2

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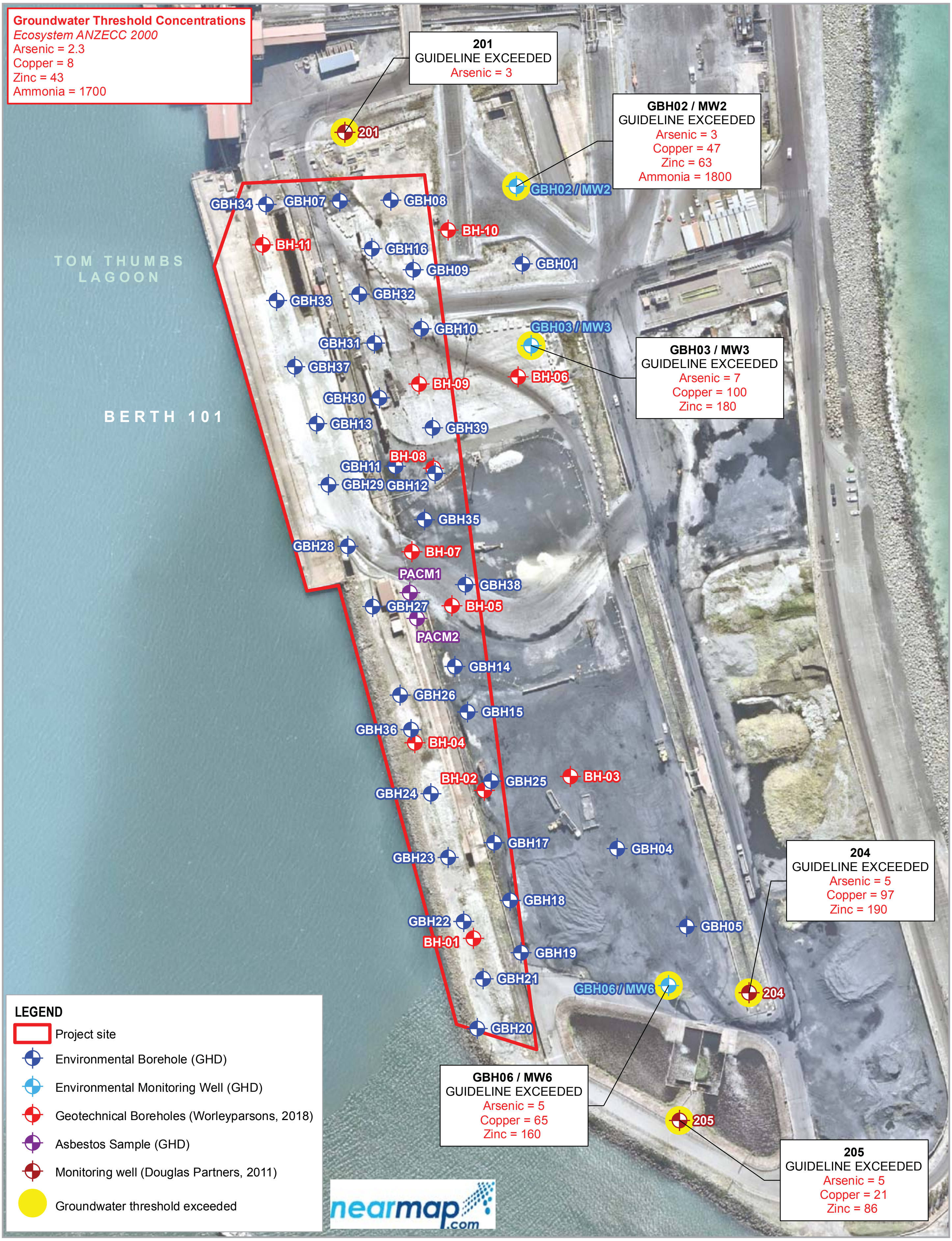
Data source: Aerial imagery - nearmap 2018 (image date 16/04/2018, date extracted 01/08/2018); General topo - NSW LPI DTDB 2017, 2015 & 2015; Berth footprint - Australian Industrial Energy. Created by: jrprice



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Groundwater Exceedances

FIGURE 3

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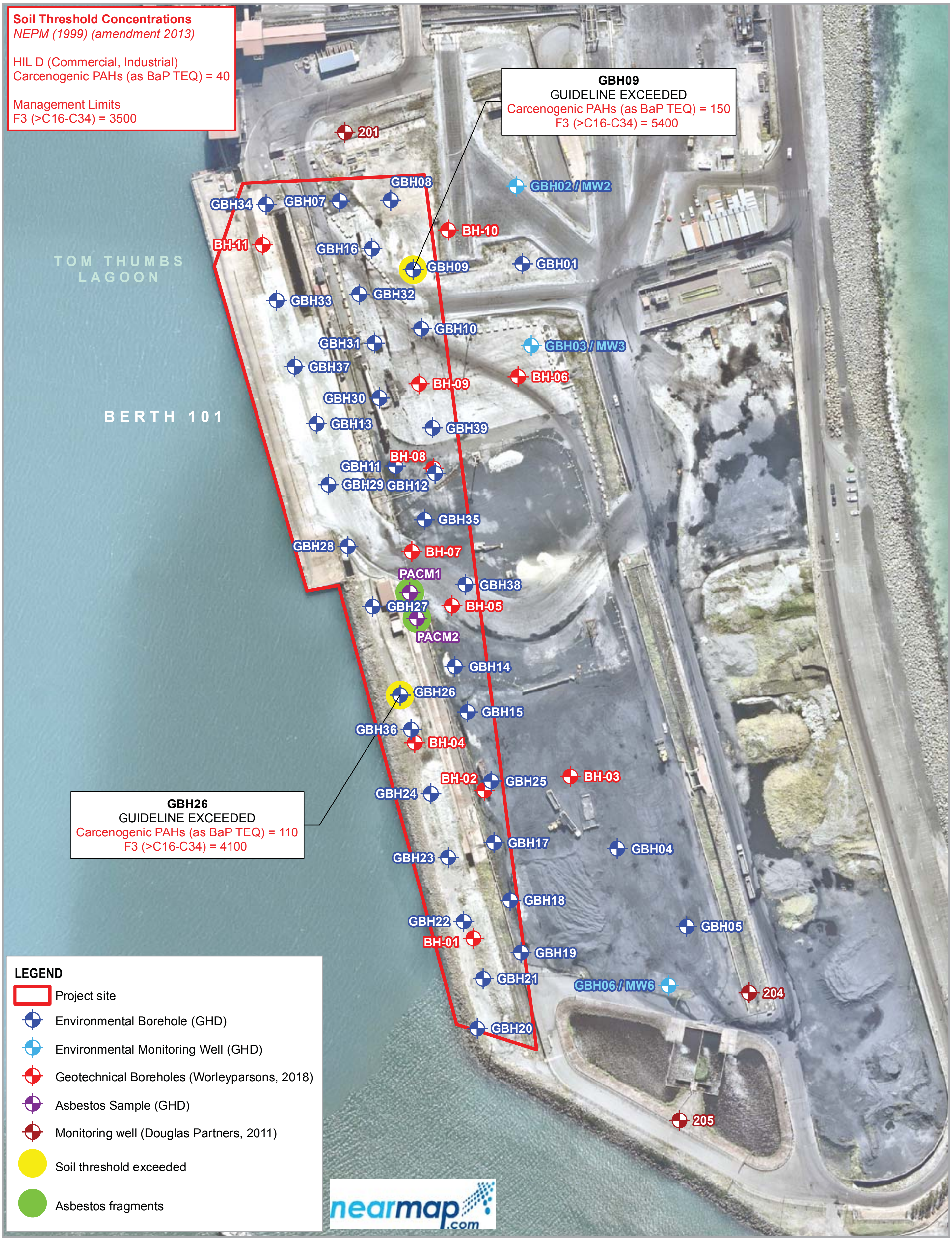

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Soil Exceedances

FIGURE 4

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