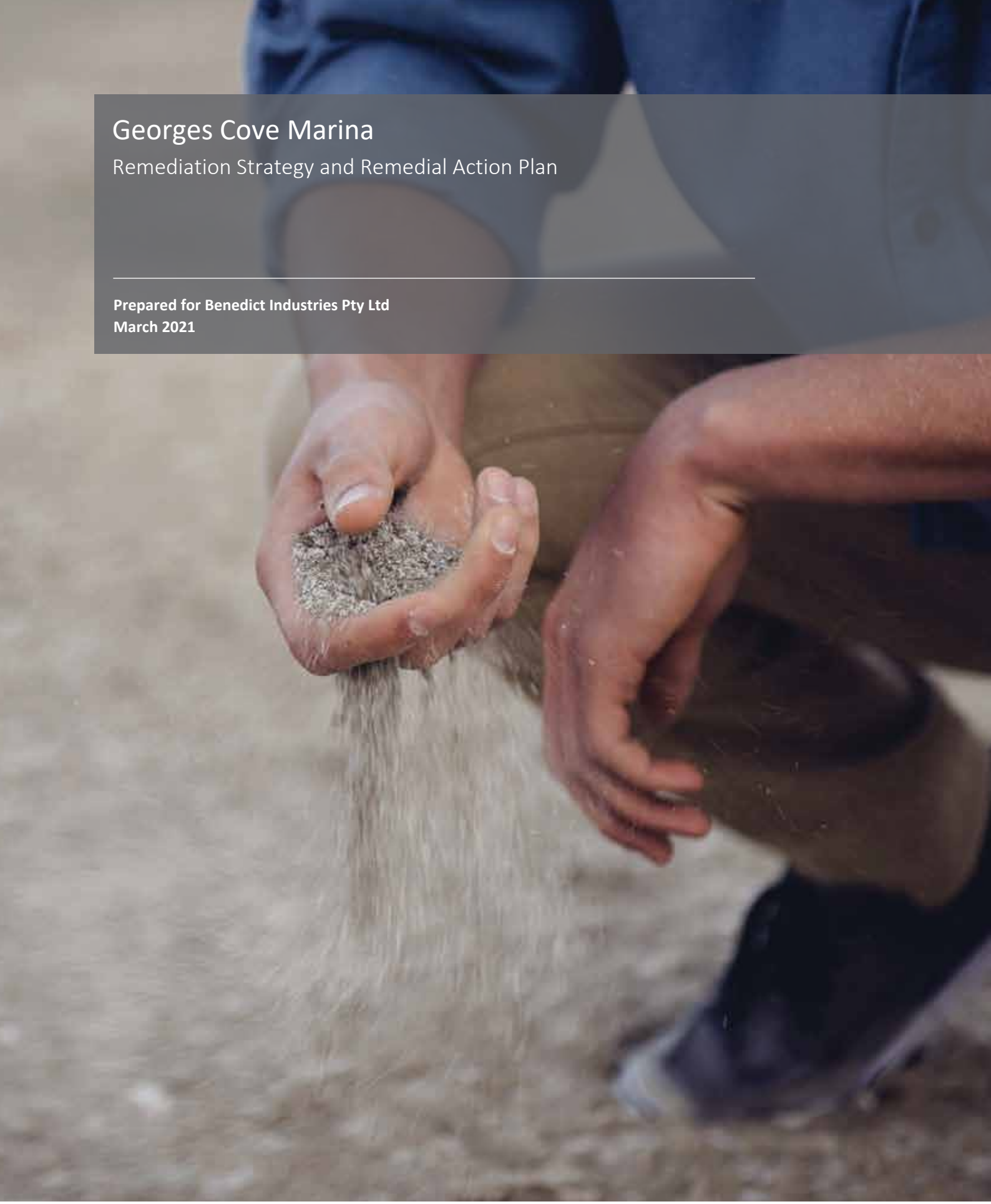
Georges Cove Marina

Remediation Strategy and Remedial Action Plan

Prepared for Benedict Industries Pty Ltd
March 2021



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Georges Cove Marina

Remediation Strategy and Remedial Action Plan

Report Number

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Client

Benedict Industries Pty Ltd

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26 March 2021

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26 March 2021

Executive Summary

EMM Consulting Pty Limited (EMM) was engaged by Benedict Industries Pty Ltd (Benedict) to prepare this Remediation Strategy and Remedial Action Plan (RAP) for the proposed Georges Cove Marina development (the 'Marina site'), comprising a 12.357 hectare (ha) parcel of land situated on the southern part of the Benedict Sand & Gravel Moorebank site ('Benedict site') at 146 Newbridge Road, Moorebank NSW 2170.

The Marina site is to be subdivided from Lot 70 to form a new Lot 3 and will be zoned RE2 'Private Recreation' and redeveloped for a mixed use marina development. Benedict and Mirvac are developing the site to the north for a residential use.

The objective of the remediation is to make the Marina site suitable for its proposed land use(s) by reducing the risk of future human and environmental receptors being exposed to soil, surface water, sediment or groundwater contaminated with contaminants of potential concern (CoPC) above the remediation acceptance criteria (RAC).

The objective of this RAP is to provide a remediation strategy and document the processes required so that the Marina site can be made suitable for the proposed land uses during future stages of development.

The overarching remedial strategy is summarised below:

- Soil – On site treatment of acid sulfate soil (ASS) and reuse/burial of suitable materials to the extent practical; off-site disposal of hotspot material and other unsuitable materials via targeted excavation and validation, capping of site with clean material to achieve design levels and finished remediated surface.

- Hazardous ground gas (HGG) –Subject to the results of additional HGG investigations, adopt a do nothing approach or, if warranted based on ongoing monitoring results, implementation of passive engineered HGG mitigation measures for proposed building structures.

- Dredge pond sediment – A combination of further assessment of sediment conditions, removal of contaminated sediment, completion of bulk earthworks and marina basin landforming including placement of infrastructure (eg piles and riprap).

- Groundwater and surface water – monitoring of dredge pond and Georges River water quality during remediation and construction to demonstrate that groundwater impacts are not occurring at the nearest sensitive receptor and that trends in improved water quality, since dredging ceased, continue and are thus not likely to impact the Georges River when the marina is opened.

The RAP has assumed that the preferred remediation strategy is to be applied across the whole site. Following completion of the detailed and additional site investigations, area specific remediation work plans (RWPs) would be prepared to detail specific requirements for each development area (eg roads and infrastructure, open space, residential and commercial and marina basin areas). The establishment of whether any groundwater and/or surface water remediation is required will be evaluated as part of the proposed validation surface water monitoring programme. The RWP's would be complimentary to this overarching RAP which provides the overarching plan and strategy for conducting remediation works at the Marina site.

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1 Introduction

1.1 Preamble

EMM Consulting Pty Limited (EMM) was engaged by Benedict Industries Pty Ltd (Benedict) to prepare this Remediation Strategy and Remedial Action Plan (RAP) for the proposed Georges Cove Marina development (the 'Marina site'), comprising a 12.357 hectare (ha) parcel of land situated on the southern part of the Benedict Sand & Gravel Moorebank site ('Benedict site') at 146 Newbridge Road, Moorebank NSW 2170.

The Benedict site is legally defined as Lot 70 in DP1254895 and located in the Liverpool City Council ('Council') local government area (LGA). The Marina site is to be subdivided from Lot 70 to form a new Lot 3 and will be zoned RE2 'Private Recreation' and redeveloped for a mixed use marina development. The location of the Marina site is shown on Figure 1.1 and current layout of the Marina site is shown on Figure 1.2.

While a RAP has previously been prepared for the Marina site (EMM, 2016b), this updated Remediation Strategy and RAP incorporates:

- Site Auditor feedback on the earlier RAP (EMM 2016), provided in a Section B Site Audit Statement (number 282, issued 27 April 2019) and address matters raised in the Site Audit Report (SAR) (Ian Swane & Associates 2019); and

- new reporting guidance which has been issued by NSW Environment Protection Authority (EPA) since the previous RAP (EMM 2016) was prepared, namely the NSW EPA (2020) Consultants Reporting on Contaminated Land Contaminated Land Guidelines.

1.2 Background

The Marina site will be zoned RE2 'Private Recreation' and is proposed to be developed for a marina, commercial and apartment buildings, with the waterway to be connected to the Georges River. Benedict and Mirvac are developing the site to the north for a residential use. The proposed layout of the Georges Cove Marina development is provided in Figure 1.3.

Information reviewed during the preparation of this document indicates the Marina site has a history of agricultural land use up to the mid-1980s, which included a dairy farm. The land use then changed to industrial when it was used as a sand quarry that involved a dredging operation. Much of the area to the north of the Marina site was then used as a solid waste landfill (non-putrescible), which filled voids created by sand extraction using mainly demolition waste and raised the elevation of the ground surface to reduce flood risks. The Marina site continued to be used for sand extraction.

From 1997, the Marina site operated as Benedict Sand and Gravel. The area to the north of the Marina site was used as a materials recycling centre, with the industrial operations including among other things quarrying, importing raw materials, fuel storage in an above ground storage tank (AST) and dumping of waste materials. The Marina site continued to be used for sand extraction.

As of 16 March 2021, the Marina site and the area to the north were not recorded as having been Declared land on the NSW EPA website[1].

[1] https://www.epa.nsw.gov.au/your-environment/contaminated-land/notified-and-regulated-contaminated-land/list-of-notified-sites

The NSW EPA website records that the combined Marina site and area to the north (previously Lot 7 in DP1065574) has been reported to the NSW EPA in 2016 or 2017 as a suspected contaminated site under the *Contaminated Land Management Act 1997* (CLM Act). A former landfill adjacent to the southern boundary of the Marina site was also reported to the NSW EPA sometime after October 2018. No other land within 200 m of the Marina site is understood to have been reported to the NSW EPA.

It is understood the Site Auditor is also undertaking statutory site audits for the area to the north of the Marina site that is to be used for a residential subdivision and a former landfill adjacent to the southern boundary of the Marina site. A Section B SAS/SAR numbered 264B and dated 23 January 2018 reviewed and approved a remediation strategy for the northern land. It is understood that no SAS/SAR has yet been issued for the former landfill adjacent to the southern boundary of the Marina site.

1.3 Objectives and scope of work

The objective of the remediation is to make the Marina site suitable for its proposed land use(s) by reducing the risk of future human and environmental receptors being exposed to soil, surface water, sediment or groundwater contaminated with contaminants of potential concern (CoPC) above the remediation acceptance criteria (RAC).

The objective of this RAP is to provide a remediation strategy and document the processes required so that the Marina site can be made suitable for the proposed land uses during future stages of development. Specific objectives for each development stage are provided in Section 11.

In accordance with the requirements outlined in NSW EPA (2020), the following scope of work was undertaken in the preparation of this RAP:

- review and summarise the findings of previous investigations and risk assessment (where applicable) previously developed for the Marina site, and present a refined conceptual site model;
- document the identified contamination risks to human health and/or the environment;
- set remediation objectives and remediation acceptance criteria (RAC) for the Marina site that ensure the remediated site will be suitable for its proposed uses with no unacceptable risk to human health or to the environment;
- confirmation of the extent of remediation required across the Marina site, or detail further investigations required during the development phase to determine the extent of remediation required;
- assess options to achieve the remediation objectives and select and justify a preferred approach, with consideration to the principles of ecologically sustainable development;
- document in detail all procedures and plans to reduce risks posed by contamination to acceptable levels for the proposed Marina site use;
- establishment of a validation procedure to ensure the remediation can be assessed as being completed in accordance with the remediation objectives;
- identify the need for and reporting requirements of remedial technology pilot trials (if applicable);
- establish the environmental safeguards required to complete the remediation in an environmentally acceptable manner, including consideration of the potential for off-site impacts (such as air quality, odour and aesthetics); and

- address contingencies and unexpected finds protocols.

This RAP has been prepared with consideration to the following key guidelines:

- NSW Department of Environment and Conservation (DECC) 2007 Guidelines for the Assessment and Management of Groundwater Contamination;
- NSW Environment Protection Authority (EPA) 1995. Sampling Design Guidelines;
- NSW EPA 2014. Waste Classification Guidelines, Part 1: Classifying Waste;
- NSW EPA 2017. Contaminated Land Management Guidelines for the NSW Site Auditor Scheme (3rd Edition);
- NSW EPA 2020. Assessment and management of hazardous ground gases Contaminated Land Guidelines
- NSW EPA 2020. Guidelines for Consultants Reporting on Contaminated Land;
- Standards Australia (2005) Australian Standard AS4482.1 - Guide to the Investigation and Sampling of sites with Potentially Contaminated Soil. Part 1: Non-volatile and Semi-Volatile Compounds;
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2018) Guidelines for Fresh and Marine Water Quality Australian and New Zealand and Australian State and Territory Governments;
- Standards Australia (1999) Australian Standard AS 4482.2 Guide to the sampling and investigation of potentially contaminated soil. Part 2: Volatile substances; and other relevant guidelines and legislation;
- National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended 2013; and
- Department of Urban Affairs and Planning. 1998. Managing Land Contamination, Planning Guidelines, SEPP 55 Remediation of Land.

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Site location

Georges Cove Marina Development
Remediation action plan

Figure 1.1

BLACKTOWN
PARRAMATTA
CHATSWOOD
SYDNEY
LIVERPOOL
SITE LOCATION
CAMPBELLTOWN
CRONULLA

NEWBRIDGE ROAD
DAWY ROBINSON DRIVE
ARALUEN AVENUE
BRICKMAKERS DRIVE
DREDGE POND
Georges River
N

KEY

- Western drainage channel
- Marina site (investigation site boundary)
- Northern portion of Lot 7
- Lot 7 'Benedict site'

0 50 100 150 m

GDA 1994 MGA Zone 56

Source: EMM (2015); GA (2015)

T:\Jobs\2014\J14149 - 146 Newbridge Road Moorebank\GIS\02_Maps\RAP001_SiteBoundary_20160311_01.mxd 11/03/2016

EMM

Site layout

Georges Cove Marina Development
Remediation action plan

Figure 1.2

EMM

Proposed development layout

Georges Cove Marina
Remediation action plan
Figure 1.3

2 Site identification

Marina site identification data is summarised in Table 2.1.

Table 2.1 Marina site identification

Item	Description
Marina site Owner	Tanlane Pty Ltd
Marina site Occupier	Benedict Pty Ltd
Marina site Address	Southern portion of the site at 146 Newbridge Road, Moorebank NSW 2170
Legal Description (Lot and DP)	Part Lot 70 DP 1254895
Local Government Authority	Liverpool City Council
Zoning and future development use	The Marina site will be zoned RE2 'Private Recreation'
Current Land Use	Benedict sand and gravel – disused quarry
Proposed Land Use	Mixed use marina development, with the marina basin to be connected to the Georges River
Geographical Coordinates (AMG)	-33.9336, 150.9658 (approximate to centre of Marina site)
Marina site Elevation	2–8 metres Australian Height Datum (m AHD) (source: Google Earth)
Marina site Area (refer to Figure 1.2)	Approximately 13 hectares (ha)
Marina site Location and Layout	Figure 1.2

3 Proposed development

The Environmental Impact Statement (EIS) previously completed for the proposed development (EMM 2018) describes the project and including the following main elements:

1. The Maritime Building, located near the western boundary of the Marina site. This structure will house:
    a) a dry berth facility providing 250 berths for small craft;
    b) a function centre;
    c) tourist, entertainment and recreational and club facilities; and
    d) an above ground petrol tank (approximately 60 kilolitres (kL)) and an above ground diesel tank (approximately 60 kL).
2. A wet berth facility for 186 small craft (including casual berths), which will consist of:
    a) a marina basin;
    b) rock protection of the basin;
    c) public recreational facilities on the internal foreshore, including bike paths, barbeque facilities and shelters;
    d) floating berths and walkways;
    e) fuel pumping facilities;
    f) sewage pump out facilities; and
    g) emergency berth access.
3. Three external car parking areas and basement carparking, providing a total of 637 car spaces.
4. A Private Marina Clubhouse on the northern portion of the RE2 (private recreation) zoned land.
5. Support infrastructure, such as water, power and sewerage.

Further details for each element are included in the EIS. The development will utilise the existing dredge pond as the basis of the final marina basin. Cut and fill will be required to create the final marina layout as indicated on Figure 3.1[2]. This includes removal of current land areas at the central eastern and south western portions of the Marina site, as well as filling in the central-western portion and south-eastern corner of the existing dredge pond. Additionally, the marina basin will be opened to the Georges River on the eastern boundary of the Marina site.

Existing stockpiles and part of a fill mound at the southern end of the Marina site may require removal in order to provide a level topography for the development. A detailed design and final earthworks plan has not yet been developed.

[2] Note Figure 3.1 uses recent Nearmap aerial imagery. Earlier figures use aerial imagery from 2015.

Source: EMM (2021); Nearmap (2021); DFSI (2017)

KEY

- Subject site
- Cadastral boundary
- Current land to become water
- Current water to become land

Proposed areas of cut and fill

Georges Cove Marina
Figure 3.1

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4 Assessment and approval process

4.1 Planning approvals

The planning regime to guide the future redevelopment of the Marina site is established by the:

- *Environmental Planning and Assessment Act 1979*;
- State Environmental Planning Policy (SEPP) No 55 – Remediation of Land (SEPP 55);
- SEPP (Infrastructure) 2007;
- SEPP (State and Regional Development), 2011; and
- Liverpool Local Environment Plan, 2008.

4.2 Legislation relevant to remediation works

The NSW EPA administers a number of Acts and legislative instruments relevant to the remediation works. These include:

- *Contaminated Land Management Act 1997* (CLM Act);
- *Contaminated Land Management Amendment Act 2008*; and
- the *Protection of the Environment Operations (POEO) Act 1997*, in particular, licensing obligations under that Act; and
- SEPP 55 – Remediation of Land.

4.2.1 Contaminated Land Management Act 1997

The CLM Act is the primary Act under which contaminated land is regulated by the NSW EPA. Relevant legislation relating to the CLM Act includes the Contaminated Land Management Regulation 2013 and the *Contaminated Land Management Amendment Act 2008*. EMM notes that the majority of the provisions in the amending Act commenced on proclamation on 1 July 2009.

This RAP addresses the following aspects of the Act:

- determination and suitability of a contaminated site for a proposed use including the generation of remediation criteria;
- existing orders and regulatory instruments applicable to the Marina site; and
- voluntary remediation proposals and agreements.

The Guidelines for the Contamination Land Management Guidelines for the NSW Site Auditor Scheme (3rd Edition) (The Auditor Guidelines) (NSW EPA 2017) were prepared by the NSW EPA under the CLM Act (1997). The Auditor Guidelines (NSW EPA 2017) describe a decision process for assessing urban redevelopment sites that should be followed by contaminated land consultants.

4.2.2 CLM Amendment Act 2008

The majority of the provisions in the amending CLM Act (2008) commenced on 1 July 2009. The purpose of the amendments was to allow contaminated sites to be cleaned up more efficiently while reinforcing the 'polluter pays' principle. The key amendments to the Act included:

- introducing new powers to enable NSW EPA to require certain persons to carry out a preliminary investigation of site contamination;
- amalgamation of the investigation and remediation stages into a single 'management' stage that can cover investigation, remediation or both;
- removing the concept of 'significant risk of harm';
- enabling NSW EPA to declare land to be 'significantly contaminated land' if it has reason to believe that land is contaminated and the contamination is significant enough to warrant regulation;
- enabling management orders to be issued to any one or more persons who are responsible for the contamination of land;
- enabling NSW EPA to issue a management order or to withdraw its approval of a voluntary management proposal that has not delivered a satisfactory outcome in managing contamination;
- provision of a more objective basis for the duty to notify NSW EPA of contaminated land based on criteria to be listed in new guidelines; and
- requiring landowners and persons carrying out certain activities to notify NSW EPA of contamination when it becomes aware of that contamination.

4.2.3 Protection of the Environment Operations Act 1997

Section 48 of the POEO Act requires a person to obtain a licence from the NSW EPA before carrying out any of the premises-based activities described in Schedule 1 of that Act.

Schedule 1 includes the following activity:

> Contaminated soil treatment works for on-site or off-site treatment (including, in either case, incineration or storage of contaminated soil but excluding excavation for treatment at another site) that:
>
> (1) handle more than 1,000 cubic metres per year of contaminated soil not originating from the site on which the works are located; or
>
> (2) handle contaminated soil originating exclusively from the site on which the works are located; and
>
> (a) incinerate more than 1,000 cubic metres per year of contaminated soil, or
>
> (b) treat otherwise than by incineration and store more than 30,000 cubic metres of contaminated soil, or
>
> (c) disturb more than an aggregate area of 3 hectares of contaminated soil.

The remediation works for the Marina site involving the management of contaminated soil originating from the Marina site only, is not likely to involve the treatment of more than 30,000 m^3 of contaminated soil and is not likely to involve disturbance of an aggregate area of 3 ha of contaminated soil. If soil treatment works are required, an Environment Protection License (EPL) licence would be required under the POEO Act. The site currently holds an EPL and has conducted water testing across the site for approximately 25 years.

The NSW EPA's General Terms of Approval for the Marina site issued 19 February 2020 recommend that the construction is managed through a Scheduled Development Works licence issued under the POEO Act.

4.2.4 State Environmental Planning Policy 55 – Remediation of Land

The remediation works require Development Consent (ie Category 1 remediation work).

Clause 9 of SEPP 55 defines Category 1 remediation works as:

a) Designated development; or

b) Being carried out or to be carried out on land declared to be critical habitat; or

c) Likely to have significant effect on a critical habitat or a threatened species, population or ecological community; or

d) Development for which another State environmental policy or regional environmental plan requires development consent; or

e) Carried out or to be carried out in an area or zone to which any classifications to the following effect apply under an environmental planning instrument -

i) coastal protection;

ii) conservation or heritage conservation;

iii) habitat area, habitat protection area, habitat or wildlife corridor;

iv) environment protection;

v) escarpment, escarpment protection or escarpment preservation;

vi) floodway;

vii) littoral rainforest;

viii) nature reserve;

ix) scenic area or scenic protection; and

x) wetland.

It should be noted that a site is not classified by an environmental planning instrument for conservation or heritage conservation if:

- "carried out or to be carried out on any land in a manner that does not comply with a policy made under the contaminated land planning guidelines by the council for any local government area in which the land is situated".

All other remediation work may be carried out without development consent and is known as Category 2 remediation work. The remediation works at the Marina site will need to comply with the provisions of SEPP 55 where appropriate.

5 Site history

5.1 Previous investigations

EMM is aware of a number of reports relating to the Marina site that has informed the understanding of site conditions and the development of the remedial strategy:

- Douglas Partners (24 June 1999) "Proposed Environmental Monitoring Program, Sorting, Recovery and Transfer (SRT) Facility, 146 Newbridge Road, Moorebank". Document No: 27879 prepared for Benedict Reclamations.

- Douglas Partners (May 2002) "Report on Preliminary Contamination Assessment, Proposed Residential Development,146 Newbridge Road, Moorebank". Document No: 43479 prepared for Benedict Sand and Gravel.

- EIS (June 2009) "Environmental Site Assessment for Proposed Earthworks at Lot 6 DP1065574 Newbridge Road, Moorebank". Document E22833K-GWRPT prepared for Concrete Recyclers Pty Ltd EIS (July 2010) "Groundwater Assessment for Proposed Earthworks for New Concrete Recycling Plant at Lot 6 DP1065574 Newbridge Road, Moorebank". Document E22833K rpt3 prepared for Concrete Recyclers.

- EIS (July 2010) "Groundwater Assessment for Proposed Earthworks for New Concrete Recycling Plant at Lot 6 DP1065574 Newbridge Road, Moorebank". Document E22833K rpt3 prepared for Concrete Recyclers.

- EIS (19 December 2013) "Report to Benedict Industries Pty Ltd on Stage 1 Environmental Site Assessment for Proposed Residential Development at 146 Newbridge Road, Moorebank, NSW". Document No: E26930KBrpt.

- EMM (28 July 2015) "Preliminary Investigation of Contamination, Proposed Georges Cove Marina". Document No: J14149RP1 prepared for Benedict Industries.

- EMM (11 March 2016) "Supplementary Preliminary Investigation, Proposed Georges Cove Marina" Document No: J14149RP1 prepared for Benedict Industries.

- EMM (11 March 2016b) "Remediation Action Plan, Proposed Georges Cove Marina". Document No: J14149RP1 prepared for Benedict Industries.

- Douglas Partners (2 September 2016) "Detailed Site Investigation, Proposed Residential Development, 146 Newbridge Road, Moorebank". Document No: 71459.03 prepared for Benedict Industries.

- Douglas Partners (17 March 2017) "Groundwater Data Review, Proposed Residential Development, 146 Newbridge Road, Moorebank". Document No: 71459.06 prepared for Benedict Industries.

- Douglas Partners (15 December 2017) "Remedial Action Plan, Proposed Residential Development, 146 Newbridge Road, Moorebank". Document No: 71459.06 (Revision 5) prepared for Benedict Industries Pty Ltd.

- Douglas Partners (28 May 2018) "Preliminary Site Investigation, Proposed Rezoning (Area 1) and Georges Cove Marina (Area 2), 146 Newbridge Road, Moorebank". Document 71459.10 prepared for Mirvac Homes NSW Pty Ltd and Tanlane Pty Ltd.

- EMM (4 July 2018) “Environmental Impact Statement Addendum, Georges Cove Marina, Volume 1 – Main report”. Prepared for Benedict Industries Pty Ltd.

- Douglas Partners (31 August 2018) “Landfill Gas Monitoring Events, Oct & Dec 2017, Feb, Apr & Aug 2018, Proposed Residential Development, 146 Newbridge Road, Moorebank”. Document No: 71459.09.R.011.Rev0 prepared for Benedict Industries Pty Ltd.

- Douglas Partners (6 September 2018) “Surface Water Sampling, Proposed Residential Development, 146 Newbridge Road, Moorebank”. Document No: 71459.09.R.014.Rev1 prepared for Benedict Industries Pty Ltd.

- Douglas Partners (17 September 2018) “Data Summary Report, Proposed Residential Development, 146 Newbridge Road, Moorebank”. Document No: 71459.09 prepared for Benedict Industries Pty Ltd.

- EMM (14 November 2018) Email providing ammonia monitoring results for dredge pond.

- Douglas Partners (April 2020) ‘Report on Landfill Gas Monitoring, Benedict Sands, 146 Newbridge Road, Moorebank’.

Other documents of relevance to the Marina site include the following:

- Liverpool City Council (29 August 2008) “Liverpool Local Environmental Plan 2008, Acid sulfate soil map – sheet ASS-014 and sheet ASS-015”.

- Liverpool City Council (29 August 2008) “Liverpool Local Environmental Plan 2008, Urban release area map – sheet URA-014 and sheet URA-015”.

- Liverpool City Council (1 September 2017 & 19 April 2013) “Liverpool Local Environmental Plan 2008, Land zoning map – sheet LZN-014 and sheet LZN-015”.

- Liverpool City Council (17 August 2012 & 19 April 2013) “Liverpool Local Environmental Plan 2008, Environmentally significant land map – sheet ESL-014 and sheet ESL-015”.

- Liverpool City Council (11 June 2015) “Liverpool Local Environmental Plan 2008, Flood planning area map – sheet FLD-014 and sheet FLD-015”.

- Matthew Freeburn (22 August 2013) “Plan Showing Levels, Contours and Stockpile Volumes as at 20-08-13, 146 Newbridge Road, Moorebank”. Drawing No: CC6-SURVEY4-32825 EPA 20-08-13.

- JMD Development Consultants (24 January 2017) Drawing “Plan of Existing Features Over Stage 1, Moorebank Cove – Stage 2, Newbridge Road, Moorebank”. Drawing No: 14005-DS1 prepared for Mirvac Homes.

- Ian Swane & Associates (23 January 2018) “Site Audit Report, Site Audit 264B by Dr Ian Swane, Review of Remediation Strategy for Residential Development at 146 Newbridge Road, Moorebank NSW 2170” (includes site audit statement).

- Alyazichi Y.M., Jones B.G., McLean E.J., Pease J and Brown H (2017) ‘Geochemical assessment of trace element pollution in surface sediments from the Georges River, Southern Sydney, Australia’. Archives of Environmental Contamination and Toxicology, 72 (2), 247-259.

- Liverpool City Council (25 October 2018) Email from Boris Santana, Senior Development Planner, titled 'Georges Cove Marina consultation with RMS' including a copy of updated SEAR 912.

5.2 Analytical results summary

Analytical results for the Marina site have been obtained through several intrusive investigations undertaken over a 20-year period between 1999 and 2018. The scope of work and methodologies adopted to undertake the Marina site investigations varied significantly over this period.

The following key previous intrusive contamination assessments undertaken at the property have been identified (herein referred to collectively as the 'previous investigations'):

- Douglas Partners (DP) 1999, Proposed Environmental Monitoring Program, Sorting, Recovery and Transfer (SRT) Facility, 146 Newbridge Road, Moorebank (herein referred to as the 1999 ESA).
- EMM 2015 Preliminary Investigation (PI) of Contamination, Proposed Georges Cove Marina.
- EMM 2016 Supplementary Preliminary Investigation (SPI), Proposed Georges Cove Marina.
- DP 2018, Preliminary Site Investigation (PSI), Proposed Rezoning (Area 1) and Georges Cove Marina (Area 2), Proposed Residential Development, 146 Newbridge Road, Moorebank (herein referred to as the 2018 ESA).
- Douglas Partners (April 2020) 'Report on Landfill Gas Monitoring, Benedict Sands, 146 Newbridge Road, Moorebank'.

It was stated in the EMM (2015) PI that several other investigations had been undertaken at the Marina site. The data provided by these investigations were considered to be outdated as they focused on groundwater and surface water quality and were conducted more than 10 years ago. These investigations comprised:

- Dames & Moore 1994, Report on Hydrogeological Investigations for Pollution Control Approval.
- Dames & Moore 1994, Report on Groundwater Sampling.
- Worley Parsons 2010, Preliminary Marina Concept Design and Environmental Assessment.
- Marine Pollution Research 2010, Aquatic Ecology Aspects & Environmental Assessment of Marine Concept Design.

The previous investigations adopted a range of soil investigation levels (SILs), comprising EMM 2015 PI – Residential B, EMM 2016 SPI – Residential B, and DP 2018 PSI – Residential A. For the purpose of consistency in the document review, the adopted guidelines were based the most sensitive of these land uses, being:

- Recreational/open space 'C' Health Investigation Levels (HILs) for most contaminants of concern and exposure pathways;
- Residential – high density/minimal opportunity for soil access 'B' HILs for petroleum hydrocarbon vapour intrusion; and

- Residential B and Recreational C Ecological Investigation Levels (EILs) adopted by site audit SAR 264B for the north Benedict site[3].

Figure 5.1 outlines sampling locations on the site layout from the previous EMM investigations and historical data.

5.2.1 Soil

The previous investigations encompassed a total of 27 test pit and borehole locations, across shallow soils, fill material and natural soils. It is understood that much of the Marina site was covered by fill, typically consisting of a mixture of silty sand or clay with gravel and mixed refuse fragments (including plastic, pipe, bricks, concrete, plastic, tyres, glass, tiles, wood, ACM, metal, charcoal and terracotta). The average depth of fill was reported to be 2.5 m but it is known to extend to at least 4 m in some locations (EMM 2016). It is noted that material thickness was not determined at seven of the sample locations.

The EMM 2015 PI and the DP 2018 PSI collected samples of shallow soil (0–0.5 m) and fill material from 12 discrete locations across the onshore areas of the Marina site, reporting:

- heavy metals, total recoverable hydrocarbons (TRH), benzene, toluene, ethylbenzene and xylenes (BTEX), polycyclic aromatic hydrocarbons (PAH) and polychlorinated biphenyl (PCB) concentrations were all below the adopted HILs and EILs;
- organochlorine and organophosphorus pesticides (OCP/OPP) and phenolics were below the laboratory limit of reporting (LOR);
- no evidence of odorous/stained soil was reported, with PID screening tests measuring low concentrations (< 10 parts per million (ppm)) consistent with typical background levels;
- fragments of bonded asbestos were identified in fill in the two test pits (TP101 and TP102) excavated by Douglas Partners in 2018, however there were no free asbestos fibres detected;
- the EMM 2015 PI collected samples of natural soil underlying fill from five locations across the onshore areas of the Marina site. The following results were reported:
    - heavy metals were below the HILs and EILs;
    - petroleum hydrocarbons, PAH, PCB and OCP/OPP were below the laboratory limit of reporting (LOR); and
    - no evidence of odorous/stained soil was reported, with PID screening tests measuring low concentrations (<10 ppm) consistent with typical background levels.

5.2.2 Sediment

The previous investigations (EMM (2015) PI and EMM (2016) SPI) presented the results of sampling undertaken within shallow sediments in the dredge pond at 16 sampling locations, including assessment against the Revision of the Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand (ANZECC/ARMCANZ) Sediment Quality Guidelines (CSIRO 2013). The following findings were noted:

[3] Ian Swane & Associates (23 January 2018) "Site Audit Report, Site Audit 264B by Dr Ian Swane, Review of Remediation Strategy for Residential Development at 146 Newbridge Road, Moorebank NSW 2170" (includes site audit statement)

- the material was described as silt, with trace to some sand, and was likely to have been deposited during dredging operations when the fine fraction was returned to the dredge pond and allowed to settle;
- no evidence of odours or anthropogenic material in sediment was reported in the previous investigations;
- arsenic, cadmium, chromium and nickel concentrations did not exceed the adopted sediment criteria (CSIRO 2013);
- copper, lead, mercury and zinc exceeded the criteria including 95% UCL average concentrations;
- petroleum hydrocarbon concentrations were measured below the criteria at most sample locations (10 of 16). No individual sample concentration exceeded the criteria but the 95% UCL average concentration was above the adopted guidelines;
- PAH concentrations were reported below the criteria; and
- PCB and OCP concentrations were reported below the LOR.

Sources of elevated contaminant levels in the dredge pond sediments are likely to include runoff from the urban and industrial catchment into the unlined stormwater drain along the western boundary of the Marina site boundary, which previously discharged onto the site and attached itself to the fine-grained sediment. As the sand was removed from site via dredging, the contaminants that were bound to the fine-grained sediment would have been concentrated.

Shallow sediments in the dredge pond are considered likely to be contaminated by nutrients such as ammonia at concentrations that exceed background levels in the Georges River. This is because ammonia concentrations were measured at 2.4–48.6 milligrams per kilogram (mg/kg), with higher ammonia concentrations associated with higher organic carbon levels.

5.2.3 Groundwater

The following findings were noted from review of previous reports which included assessment against the most recent guidelines (Australian New Zealand Guidelines (ANZG) 2018 water quality criteria and the National Health and Medical Research Council (NHMRC) 2018 Australian Drinking Water Guidelines), which superseded some of the guidelines adopted in the original investigations:

- groundwater levels are shallow, typically 2−3 metres below ground level (mbgl), tidally influenced and in hydraulic connection with the nearby Georges River;
- field records provided in the EMM (2016) SPI indicate that the groundwater samples collected from wells MP-3 to MP-5 showed no evidence of discolouration, separate phase contaminants (ie LNAPL and DNAPL) or anthropogenic odours;
- the laboratory analysis undertaken on groundwater samples from wells MP-3 to MP-5 measured nondetectable petroleum hydrocarbon and PAH concentrations, which supported the absence of chemical odours and separate phase hydrocarbons (Section 3.7.3);
- concentrations of arsenic, chromium, lead and mercury were below the marine Groundwater Investigation Levels (GILs) at MP-3 to MP-5;
- elevated concentrations of cadmium, copper, manganese, nickel and zinc exceeded the marine GILs at MP-5, and multiple locations for copper (MP-4) and zinc (all wells);

- elevated ammonia (as N) levels that exceeded the marine GIL at all wells; and
- acidic pH levels (4.07-5.75) recorded outside the recreational GIL range at well MP-5.

No groundwater monitoring wells were located in the north-west and south-west corner of the site and no monitoring wells were located along the northern and southern property boundaries adjacent to former off-site landfills.

5.2.4 Surface water

Surface water quality in the dredge pond, western drainage channel and in the part of the Georges River adjacent to the Marina site have been extensively investigated through historical sampling for the EPL monitoring, EMM (2015) PI, EMM (2016) SPI, DP (2016) DSI and DP (2018) ESA. The 2015–2016 data showed:

- concentrations of ammonia exceeded both the marine and recreational adopted criteria at multiple locations from the dredge pond and also in the western drainage channel;
- concentrations of heavy metals were reported below the adopted criteria, with the exception of manganese, copper and zinc at locations within the dredge pond and also in the western drainage channel (excluding copper);
- for phosphorus, all samples collected by the DP (2016) DSI measured non-detectible concentrations, however, the ten samples collected by EMM from the dredge pond (WAT-4s/d to WAT-8s/d) measured concentrations mostly exceeding the adopted criteria (77 micrograms per litre (µg/L));
- concentrations of TRH, BTEXN and volatile organic compounds (VOCs) were below the LOR with the exception of three samples (WAT-6s, WAT-4d and WAT-8d) collected from the dredge pond in the EMM (2016) SPI, ranging from 1,520–4,620 µg/L. It is noted that the high organic matter content present on the Marina site can feature naturally occurring elevated levels of hydrocarbons, and therefore it is not understood what this background influence may be on the reported concentrations;
- concentrations of PAHs and phenols were similarly below the LOR with the exception of the same three samples where elevated TRH concentrations were detected along with PAH (21.3–108 µg/L). The SAR suggests that these may similarly be false positives such as suspended ash particles;
- pH, nitrate and nitrite and OCP concentrations were reported below the adopted criteria; and
- OPPs and PCBs were reported below the laboratory LORs.

As indicated in the DP (2018) ESA, more recent data including the EPL monitoring data (2016–2018) supports the conclusion that, in terms of ammonia levels:

- a significant improvement in surface water quality in the dredge pond occurred when dredging operations ceased in October 2016;
- contaminated groundwater is unlikely to have been migrating from the fill material at the Benedict site into the dredge pond or the Georges River; and
- ammonia levels in the Georges River can vary significantly between sampling events, which is unlikely to be associated with any activities at the Marina site.

The EMM (2016) SPI report provided aesthetic data from five surface water sample locations (WAT-4 to WAT-8) spread around the dredge pond. The field records showed none of the samples were odorous or had a sheen.

5.2.5 Hazardous ground gas

The DP (2018) PSI documented the only hazardous ground gas (HGG) monitoring conducted at the Marina site. DP reported that the work involved the construction of three gas monitoring wells (MW101–MW103) to depths of 4.0−5.5 m along the western site boundary adjacent to where buildings and carparks are proposed to be constructed.

The following findings were noted:

- the maximum recorded concentration of methane was 2.1% at MW102 on 20/03/18 and the maximum recorded concentration of CO2 was 11.1% at MW101 on 20 March 2018;
- the HGG results indicate generally low concentration and flow readings with a calculated characteristic gas situation (CGS) of 1 for all three monitoring wells. However, as per Table 6 in NSW EPA (2012), consideration should be given to raising the CGS to 2 where methane exceeds 1% and/or CO2 exceeds 5%; and
- whilst the initial screening for HGG across the Marina site indicated a generally low risk, given the results across the rest of the site, the final gas risk profile would need to be confirmed through additional monitoring events and on completion of the final Marina site landform.

Updated monitoring data undertaken primarily at the Benedict north site (DP, 2020) exceeded the criteria (NSW EPA 2016) for carbon dioxide at two locations within/near the Marina site, MW101 (Marina site) and EB5. Methane levels exceeded criteria along the eastern boundary of the Benedict north site.

DP (2020) subsequently prepared a report documenting the results of additional HGG sampling conducted at the Benedict north site at 146 Newbridge Road, Moorebank. The monitoring was required under:

- DP (2019) Landfill Closure Management Plan, Benedict Sands, 146 Newbridge Road, Moorebank, Revision 4 (ref: 71459.09.R.024) dated 17 October 2019.

DP (2019) was prepared with reference to the NSW EPA (2016) Environmental Guidelines, Solid Waste Landfills, Second Edition 2016. DP (2019) relates to the Benedict north site and excludes the proposed future Marina site occupying the southern portion of 146 Newbridge Road. DP (2019) documented the proposed final landform, capping detail, leachate, gas management and monitoring protocols proposed to be adopted as part of the landfill closure process.

The monitoring required under the plan included the following:

- monthly HGG monitoring from five fixed wells (designated EB1 to EB5) located along the eastern boundary of the site following their installation on 14 May 2019 (NB: monitoring well EB2 was installed on 9 December 2019 due to landform earthworks required at this section on the boundary that had not been completed in May 2019);
- monthly HGG monitoring from one fixed well (designated MW101) located beyond the southern boundary of the site until this well was destroyed in late 2019 due to earthworks occurring at this part of the site and to the south (proposed Marina site);
- quarterly surface HGG surveys completed across the completed sections of landfill cap (NB: lower 1.0 m of cap comprising site-won material completed, with additional 2.0 m of imported virgin excavated natural material (VENM) cap yet to be completed);

- The concentrations of HGG at the eastern boundary (perimeter) monitoring wells have exceeded the criteria set out in NSW EPA (2016). The guideline states that: '…gas concentration levels in all perimeter gas wells must be less than 1% methane (volume/volume) and less than 1.5% carbon dioxide (volume/volume) above the established natural background for a period of 24 months.";

- The HGG monitoring data from the wells in the vicinity of the deeper fill area of the site (ie EB3 and EB4) suggests that higher concentrations of methane (maximum peak of 13.8% at EB3) are associated with the deeper fill. This is generally consistent with the data collected over the duration of the various HGG monitoring programmes;

- Landfill gas monitoring at the other boundaries (north and west) of the waste mass was not required due to their physical layout such that a potential gas migration pathway of significance is not present; and

- The data from the successive quarterly surveys of HGG indicate that fugitive emissions from the cap remain well below the threshold criterion of 500 ppmv (ie 0.05% v/v). On this basis, there is currently no requirement to undertake flux chamber monitoring nor to rectify any segments of the cap.

The fixed well gas data from the eastern boundary support the need for the contingency perimeter HGG interception trench. Concept designs have been developed by DP and the final detailed design has been prepared by the project Civil Engineer John M Daly & Associates Pty Ltd (JMD) which is undergoing review by the Site Auditor. It is understood that the interception trench will be installed over the coming weeks and the appropriate validation monitoring to verify performance will be undertaken post-installation. The relevant construction quality assurance (CQA) data will be collected and documented in accordance with the CQA plan included in DP (2019).

As per DP (2019), the following ongoing HGG data was recommended to be collected prior to and during civil works at the Benedict north site:

- monthly monitoring from the five fixed HGG monitoring wells EB1 to EB5 including post-installation of the interception trench to verify trench performance;

- quarterly surface gas emission surveys according to the methodology outlined in NSW EPA (2016);

- installation of approximately eight HGG monitoring wells at strategic locations within the site following the progressive installation of the final VENM portion of the cap. The final number, location and monitoring frequency of the proposed wells will be determined following the construction of the cap and will be reviewed and agreed with the Site Auditor. The monitoring data will validate that the site remains a characteristic gas situation 3 (CGS 3), or lower, and will be used to assess whether any gas pressures changes within the waste mass following installation of the final (permanent) cap are present and/or are significant;

- monitor the gas pressure and concentrations within the trench, post-installation; and

- monthly surface gas emission monitoring along the alignment of the HGG interception trench (post-installation) using the same method as the quarterly HGG surface survey.

5.3 Marina site history summary

The EMM (2015) PI included a review of the Marina site history, comprising historical land titles and aerial photographs. A summary of the Marina site history is provided below:

- the Marina site was used for farming prior to 1965, including as a dairy farm between 1960 and 1972;

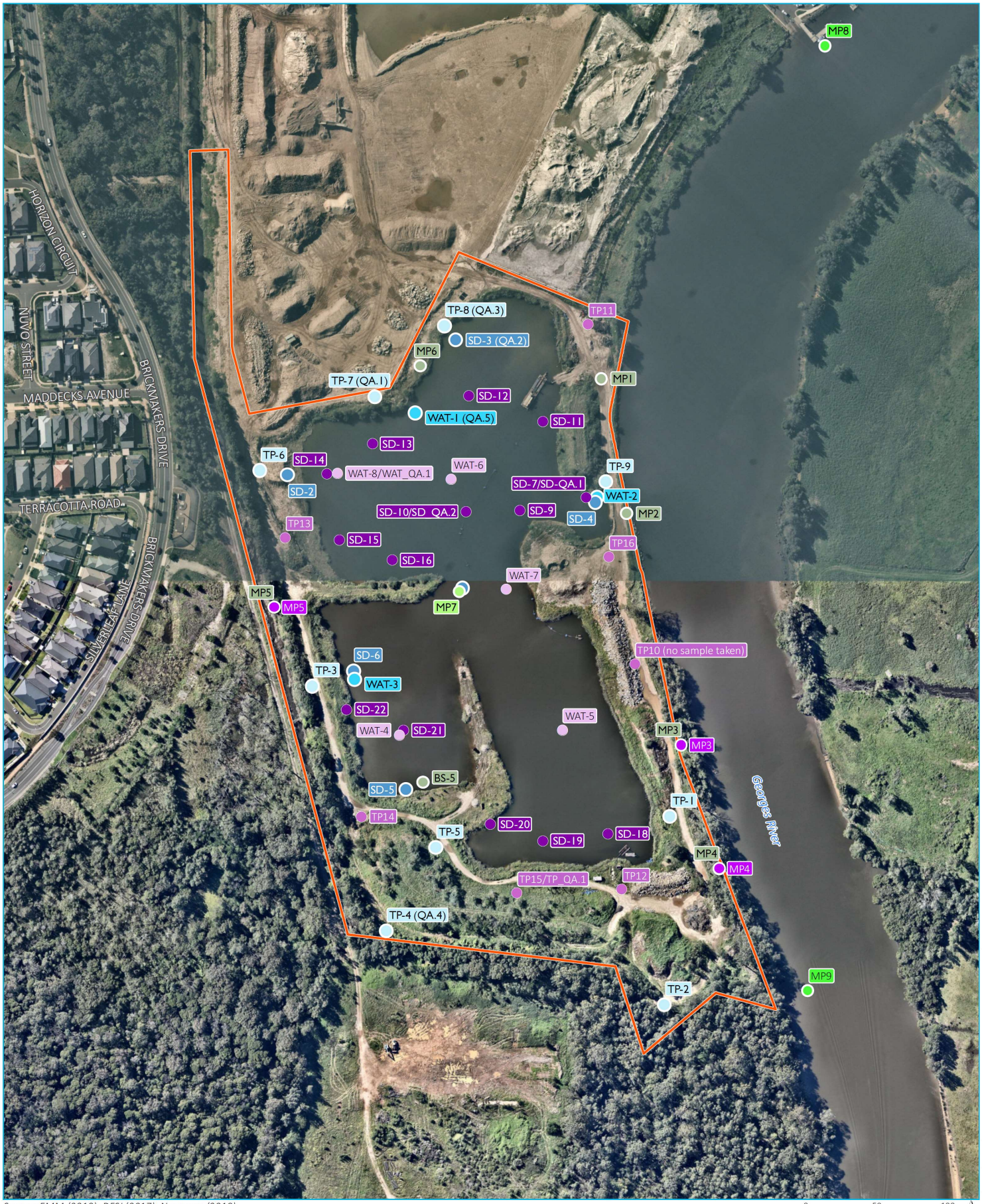
- between 1972 and 1993, it is understood that parts of the Marina site may have been used as a landfill, likely for construction and demolition waste. At this time, landfilling activities were underway on land to the north and south of the marina site. The landfill operation was approved by Liverpool Council and operated under Environmental Protection Licenses (EPLs) issued by thew NSW EPA;

- development consent was granted in 1993 to extract sand by dredging, and fill the dredged void with clean fill back to natural ground level. The owners of the Marina site have indicated that since this consent was granted in 1993, no further waste materials were deposited on the Marina site. Sand extraction operated under additional EPLs issued by the NSW EPA;

- aerial photographs showed the presence of two large dams in the centre of the Marina site by 1998, which expanded to approximately 70% of the Marina site area by 2005;

- by 2015, the dams were noted to have increased in area to the north, however decreased in the southern portion of the Marina site. Overall, surface water was estimated to cover approximately 60% of the Marina site at this time; and

- extractive industries on the Marina site have reached the end of their economic life and are no longer operating. Restoration of the extraction voids (ie the dredge pond) has not commenced as it is anticipated that the proposed marina basin will eliminate the need to backfill the voids with imported fill materials (EMM 2018).



Source: EMM (2019); DFSI (2017); Nearmap (2019)

0 50 100 m

GDA 1994 MGA Zone 56

N

T:\Jobs\2018\180179 - Georges Cove Marina 2018 EIS\GIS

KEY

Subject site

Historic sampling locations
- Dredge pond water
- Georges River
- Groundwater
- Stormwater

PI sampling location
- Sediment
- Soil
- Dredge pond water

SPI sampling location
- Soil
- Dredge pond water
- Sediment

Previous EMM sampling locations and historical data

Georges Cove Marina
Remediation action plan
Figure 5.1

EMM
creating opportunities

6 Site condition and surrounding environment

This section describes the present condition of the Marina site and surrounding areas based on data provided in the EMM 2015 PI, the EMM 2018 EIS and more recent data.

6.1 Current land use

Extractive activities at the Marina site have ceased, however restoration activities have not yet commenced. The Marina site is currently vacant and unoccupied. The Marina site comprises a large dredge pond covering approximately 60% of the site area. There are stockpiles of soil and overburden at the eastern and south-eastern boundaries of the Marina site. Additionally, a mound is present at the southern and south-western boundary, constructed of fill and overburden and covered with grasses and small shrubs.

6.2 Surrounding land use

Notable land uses in the surrounding area are summarised in Table 6.1.

Table 6.1 Surrounding land uses

Direction	Surrounding land uses
North	The area north of the Marina site was a licensed waste recycling facility, and historically previously operated as a landfill prior to their ownership. This land was also utilised as a workshop for the dredging operation and recycling facility. The land has since been rezoned for residential land use, with construction commenced on the residential estate during 2020. This land is bounded to the far north by Newbridge Road (a six lane Roads and Maritime Service (RMS) Class 1 Road) with industrial land uses to the north of Newbridge Road. Landfilling previously occurred on this land. Although the landfill is outside the marina site boundary, landfill leachate generated from the interaction of water and waste material has the potential to enter groundwater and migration to adjacent properties. A major remediation program commenced at the former Benedict recycling facility five years ago, which involved the selective removal of hazardous ground gas (HGG) hot spots, a program of roller dynamic compaction followed by the construction of a 3m thick cap. Cap construction is likely to be completed in May 2021, after which a low to medium density residential subdivision with landscaping and supporting infrastructure is to be constructed by Mirvac.
East	The Marina site is bounded by the Georges River to the east. There is expansive recreational open space within the Bankstown LGA on the eastern side of the Georges River. This area is characterised by open grasslands with some rural sheds, outbuildings and three to four residential dwellings. The former 81.2 ha Riverlands Golf Course on the eastern side of the Georges River was purchased several years ago by Mirvac, who intend to develop a large low density residential subdivision on part of the property together with major landscaping and riverbank protection work.
South	The southern adjacent property comprises undeveloped, vegetated land (Wurrungwuri Reserve) that is zoned Environmental (E2) within the Liverpool LEP (2008). There is a golf course and other recreational facilities beyond. The land to the south of the marina facility was approved to be developed into a materials recycling centre. However, the land was sold by Concrete Recycling several years ago to a property developer, with the intention of remediating the land for high-density residential and open space land uses. At the current golf course location landfilling was undertaken between 1972 and 1979 by Collex, following an approval from the Metropolitan Waste Disposal Authority and the State Pollution Control Commission. The landfill was licensed to accept non-putrescible wastes (eg builders' rubble). Vegetation and other organic biodegradable materials may have been accepted at the landfill as they were considered as non-putrescible at the time landfilling was operating.

Table 6.1 Surrounding land uses

Direction	Surrounding land uses
West	The adjacent property to the west incorporates the Georges Fair residential estate comprising approximately 960 houses and completed a few years ago by Mirvac. Prior to the housing development, this land was used as a brick works by Boral.

6.3 Topography and surface drainage

Portions of the site that are not occupied by the dredge pond are generally unsealed, allowing infiltration to the underlying soils. Any surface water runoff generated at the Marina site would predominantly drain towards the dredge pond. A small portion of the Marina site, to the east of the dredge pond, could drain towards the adjacent Georges River. A surface drainage channel is present at the western and southern boundaries of the Marina site, which drains to the Georges River to the south of the Marina site.

The Georges River is located immediately to the east of the Marina site, flowing in a south/south-easterly direction towards Botany Bay, approximately 20 km to the south-east of the Marina site. The Georges River is tidal as far as Liverpool Weir, approximately 10 km upstream of the Marina site.

Flood potential at the current low-lying Marina site is high due to the adjacent Georges River. The results of a flood study (Worley Parsons 2010), including a numerical flood model, indicated that:

- in a 20-year average reoccurrence interval (ARI) flood, the impact of the planned development on flood hazard will be negligible except on the western side of the Marina site where the proposed development will increase the ground level, eliminating the flood hazard; and
- in a 100-year ARI flood, the impact of the planned development on flood hazard will be negligible.

The proposed development is anticipated to have a negligible impact on the behaviour of flooding in the flood storage area in the south-west of the Marina site and negligible impacts on adjacent properties. It is understood that the marina development will not increase the flood hazard category.

6.4 Soils

The Soil Landscape Map of Penrith, Soil Landscape Series Sheet 9030, Scale 1:100,000 prepared by the Soil Conservation Service of NSW (Hazelton et al. 1989), indicated that the marina site is located within the “Richmond Landscape Area” and typically consists of clays, clay loams, sands and ironstone nodules. Fill is known to be present on the Marina site, overlying the natural soils with an average thickness of 2.5 m. The fill has been identified (EMM 2015, DP 2018) as comprising a mixture of silty sand or clay with gravel and mixed refuse fragments (including plastic, pipe, bricks, concrete, plastic, tyres, glass, tiles, wood, ACM, metal, charcoal and terracotta).

The project area has been identified on the Liverpool LEP (2008) Acid Sulfate Soils (ASS) map (class 1, 2, 4, and 5), and reference to the Atlas of ASS indicates there is a high probability for ASS. The ASS Atlas is a dataset of available national ASS mapping and ASS qualification inferred from surrogate datasets, prepared by CSIRO Land and Water. ASS investigations on the Marina site and adjacent properties have inferred the presence of ASS and PASS predominantly in natural soils below the water table at the Marina site (refer to Appendix B). In addition, it is understood that PASS materials have previously been imported to the Marina site and placed below the water level in the dredge pond.

The creation of a channel between the marina basin and the Georges River will require the removal of the existing soils between the dredge pond and the river. These soils have the potential to be ASS and require classification and may require specific management.

An ASS management plan (ASSMP) will be implemented during works on the Marina site where ASS/PASS may be disturbed. An ASSMP is included in Appendix B of this RAP.

6.5 Geology and hydrogeology

Geologically, the Marina site in located in the middle of the Permo-Triassic Sydney Basin on the Cumberland Plain. The geology of the Sydney basin comprises thick stratigraphical sequences of Permian and Triassic sedimentary rocks including sandstone, siltstone and shale formations (with interbedded coal seams in the lower Permian sequence with deposition occurring between 210 and 290 million years ago).

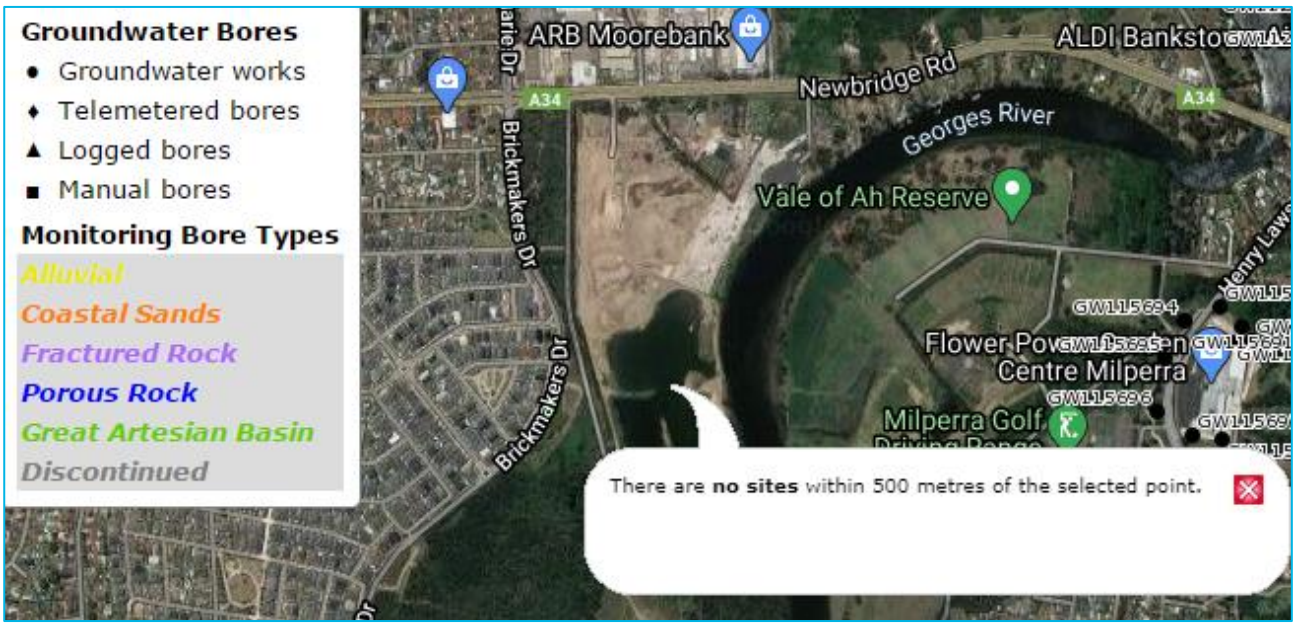
Reference to the Geological Map of Penrith, scale 1:100,000 (1991) shows the Marina site is situated on Quaternary aged deposits of medium grained sand, clay and silt. Within the Georges River floodplain the Quaternary deposits are underlain by Tertiary quartzose sands and clays. The underlying Triassic Wianamatta Group, Mittagong Formation, Hawkesbury Sandstone and Narrabeen Group are shown to be steeply folded at the marina site, such that the Wianamatta Group outcrops to the west, and the Hawkesbury Sandstone outcrops to the east of Georges River. These porous rock units comprise quartz sandstone and carbonaceous claystones and siltstones, with shale and laminate lenses (Geoscience Australia, Australian Stratigraphic Units database).

The unconsolidated deposits beneath the Marina site are likely to form a single, unconfined aquifer. Groundwater levels are shallow, typically 2 m−3 mbgl, and are in hydraulic connection with the river tidal levels (Dames and Moore 1994a).

The measured permeability in the monitoring wells adjacent to Georges River ranged from 12−47 m/day averaging 30 m/day, while permeabilities of less than 1 m/day were measured in the finer sediments on the western side of the Marina site (Dames and Moore 1994a). Horizontal flow is expected to dominate due to the relatively impermeable underlying Wianamatta Group Shales.

Dames and Moore (1994a) inferred that there was an overall flow of groundwater in a south-easterly direction towards the Georges River. They concluded that groundwater flows in the zone adjacent to the river were likely to be influenced by the intrusion of brackish/saline river water at depth, with fresh water flows towards the river concentrated in the shallow zone at approximately 5−6 m depth. Groundwater at depth adjacent to the Georges River can be influenced by relatively higher salinity water from the adjacent creek.

A search of the NSW Office of Water registered bore database was undertaken on 17 March 2021 and did not identify registered bores at the marina site or within a 500 m radius as shown in Figure 6.1 below.



Source: WaterNSW (2021)

Figure 6.1 Groundwater bore search result

6.6 Background contaminant concentrations

A number of studies have been undertaken in the upper Georges River area which provide context and indicate that the Marina site is located in a heavily developed industrial/urban area with multiple contaminant sources that have caused background contaminant concentrations in surface water, sediments and groundwater to be elevated. Specific examples obtained from publicly available documents include the following:

- CH2M (2018) 'Detailed Site Investigation, Holsworthy Barracks – PFAS Investigations'.
    - Concentrations of per-and poly-fluoroalkyl substances (PFAS) were reported to be consistently higher downstream of Liverpool Weir (compared to upstream). An upward trend in concentrations was observed further downstream past the confluence with Anzac Creek, the Liverpool wastewater treatment plant (WWTP) and the Liverpool Industrial Area. The highest concentration (exceeding the drinking water guidance value) was reported adjacent to Cabramatta Creek, approximately 5 km upstream of the Marina site. Concentrations were then reported to trend downwards, however, PFAS concentrations still approached the upper Sydney Harbour averages[4] most samples beyond the Deadmans Creek confluence approximately 6 km downstream of the Marina site. It is noted the discharge point for surface water flows from the main Holsworthy Barrack (PFAS source), the Williams Creek confluence, is situated approximately 2 km downstream of the Marina site.
    - The sum of PFHxS and PFOS concentrations in the Georges River adjacent to the northern Benedict site (former Newbirdge Rd Landfill) and southern site (former Collex landfill) were elevated, recorded at 0.05 and 0.06 µg/L respectively, slightly below the PFAS NEMP (2020) Drinking water guideline (0.07 µg/L).

[4] CH2M (2018) made reference to Thompson J et al (2011) 'Perfluorinated alkyl acids in water, sediment and wildlife from Sydney Harbour and surroundings'

- Contamination due to unspecified “industrial pollutants” in the Georges River has resulted in fishery closures being issued by the Department of Primary Industries available at https://www.dpi.nsw.gov.au/fishing/closures/location-closures/botany-bay-and-georges-river.

  - A closure for shellfish applies approximately 3 km upstream of the Marina site while a closure for oysters exists for the whole of the waters of the Georges River (including adjacent to the Marina site).

- The NSW EPA website at https://www.epa.nsw.gov.au/news/mediareleases/2017/epamedia171215dietary-advice-for-fish-caught-in-botany-bay-and-georges-river provides information on dietary advice for fish caught in the Georges River due to PFAS contamination.

  - The dietary advice applies for a stretch of river commencing at Rabaul Road Boat Ramp (approximately 3 km upstream of the Marina site, continuing adjacent to the Marina site and ending far downstream at Tom Ugly’s Bridge near Botany Bay.

7 Site characterisation and conceptual site model

7.1 Conceptual site model

A conceptual site model (CSM) is a qualitative description of the mechanisms by which potential and/or complete exposure pathways exist between known or potential sources of site contamination and human or environmental receptors.

In order for a receptor to be exposed to a chemical contaminant derived from the site, a complete exposure pathway must exist. An exposure pathway describes the course a chemical or physical agent takes from the source to the exposed individual and generally includes the following elements:

- a source and mechanism of chemical release;
- a retention or transport medium (or media where chemicals are transferred between media);
- a point of potential human contact with the contaminated media; and
- an exposure route (eg ingestion, inhalation) at the point of exposure.

Where one or more of the above elements is missing, the exposure pathway is considered to be incomplete and there is therefore no direct risk to the receptors. Where this is identified, the exposure pathway does not warrant further assessment.

Based on the information obtained during the previous investigations, and the 2016 EMM RAP, a CSM has been developed to identify complete or potentially complete linkages between contaminant sources of sensitive receptors. The CSM is summarised below.

7.1.1 Sources

The identified sources of potential contamination at the site have been evaluated in Table 7.1.

Table 7.1 Contamination sources

Source and CoPC	Evaluation
Historical use of the Site for agricultural purposes OCPs, OPPs, metals	Unlikely Almost all concentrations of OCP/OPP in previous investigations were reported below the limit of reporting, with low concentrations of OCPs below adopted investigation levels found in soil fill material and Georges River surface water. It is likely that these reported OCP concentrations are attributed to those other sources as detailed below.

Table 7.1 Contamination sources

Source and CoPC	Evaluation
Presence of acid sulfate soils ASS/PASS	Likely The Atlas of Australian ASS (CSIRO) indicated that there was a high probability for ASS (EMM 2015). The Marina site was also identified on the Liverpool LEP (2008) Acid Sulfate Soils (ASS) map as containing class 1, 2, 4, and 5 ASS. Scheduled Activities under the POEO Act 1997 undertaken at the Benedict site included PASS for backfilling the sand quarry, including a licence variation to store PASS underwater. It was noted that approximately 1,000 tonnes of PASS has been disposed on the Marina site (EMM 2015). Additionally, laboratory analysis from investigations undertaken on the adjacent northern Benedict site (EIS 2013 and DP 2017) confirmed the presence of ASS and PASS.
Use of fill materials on the Marina site Metals, TRH/BTEXN, PAHs, VOCs/SVOCs, PCBs, OCP/OPPs, PFAS, nutrients, degradation products (ammonia/methane/carbon dioxide/hydrogen sulphide) and asbestos	Known – asbestos and metals Potential – other CoPC It is understood that a portion of the Marina site was covered by fill, typically consisting of a mixture of silty sand or clay with gravel and construction/demolition waste that was disposed on-site under a Consent issued by Liverpool Council under an EPL issued by NSW EPA. The average depth of fill was reported to be 2.5 m but it is known to extend to at least 4 m in some locations (EMM 2016). Previous investigations reported concentrations of select CoPC in fill soil below the adopted HILs and EILs with the exception of fragments of bonded asbestos in two test pits (DP 2018). It is noted that other CoPC including VOCs/SVOCs, PFAS, nutrients and degradation products have not been assessed in fill material. The presence of fill materials containing timber demolition waste may also result in the generation of hazardous ground gas (HGG) at the Marina Site.
Urban runoff – western drainage channel Metals, TRH/BTEXN, PAHs, VOCs/SVOCs, PCBs, OCP/OPPs, PFAS, nutrients, degradation products (ammonia/methane/carbon dioxide/hydrogen sulphide)	Likely Urban runoff from the surrounding catchment flows into the western drainage channel that runs adjacent to the western boundary of the Marina site and discharges into the Georges River. The runoff would impact the water quality of the Georges River adjacent to the Marina site. Some runoff may also impact the quality of groundwater that flows from the west and into the Marina basin. Previous investigations reported concentrations of ammonia, manganese and zinc exceeding the adopted investigation levels within the western drainage channel surface water.

Table 7.1 Contamination sources

Source and CoPC	Evaluation
Groundwater migrating from former northern recycling operation Metals, TRH/BTEXN, PAHs, VOCs/SVOCs, PCBs, OCP/OPPs, nutrients, degradation products (ammonia/methane/carbon dioxide/hydrogen sulphide)	Onsite: potential. Offsite: known. It is understood that waste material sorting, crushing, washing and stockpiling was undertaken at the adjacent northern portion of the Benedict site until residential redevelopment commenced in 2020. Material was washed using recirculated dredge pond water including runoff from that site (EMM 2016). The site was also licenced to carry out extractive activities, with various metals used in the extraction process. Petroleum hydrocarbons including oil and diesel were used and stored on site along with car batteries. Asbestos (typically bonded ACM) had previously been found in stockpiles, in fill and at the ground surface within the site (DP 2017) although Asbestos is not soluble. Large sections of the northern Benedict site were filled between 1982 and 1991 (DP 2018). Previous investigations reported elevated concentrations of various CoPC in fill including heavy metals, PAHs, PCBs, ammonia, methane and asbestos. The fill material varied in thickness up to 11.5 m depth at the southern central portion of the site (DP 2017). Demolition and construction waste that was placed by the former landfill and waste recycling operation is in the process of being covered by a 3 m thick capping layer of clean fill. Thus, there is an ongoing potential for contaminants from these waste materials to migrate into the Marina site via groundwater flow. However, significant continued onsite migration is considered unlikely given the source removal activities already carried out, the 3 m thick cap design and engineered HGG barrier that is being installed at the northern Benedict site.
Former landfill to south of Marina site Metals, TRH/BTEXN, PAHs, VOCs/SVOCs, PCBs, OCP/OPPs, PFAS, nutrients, degradation products (ammonia/methane/carbon dioxide/hydrogen sulphide)	Onsite: potential. Offsite: known. Contamination is known at the former landfill immediately south of the Marina site (DP 2018). A landfill operated at the site from 1972 to 1979 and it is understood that the northern section adjacent to the Marine site was unlined (EIS 2009, 2010). Historical analysis of groundwater within the Lot 6 southern landfill measured elevated concentrations of heavy metals, phenolic compounds, VOCs, petroleum hydrocarbons, pesticides and ammonia, along with methane detected in boreholes. The dominant groundwater flow direction in land adjacent to the Georges River would be towards the river in an easterly direction. Furthermore, an open stormwater drain flows along the southern boundary of the Marina site. For these reasons, the potential contamination risk to the Marina site is considered low but possible. It is understood that the former landfill to the south of the Marina site is currently owned by a developer who intends to remediate contamination at the property as part of a large residential development.
Georges River water Metals, PCBs, OCP/OPPs, PFAS, nutrients	Onsite: potential. Offsite: known. Limited sampling from previous investigations (DP, 2016 and 2018) revealed elevated concentrations of heavy metals (copper, manganese, nickel and zinc), phosphorus, OCP (dieldrin) and PFAS (PFOS and PFHxS) within surface water of the Georges River adjacent to the dredge pond and/or upstream of the Marina site. Elevated concentrations of PFOS and PFHxS, marginally below the NEMP (2020) Drinking water guideline, were similarly noted adjacent to the northern Benedict site and southern former landfill site (CH2M 2018), with dietary advice and fishery closures in effect for the Georges River adjacent to the site due to this known PFAS contamination (refer to Section 6.6).

Table 7.1 Contamination sources

Source and CoPC	Evaluation
Georges River sediments	Potential
Metals, PCBs, OCP/OPPs, PFAS, nutrients	With the presence of CoPC identified in surface water (see above), deposition and entrainment of contaminants in sediments of the Georges River near the site is also potential and has been identified in a recent study including heavy metals exceeding adopted criteria (Alyazichi et al. 2017). Additionally, the NSW EPA issued a 'Dietary advice for fish caught in Botany Bay and Georges River' on 15/12/2017 due to PFAS contamination. While the previous investigations did not assess sediments from the Georges River adjacent to the Marina site to establish background levels, the EMM (2016) SPI did review a study by Birch et al. (1996) that found that sediments of the Georges River and tributaries also have high copper, zinc and lead concentrations. Sediments in the Georges River will be able to migrate as suspended sediment and be deposited in the Marina site when the former dredge pond is opened to the Georges River as part of the proposed development.

7.1.2 Pathways

The following transport mechanisms may apply at the Marina site:

- surface water flows in western drainage channel seeping into groundwater or flowing into the Georges River and then flowing into Marina basin;
- excavation and re-location of soil/fill during future construction activities;
- seepage of leachate from on-site construction and demolition rubble into underlying natural soils and into local groundwater;
- migration of groundwater from surrounding properties into Marina site;
- flow of Georges River into Marina basin;
- migration and infiltration of vapours (ie soil gas) from soil, fill and/or groundwater beneath the Marina site or from adjacent offsite former landfills; and
- atmospheric dispersion (aeolian transport) of dust or fibres, derived from contaminated soil.

Identified potential exposure pathways for the nominated CoPC include:

i) dermal contact and incidental ingestion of soil;

ii) inhalation of dust (including soil derived) or fibres;

iii) dermal contact and incidental ingestion of groundwater;

iv) inhalation of soil/groundwater vapours in outdoor air;

v) inhalation of soil/groundwater vapours within a trench;

vi) plant uptake and/or ingestion by animals;

vii) uptake of CoPC from groundwater (stygofauna and microorganisms); and

viii) vertical leaching of CoPCs via rainfall.

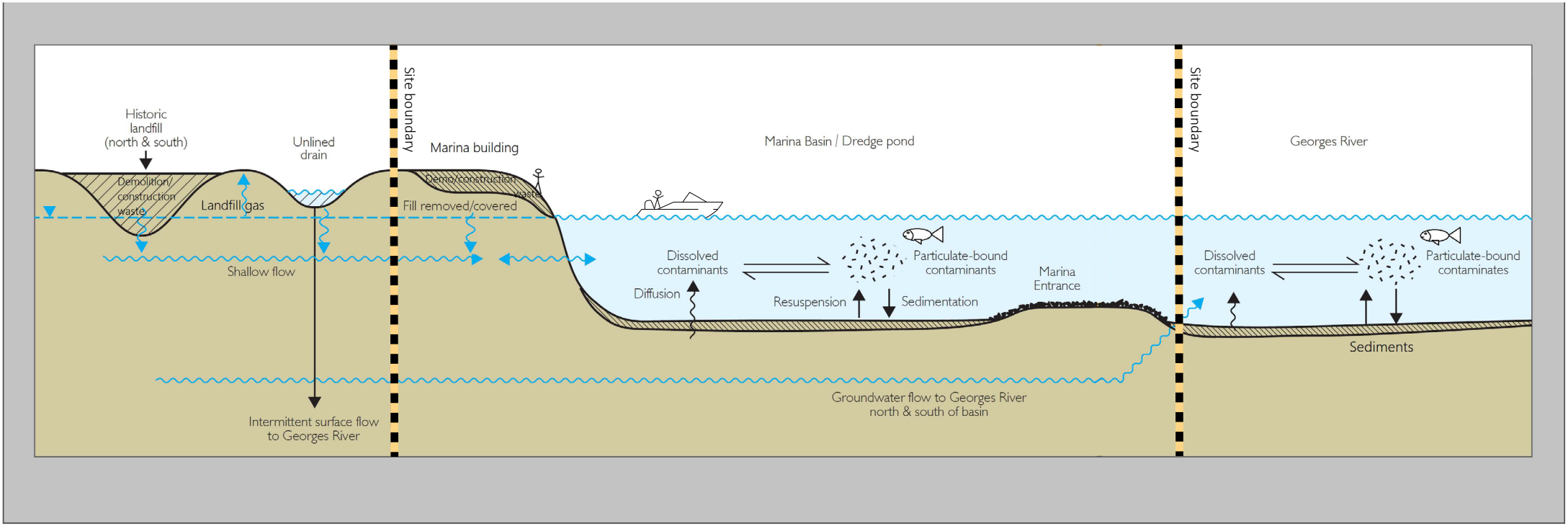
7.1.3 Potential receptors

Potential sensitive receptors at the Marina site, in the context of mixed residential, commercial and open space land uses, comprise:

- future site users associated with the proposed marina development (ie high density residential, recreational and commercial);
- construction and maintenance workers involved in the development of the Marina site;
- construction and maintenance workers during the operational phase of the Marina site;
- users of adjacent properties (ie sensitive residential receptors to the north and west);
- users of surface water downgradient from the Marina site;
- surface and groundwater ecology; and
- terrestrial ecosystems.

7.1.4 Source-pathway-receptor model

The source-pathway-receptor model is outlined in the CSM schematic provided in Figure 7.1 below.



Conceptual site model
Remediation action plan
Georges Core Marina Development
Figure 7.1

7.2 Site characterisation

Table 7.2 summarises the nature and extent of contamination at the Marina site based on an assessment of the available data, and identifies data gaps that need to be addressed.

Table 7.2 Site characterisation summary

Media	Nature of contamination	Estimated extent of remediation	Data gaps
Soil	Fragments of bonded ACM are expected to be present in fill materials across the Marina site. This includes at the current ground surface and in fill deposits up to 4 m bgs. It is noted that the depth of fill may be deeper than 4 m in some areas. Chemical contaminants, including heavy metals have generally been found to be below the investigation levels and are likely to be acceptable for the proposed land use when assessed as 95%UCL contaminant concentrations. However, some as yet unidentified hotspots greater than 2.5 times the investigation levels may be present. Aesthetic issues in soil, including anthropogenic materials, ACM and other uncontrolled fill, have been observed. ASS/PASS is likely to be present beneath the water table, including sediments in the dredge pond.	Some shallow fill would require removal due to the presence of contamination and high risk to potential receptors. This is because of fragments of bonded asbestos are likely to be randomly scattered in fill at the site. Visible asbestos will need to be removed from the final ground surface achieved by the proposed development or capped with clean soil. Chemical contamination in fill is likely to be generally low, with 95% UCL average concentrations below the remediation acceptance criteria. The available data indicates that hot-spots should be localised and of a manageable number and extent. Such hot-spots require removal from the Marina site or capping with clean soil (if appropriate). The Marina site is located in an ASS risk area. Excavation work undertaken at the Marina site requires procedures to be in place for managing disturbance to ASS if there was a requirement for deep excavation work to occur, particularly into the natural soils underlying the fill layer.	Additional investigations are required to characterise fill materials for reuse on-site or off-site disposal, including an assessment of asbestos in soils. Additional CoPC need to be considered, including VOCs and PFAS.

Table 7.2 Site characterisation summary

Media	Nature of contamination	Estimated extent of remediation	Data gaps
Sediment	The shallow sediments in the dredge pond are contaminated with copper, lead, zinc and possibly mercury at concentrations that exceed background levels in the Georges River and the SQGVs. However, all 95% UCL average concentrations were below the SQG-high criteria. The shallow sediments in the dredge pond are likely to be contaminated by nutrients such as ammonia at concentrations that exceed background levels in the Georges River. This is because ammonia concentrations were measured at 2.4–48.6 mg/kg, with higher ammonia concentrations associated with higher organic carbon levels.	Fine-grained sediments that may need to be excavated to construct the marina waterway may pose an aesthetic impact during the construction period.	Investigation of sediments in the Georges River adjacent to the Marina site to understand onsite contamination in the context of background concentrations, particularly if the marina will be opened to the Georges River. Provide some further characterisation of the dredge pond, particularly in areas where previous sampling densities were limited, namely the central part of the southern dredge pond where no previous sediment sampling has been undertaken.
Surface water	Concentrations of ammonia, phosphorus, heavy metals exceeded adopted criteria at multiple locations from the dredge pond and/or in the western drainage channel. Concentrations of TRH, BTEXN and Volatile Organic Compounds (VOCs) PAHs and phenols were mostly below the LOR but were recorded at elevated concentrations during one sampling event. pH, nitrate and nitrite, OCP, OPPs and PCBs were reported below adopted criteria.	Management only.	Define the background concentrations of CoPC (as identified in the CSM) in the Georges River adjacent to the Marina site. Include analysis of CoPC identified in the CSM from samples within the dredge pond including those which were not previously assessed (ie OCPs, VOCs/SVOCs, phenols, PFAS). Samples should also be collected along the western drain to provide data on background levels and so comparisons can be made in surface water quality in the Georges River and Marina basin.
Groundwater	Groundwater levels are shallow, typically 2–3 mbgl, tidally influenced and in hydraulic connection with the nearby Georges River. Elevated concentrations of heavy metals and ammonia exceeded the adopted criteria at select locations, with other CoPC reported below the adopted criteria (where analysed). Acidic pH levels (4.07–5.75) were recorded outside the recreational GIL range at well MP-5.	Management only.	No monitoring wells were located in the north-west and south-west corner of the site and no monitoring wells were located along the northern and southern property boundaries adjacent to former off-site landfills. Additional investigation to focus primarily on assessing potential groundwater contamination migration from the former southern landfill towards the Marina site. Include analysis of all CoPC identified in the CSM including those which were not previously assessed (ie OCPs, VOCs/SVOCs, phenols, PFAS).

Table 7.2 Site characterisation summary

Media	Nature of contamination	Estimated extent of remediation	Data gaps
Landfill gas	Background methane levels measured at the north-eastern corner of the Marina site indicate that the local estuarine alluvial soils (possibly swamp deposits) are unlikely to be contributing a significant amount of methane to subsurface soils at the Marina site. Much of the western area of the Marina site is presently part of the dredge pond and does not contain fill material (other than deposited sediments).	Sufficient data is available to support the adoption of a CGS of 2 for the design of the marina development. As much of the western area of the Marina site is presently part of the dredge pond and does not contain fill material (other than deposited sediments), there is a low risk that construction of filled areas required by the proposed development will cause the generation of HGG at levels that will need to be managed provided the fill used to construct these areas contains no degradable material that would contribute to the production of HGG.	Data gaps exist in the characterisation of HGG across the filled areas of the Marina site. Additional HGG monitoring would be undertaken during the design stage and remediation works, to confirm the CGS design parameter. Assess potential soil gas contamination migration from the former southern landfill towards the Marina site.

7.3 Potential for off-site contamination

Based on the available information summarised in this report, contamination at the Marina site is generally considered to present a low contamination risk to off-site receptors. Given the context of the Marina site being surrounded by known background sources of contamination including adjacent properties and the Georges River, it is unlikely to be contributing to a significant portion of off-site contamination (if any). This finding can be supported through undertaking additional investigations to address the identified data gaps (refer to Table 7.2). Section 8 outlines the additional site investigation requirements.

7.4 Extent of contamination

The historical, site condition and available sample data support the conclusion that the extent of contamination at the Marina site should comprise:

- ACM fragments scattered in the construction and demolition waste, with the occasional pocket of multiple fragments;
- Localised hot-spots of other types of contamination, most likely heavy metals and possibly PAHs as slag or ash;
- Timber and other types of biodegradable waste scattered in the construction and demolition waste, with the occasional pocket of large/multiple pieces;
- Pockets of rubbish/oversize material that is geotechnically unsuitable for use as controlled fill;
- Relatively low HGG levels, with the occasional pocket of higher concentrations/flow rates;
- Sediments in the Marina basin; and
- Unexpected finds in localised pockets.

Additional site investigations will be undertaken prior to the commencement of remediation work, to better define background concentrations and to address data gaps that will allow the extent of remediation work to be refined, minimise the potential for unexpected finds during the remediation work, and minimise the risk of wasting resources in undertaking unnecessary remediation work. Other additional site investigations will be undertaken as part of the validation program during the bulk earthworks program, to identify small pockets of contamination that cannot be identified using discrete sampling techniques. The scope and design of these additional investigations are described in the following section.

8 Additional site investigation requirements

As detailed in Section 5, a number of previous phases of investigation have been undertaken at the Marina site. Based on the summary of the work completed to date, further assessment in the form of an additional detailed site investigation (DSI) is not considered warranted prior to the preparation of this RAP for the following reasons:

- the CLM Act permits the amalgamation of investigation and remediation stages into a single 'management' stage that can cover investigation, remediation or both;
- based on the work conducted, the Marina site has a low risk of elevated concentrations of contamination being present that would preclude the Marina site being made suitable for the propose land uses;
- widespread contamination has not been identified during previous investigations;
- potential hotspots of contamination may not be identified during a DSI and would require further assessment if encountered during the earthworks program;
- further assessment of fill and soil will be required during the bulk earthworks phase to assess suitability for reuse or offsite disposal;
- further assessment will be required as part of the Marina site validation program to ensure the Marina site is suitable for the intended land use; and
- this RAP effectively summarises the condition of the Marina site and work completed to date and acknowledges that additional assessment and validation sampling will be required as part of the future bulk earthworks program, which will be required to reshape the Marina site to the proposed future landform.

Data gaps that have been identified to require further assessment during the remediation works phase should be undertaken as part of a program of additional investigations, once the detailed design is available. The investigations should in general:

- be undertaken by a suitably qualified environmental consultant in general accordance with the ASC NEPM (2013), NSW EPA guidelines and other relevant guidance documents as applicable;
- be outlined in a Sampling Analysis and Quality Plan (SAQP) prior to intrusive field investigations commencing. The SAQP will be reviewed and approved by the Site Auditor prior to commencing the investigation;
- involve subsurface excavation, in-situ screening tests, sample collection and laboratory analysis; and
- include a survey plan of Marina site showing topographic contours of the terrain and bathymetric contours of the dredge pond.

8.1 Soil

The additional soil investigation undertaken as part of this RAP should:

- further characterise the quality of existing fill that is to remain at the Marina site in accordance with NSW EPA guidance;

- incorporate in situ waste characterisation of fill that is to be removed from the Marina Site (in order to remove the need for on-site stockpiling);
- characterise the extent of timber and other types of biodegradable waste in the construction and demolition waste;
- characterise the extent of rubbish/oversize material that is geotechnically unsuitable for use as controlled fill;
- provide stratigraphic cross-sections showing the variation in subsurface conditions; and
- evaluate aesthetic issues in soils (eg anthropogenic contents, including ACM).

8.2 Sediment

The additional sediment investigation undertaken as part of this RAP should:

- focus primarily on sampling of sediments in the Georges River adjacent to the Marina site to understand onsite contamination in the context of background concentrations, as the marina will be opened to the Georges River; and
- provide some further characterisation of the dredge pond, particularly in areas where previous sampling densities were limited, namely the central part of the southern dredge pond where no previous sediment sampling has been undertaken.

8.3 Surface water

The additional surface water investigation undertaken as part of this RAP should:

- include analysis of CoPC identified in the CSM from samples within the western drain and dredge pond to provide background data including those CoPC which were not previously assessed (ie OCPs, VOCs/SVOCs, phenols, PFAS); and
- include multiple rounds/events (at least 3 recommended) of surface water sampling to compare results.

8.4 Groundwater

The additional groundwater investigation undertaken as part of this RAP should:

- focus primarily on assessing potential groundwater contamination migration from the former southern landfill towards the Marina site;
- include analysis of all CoPC identified in the CSM including those which were not previously assessed (ie OCPs, VOCs/SVOCs, phenols, PFAS);
- quantifiably assess changes in groundwater quality that have occurred since the previous groundwater investigations were undertaken in 2015; and
- assess naturally occurring sources of ammonia contaminated groundwater at the Marina site due to the presence of organic peat soils in the area, noting that the presence of such naturally occurring groundwater contamination may require the GILs for ammonia to be increased to background levels measured in areas where groundwater flows through soil profile with high organic peat content.

8.5 Hazardous ground gas

Data from the previous investigations supported the adoption of a CGS of 2 for the design of the marina development. However, data gaps in the characterisation of HGG across the filled areas of the Marina site were identified. Therefore, additional HGG monitoring can be undertaken as part of the further investigations during the detailed design stage, which may justify a reduction in the CGS design parameter.

The additional HGG investigation undertaken as part of this RAP should:

- assess potential soil gas contamination migration from the former southern landfill towards the Marina site, including the large fill mounds at the southern end of the Marina site; and

- be undertaken over multiple sampling rounds to compare results (recommended for a minimum of three rounds at six monthly intervals - or to the extent practical based on the timing of the redevelopment works).

9 Remediation acceptance criteria

9.1 Remediation assessment screening criteria

9.1.1 Soil criteria

The following guidelines are applicable to the soil investigation:

- National Environment Protection Council (NEPC) (1999). National Environment Protection (Assessment of Alignment Contamination) as amended, 2013 – Soil Health Investigation Levels (HILs) (for metals, PAHs, VOCs, SVOCs, OCPs, asbestos) and Health Screening Levels (HSLs) (for asbestos) (ASC NEPM 2013).
- Cooperative Research Centre for Contamination Assessment and Remediation of the Environment (CRC CARE) Technical Report No.10 - Health Screening Levels for Petroleum Hydrocarbons in Soil and Groundwater. September 2011. (Friebel and Nadebaum 2011) – Soil HSLs (for TPH and naphthalene).
- United States Environmental Protection Agency (US EPA 2016). Regional Screening Levels (RSLs) for Industrial Soil, as updated May 2016 (SVOCs and VOCs without Health Investigation Levels (HILs) or HSLs.
- Heads of EPAs Australia and New Zealand (HEPA 2020) Per and poly-fluoroalkyl substances (PFAS) National Environmental Management Plan.
- NSW EPA (2014). Waste Classification Guidelines – Part 1 Classifying Waste.
- NSW EPA (2016). Addendum to the Waste Classification Guidelines (2014) – Part 1 Classifying Waste.
- NSW Acid Sulfate Soils Management Advisory Committee (ASSMAC), 1998. Acid Sulfate Soil Assessment Guidelines. August 1998.

The most applicable land use scenarios in the ASC NEPM 2013 for the Marina site are:

- residential (should there be future high density residential as part of the Marina Building);
- recreational/open space (for open space areas); and
- commercial/industrial land use (for the proposed commercial occupants of the Marina Building and carpark areas along the western and southern sides of the site).

The most sensitive users of each area of land use should be covered by the adopted screening criteria. Therefore, the Marina Building area land use should adopt the high-density residential criteria.

The human health based screening criteria are listed below in Table 9.1.

Table 9.1 Adopted human health screening criteria

Guideline	Screening criteria adopted	CoPC
ASC NEPM (NEPC, 2013)	Table 1A(1) Health investigation levels (HILs) for soil contaminants: • HILB (residential with minimal opportunity for soil access); • HILC (open space); and • HILD (commercial / industrial).	Metals, polycyclic aromatic hydrocarbons (PAHs), phenols, benzenes, volatile organic compounds (VOCs), semi volatile organic compounds (SVOCs), organochlorine pesticides (OCPs), polychlorinated biphenyls (PCBs)
ASC NEPM (NEPC, 2013)	Table 1A(3) Health screening levels (HSLs) for vapour intrusion: • $HSL_{A/B}$ (residential); • HSL_C (recreational/open space); and • HSL_D (commercial/industrial).	Total recoverable hydrocarbons (TRH), benzene, toluene, ethylbenzene, xylenes and naphthalene (BTEXN)
Friebel, E. and Nadebaum, P. (2011)	Table B4 HSLs for direct contact: • HSL_B (high density residential); • HSL_C (recreational/open space); and • HSL_D (commercial/industrial). Table B3 HSLs for vapour intrusion: • Intrusive Maintenance Worker; 0 to 2 m; Sand (most conservative value adopted).	
ASC NEPM (NEPC, 2013)	Table 1B (7) Management Limits: • Residential/parkland/open space for TPH fractions F1-F4 in soil coarse soils (most conservative value adopted).	Total Petroleum hydrocarbon (TPH) fractions
USEPA (2018)	• Regional Screening Levels (RSLs) – Industrial Soil	CoPC without HIL or HSLs
PFAS NEMP (HEPA 2020)	Table 2 Soil – Human health screening values • Residential with minimal opportunities for soil access (HIL B); • Public open space (HIL C); and • Industrial/commercial (HIL D).	Perfluorooctane sulfonate (PFOS)/ Perfluorohexane sulfonate (PFHxS), perfluorooctanoic acid (PFOA)

It is noted that asbestos will be analysed for absence and presence only, as such the asbestos results will not be compared to the quantification levels in the ASC NEPM 2013.

The ecological based screening criteria are listed below in Table 9.2.

Table 9.2 Adopted ecological health screening criteria

Guideline	Screening Criteria Adopted	CoPC
ASC NEPM (2013)	Ecological Investigation Level (EIL) [Ambient Background Concentration (ABC) + Added Contaminant Level (ACL)]: • Table 1B(1) Soil-specific added contaminant limits for aged zinc in soil; • Table 1B(2) Soil-specific added contaminant limits for aged copper in soils; • Table 1B(3) Soil-specific added contaminant limits for aged chromium III and nickel in soil; and • Table 1B(4) Generic added contaminant limits for lead in soils irrespective of their physicochemical properties.	Zinc, copper, chromium, nickel, lead

Table 9.2 Adopted ecological health screening criteria

Guideline	Screening Criteria Adopted	CoPC
	• Table 1B(5) Generic EILs for aged arsenic, fresh dichlorodiphenyltrichloroethane (DDT) and fresh naphthalene in soils irrespective of their physicochemical properties.	Arsenic, DDT and naphthalene
	• Table 1B(6) ESLs for TPH fractions F1 – F4, BTEX and benzo(a)pyrene in soil.	TRH, BTEX, benzo(a)pyrene
PFAS NEMP (HEPA 2020)	• Table 3 – Ecological guidelines for soil – ecological direct exposure – all land uses.	PFOS / PFOA
	• Table 3 – Ecological indirect exposure – all land uses.	PFOS
ASSMAC (1998)	Table 4.4: • Acid trail criteria >1,000 tonnes disturbed; • Coarse Texture Sands to Loamy Sands; and • <5% clay content.	Peroxide Oxidisable Sulfur (POS) Titratable Peroxide Acidity (TPA)

It is noted that the EILs and ESLs are only applicable to the top 2 metres. For contaminants that do not have an EIL in the NEPM guidelines, the Canadian EILs should be adopted.

It is noted that the Added Contaminant Level (ACL) for the EIL criteria for metals will be selected based on the NEPM Soil Parameters Suite (Cation Exchange Capacity (CEC), pH, clay content and grain size) in accordance with Table 1B(1) to (4) in ASC NEPM (NEPC 2013).

The ABCs considered applicable to the investigation area and that will be adopted are those published in ASC NEPM 2013 Schedule B5c from Olszowy et al. (1995) for old suburb with high traffic in NSW (lead: 160 mg/kg; nickel: 5 mg/kg; chromium: 15 mg/kg; zinc: 120 mg/kg; arsenic: 5 mg/kg; and copper: 30 mg/kg).

Soil analytical results will also be compared (where required) to the NSW EPA (2014) Waste Classifications – Part 1 Classifying waste and – Part 4 Acid sulfate soils, including the concentration threshold (CT) and specific contaminant concentration (SCC) values. Given that the site is part of a sensitive waterway, it is important that contaminants in fill also have a low leachate generation potential. Consequently, for any substance that exceeds the general solid waste (GSW) CT criteria, a neutral leachate test should be performed to demonstrate the soil has a leachate concentration less than the toxicity characteristic leachate procedure (TCLP) GSW criteria.

9.1.2 Groundwater criteria

The following guidelines will be adopted for the screening of groundwater data:

- ASC NEPM (NEPC 2013). Health Screening Levels (HSLs) for Groundwater.

The following guidelines will also be adopted for the assessment of groundwater concentrations based on ASC NEPM (NEPC, 2013):

- Australian Drinking Water Guidelines Paper 6, National Water Quality Management Strategy. NHMRC National Resource Management Ministerial Council (NRMMC), Commonwealth of Australia, Canberra Version 3.5, August 2018. (NHMRC 2018). And as tabulated in Schedule B1 of NEPC (2013);
- Drinking Water Guidelines. World Health Organisation, 2011 (WHO 2011);
- Petroleum Products in Drinking Water. World Health Organisation, 2008. (WHO 2008);

- USEPA. Regional Screening Levels (RSLs) - Generic Tables, Tables as of May 2020;
- Australian and New Zealand Governments (ANZG) 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality; and
- Australia Heads of EPAs Australia and New Zealand (HEPA) (2020) Per and poly-fluoroalkyl substances (PFAS) National Environmental Management Plan (NEMP).

As there are no drinking water receptors identified in the preliminary conceptual site model (CSM), the drinking water guidelines will be multiplied by 10 to use as screening criteria for recreational receptors.

The adopted screening criteria are listed below in Table 9.3.

Table 9.3 Groundwater screening criteria

Receptor	Guideline	Level adopted
Human Health	Friebel, E. and Nadebaum, P. (2011)	Table 1A(4) Groundwater HSLs for Vapour Intrusion: • HSL A&B (residential) • HSL C (recreational/open space) • HSL D (commercial/industrial)
	NHMRC (2011)	Health Drinking Water Guidelines*
	WHO (2008)	Petroleum Products in Drinking Water*
	WHO (2011)	Drinking Water Guidelines*
	ANZG (2018)	Recreational primary contact
	US EPA (2016)	Regional Screening Levels – Tap water*.
	HEPA (2018)	Recreational water
Ecological	ANZG (2018)	Marine - Highly disturbed systems
	HEPA (2018)	Interim marine - Highly disturbed systems

*groundwater screening criteria multiplied by 10 to be applicable to recreational receptors.

9.1.3 Surface water

Surface water samples analytical results will be compared to ANZG (2018) Guidelines for Fresh and Marine Water Quality.

ANZG (2018) provides trigger values for chemicals within the water, which represent estimates of the concentration of chemicals that should have no significant adverse effects on the aquatic ecosystem. EMM notes that trigger values are not intended to determine whether there is significant risk to the health of aquatic organisms, rather they are to be used to indicate whether or not further investigation and consideration of the risks may be required.

ANZG (2018) Marine trigger levels for 95% species protection (given that the ultimate receiving water is Botany Bay) would typically apply for non-bioaccumulative chemicals. However, for PFOS and PFOA, the 99% percent species protection level would apply, to allow for potential bioaccumulative effects.

Where there is no applicable trigger value for the CoPC, the LOR will be adopted as the screening criteria.

9.1.4 Hazardous ground gas assessment criteria

The following guidelines will be adopted for the screening of HGG data:

- NSW EPA (2016) Environmental Guidelines Solid Waste Landfills, Second Edition
- NSW EPA (2020) Contaminated Land Guidelines Assessment and management of hazardous ground gases.

A summary of the application of the screening criteria is provided below.

Table 9.4 Hazardous ground gas screening criteria

Guidelines	Level adopted	CoPC
NSW EPA (2020) Assessment and management of hazardous ground gases	Gas Screening Value (GSV) to be calculated using the flow rate (L/hr) and concentration (%) to determine characteristic gas situation (CS). GSV = maximum borehole flow rate (L/hr) x maximum gas concentration (%).	Methane and carbon dioxide
NSW EPA (2016) Environmental Guidelines Solid Waste Landfills	Threshold values for methane (1% volume/volume) and carbon dioxide (1.5% volume/volume).	Methane and carbon dioxide

9.1.5 Sediments

The current assessment criteria used in NSW to assess sediment, marine water quality, dredging and environmental impact assessment are based on the following guidelines:

- CSIRO Revision of the ANZECC/ARMCANZ Sediment Quality Guidelines (CSIRO 2013).
- National Assessment Guidelines for dredging (NADG 2009).
- For the purpose of screening sediment quality, the CSIRO (2013) revised guidelines provide sediment quality guideline values (SQGVs) and SQG-high values. Low SQGV (or trigger value) concentrations are threshold concentrations, and below this concentration the frequency of adverse biological effects is expected to be low. SQG-high values represent a high probability of effects.

The sediment guidelines were developed to serve three principal purposes:

- to identify sediments where contaminant concentrations are likely to result in adverse effects on sediment ecological health;
- to facilitate decisions about the potential remobilisation of contaminants into the water column and/or into aquatic food chains; and
- to identify and enable protection of uncontaminated sediments.

In addition, the guideline numbers are trigger values that, if exceeded, prompt further action as defined by the decision tree detailed in the guidelines. The first-level screening compares the trigger value with the measured value for the total contaminant concentration in the sediment. If the trigger value is exceeded, then this triggers management/remedial action or further investigation to consider the fraction of the contaminant that is bioavailable or can be transformed and mobilised in a bioavailable form.

In the absence of the guideline values, laboratory limits of reporting (LORs) will be used as an initial screen to assess the contaminant concentrations in the sediments.

9.1.6 Aesthetics

In addition to the criteria outlined in this RAP, aesthetics, specifically odour, discolouration and soil structure will be assessed during remediation. The dredge pond currently supports fish and waterbirds.

The Remediation Acceptance Criteria (RAC) for aesthetics are:

- soil or dredge pond water is not discoloured as a result of contamination;
- soil or dredge pond water is not malodorous as a result of contamination; and
- the soil retains a structure and form that can be considered natural, given the soil type and observed natural soil structures in the area.

9.1.7 Geotechnical criteria

Fill is to be placed, compacted and geotechnically tested at the Marina site in accordance with Australian Standard AS3798-2007 'Guidelines on earthworks for commercial and residential developments', with geotechnical validation data to be either included in the validation report or a standalone report.

10 Remediation trials

10.1 Context

The redevelopment of the Marina site from a disused quarry to a Marina incorporating open space and commercial areas will provide significant environmental and community benefits compared with the land in its current condition. These benefits include:

- improvement of amenity;
- removal and management of existing contamination to a standard suitable for the proposed land use, with associated improvements to local groundwater and surface water quality; and
- public access to the Marina site, associated open space and Georges River.

Based on the background information summarised in Section 5.2, the remediation of the Marina site will present a number of remediation challenges, including (but not limited to):

- management of anthropogenic fill materials;
- management of HGG;
- management of acid sulfate soil; and
- management of dredge pond sediment and surface water quality.

Some of these challenges (in particular anthropogenic fill, HGG and acid sulfate soils) have been previously considered by Benedict who have conducted a program of trials on the neighbouring Benedict north site as reported in the Douglas Partners (2017) RAP. The outcome of these trials may be applicable to the remediation works conducted on the Marina site and are described in the following sections.

10.2 Landfill gas reduction trials (north of the Marina site)

The Benedict north site, which is located to the north and directly adjacent to the Marina site has been subject to a number of small HGG treatment trials with the objective of monitoring HGG in the vicinity of backfilled and screened excavations to evaluate whether the process resulted in a reduction in HGG (methane) concentrations. The screening process is understood to have included the removal of methane generating timber from the fill that was retained on the screen prior to backfilling with the residual material.

Both monitoring wells monitored during the trial (designated as JK102 and JK107) had previously recorded methane concentrations of around 30 %v/v. JK102 was retained following backfilling of the excavation and has since recorded methane concentrations of between 12 %v/v and 13.2 %v/v over three monitoring events suggesting a reduction in methane concentration volume of two thirds of those prior to excavations. JK107 (destroyed) was replaced by JKBH/MW107a following backfilling of the excavation. A shallow gas well, JK107b, was installed adjacent to JKBH/MW107a. The wells have recorded methane concentrations of:

- JKBH/MW107a – between 3 %v/v (first monitoring event following backfilling) and 16.4 %v/v (most recent monitoring event following backfilling) over three monitoring events suggesting a gas concentration reduction of half; and

- JK107b – between 10.2 %v/v (first monitoring event following backfilling) and 17.3 %v/v (most recent monitoring event following backfilling) over three monitoring events suggesting a gas concentration reduction of half to one third.

The results at JKBH/MW107a and JK107b indicated a trending increase in methane concentrations but still significantly less than the original results. It is understood that ongoing HGG monitoring was being conducted as part of the trial as reported by Douglas Partners (2020).

The separation/screening of excavated material and backfilling of these excavations was undertaken by Benedict and it is reported by Douglas Partners (2017) that timber was removed from the fill. Removal of methane generating timber also has the potential to reduce leachate generation impacts to groundwater.

Another larger HGG reduction trial has also been reported by Douglas Partners (2017) which involved the excavation of an area known as the central 'deep fill' portion of the site north of the Marina site. The primary purpose of the trial, as with the earlier trial, was to stockpile, screen timber and excess waste materials and backfill the excavation and monitor HGG in the vicinity of the backfilled excavation to evaluate whether the process resulted in a reduction in methane concentrations in the relevant adjacent monitoring wells. The secondary purpose of the trial was associated with geotechnical site improvement.

The screening process is understood to have included the removal of methane generating timber from excavated fill which was subsequently screened and reinstated. The process reported by Douglas Partners (2017) involved the following:

- The excavation was being dewatered by a pump and dewatered fluid was discharged overland to flow into the dredge ponds located to the south of the proposed development.
- Excavation of those fill materials that presently comprise a significant contribution to HGG and leachate, followed by their separation into various product / waste streams.
- Oversize concrete and brick (>120 mm) was to be crushed and reused on-site as a coarse fill.
- Soils were being screened and then hand-picked to remove unsuitable materials. The screen fractions were <16 mm, 16–40 mm and 40–120 mm.
- Timber waste was being removed from the fill and recycled at a licensed Benedict green waste facility.
- Metal waste was removed from the fill for recycling by a metal waste recycler.
- Other deleterious materials extracted from the excavated material (eg rubber, plastics, vegetation, asbestos, bitumen, drums/containers) were removed from the fill and disposed to landfill.
- Residual coarse fill and soils were subsequently treated and validated to criteria specified in the Douglas Partners (2017) RAP and validated.

10.3 Potential acid sulfate soil, base of current trial remediation (north of the Marina site)

During the conduct of the HGG remediation trials documented by Douglas Partners (2017) on the site north of the Marina site, iron staining at the base of the excavation was observed, which was noted to have been potentially indicative of the oxidation of naturally occurring acid sulfate soils beneath the fill. This material is considered to be representative of the conditions that may be encountered at the Marina site during bulk earthworks and landforming. Testing of the soils and water at the base of the excavation was subsequently undertaken to evaluate whether:

- potential acid sulfate (PASS) soils were being oxidised;
- the pH and dissolved metal concentrations in the dewatered fluid was being affected by the generation of sulfuric acid; and
- liming of the excavation base should occur to neutralise the acid generating capacity of any exposed PASS (if present).

Douglas Partners (2017) reported that stockpiled material from the excavation (designated stockpile SSP1) was tested and reported (Validation of Screening Process) on 8 June 2016, and subsequently on 5 October and 13 October 2016. The assessment comprised:

- testing of approximately 4,400 m^3 of <16 mm screened material from stockpile 1 (SSP1); and
- testing at the base of the excavation (acid sulfate soil sample and dewater sample).

The results of the testing indicated that:

- one of the two samples analysed was characterised as potential acid sulfate soil (PASS). The water sample (field filtered) collected from the ponded water at the base of excavation reported relatively low concentrations of dissolved metals compared to those detected in groundwater wells in the vicinity of the excavation;
- organic matter results on soil ranged from 18,000 mg/kg to 23,000 mg/kg indicating that organic matter in the screened soil is 1.8% to 2.3%;
- foreign materials content test on soil (bulk >10L sample) ranged from 1% to 2.4% (i.e. <5% which was the nominal target set by the RAP);
- a grid-based walkover over accessible areas of the northern 'raw feed' stockpile was undertaken and four fragments of asbestos containing material (ACM) were observed. The southern 'raw feed' stockpile was inaccessible due to steep stockpile walls;
- asbestos (ACM or fibrous asbestos (FA) and asbestos fines (AF)) was detected in five of the eight 500 ml samples and the concentration of FA and AF in one sample exceeded the NEPC residential land use criterion of 0.001% w/w; and
- PCB was recorded in all soil samples, however, at concentrations that were below the adopted remediation acceptance criteria (RAC) for the Benedict Site of 1 mg/kg.

The following summary was provided by Benedict to DP in relation to the screening process for materials from SSP1:

- prior to processing the material is dampened or is damp due to the nature of the material and the location from where it has been removed;
- whilst screening the material to remove timber and other contaminants no asbestos pieces are or have been picked/removed during the screening process;
- all pickers (labourers) on the conveyer wear PPE gear which includes eye, hearing, hard hats, gloves and P2 respirator masks;

- since the commencement of screening operations on 3 March 2016 and 14 June 2016, Prensa (NATA accredited environmental consultants) were contracted to carry out airborne asbestos monitoring on site at Moorebank whilst screening operations are active;

- 237 individual (air) monitoring samples were reported. The airborne asbestos monitors are placed on picking platforms adjacent to pickers and inside earthmoving equipment such as excavators and wheel loaders working on the screening process;

- no asbestos fibres were reported in the samples analysed; and

- during the placement of the screened material, airborne asbestos monitoring was conducted, and a water cart used to dampen excavated material (if required).

10.4 Compaction trials on landfilled waste (north of the Marina site)

Based on information documented in Douglas Partners (2017), two Trial Areas designated A and B were subjected to forty passes of a three-sided roller to assess the effectiveness high energy impact compaction (HEIC) on the site north of the Marina site. The results of the trial indicated that after 40 passes of HEIC, the near surface profile appears to have been compacted in both trial areas based on the low to medium results of the 'continuous impact response'.

The measured settlements indicated an average settlement of 63 mm for Area A and 60 mm for Area B. Area A ranged from less than 20 mm to 200 mm with some minor areas up to 300 mm. Area B has a similar range of settlement. The difference in settlements is often expressed over a short distance and was not uniform across the site.

HEIC is generally considered to be effective over depths of about 1–2 m for clayey material which appears to make up most of the filling material where the trial was conducted on the site north of the Marina site. Therefore, it could be expected that HEIC has created a compacted layer of approximately 1−2 m thick across the trail area. However, the filling beneath 'compacted layer' is expected to have not been noticeably affected by the HEIC. It was concluded that the HEIC provided a relatively uniform subgrade over the trial areas except for one localised area.

The compaction trials undertaken on the northern portion of the Benedict site are considered relevant to the Marina site, as similar uncompacted ground may be encountered, and similar technologies may be adopted to make the ground suitable for the future land use.

11 Remediation objectives

The goals of the remediation are to render the Marina site suitable for the proposed Marina development. In doing so, the potentially complete exposure pathways between identified site contamination sources (ie localised soil contamination, surface water, groundwater and HGG) and receptors will need to be rendered incomplete.

Additional remediation goals include:

- demonstrating that the proposed remediation strategy for the Marina site is environmentally justifiable, practical and technically feasible;
- adopting remediation criteria appropriate for the future use(s) of the Marina site to mitigate possible impacts to human health and the environment;
- mitigating possible off-site migration of contaminants;
- consideration of the principles of ecologically sustainable development in line with Section 9 of the CLM Act;
- minimising waste generation under the Waste Avoidance and Resource Recovery Act 2001; and
- demonstrating that the plans for site management or remediation work consider issues related to worker health and safety, environmental management, community relations and site contingencies such as unexpected finds.

12 Assessment of remediation technologies

The different types and extent of contamination identified at the Marina site requiring remediation are summarised in Section 12.1. Applicable technologies suitable for remediating this type of contamination are summarised in the following sections.

12.1 Contaminated soil

The different types of contaminated soil requiring remediation include the following:

- surface soils and fill contaminated with asbestos;
- contaminated soil hot-spots (likely to include heavy metals);
- aesthetically unsuitable fill due to the presence of a high proportion of anthropogenic material; and
- ASS/PASS that needs to be excavated.

The remediation options applicable to these types of contamination commonly include the following (in order of the preferred NEPM hierarchy):

- excavation and on-site treatment by screening or liming (for ASS) followed by on-site reuse;
- excavation/scraping and hen-picking of asbestos fragments;
- capping;
- excavation and on-site burial; and
- excavation and off-site disposal.

12.2 Dredge pond sediments and surface water quality

Sediment and surface water quality requiring remediation or management at the Marina site include:

- contaminated surface water runoff from off-site sources impacting water quality in the Marina basin; and
- resuspension of dredge pond sediment due to the:
  - excavation of dredge pond sediment;
  - construction of the fill platform for the marina building;
  - driving piles;
  - placement of rock rip-rap; and
  - run-off from construction areas.

12.3 Landfill gas

Based on the HGG concentrations previously detected at the Marina site, it is anticipated that either no management (for unsealed open space areas) or passive management techniques would be appropriate to mitigate HGG hazards that may be identified as an outcome of additional investigations undertaken as part of the future remediation and landforming works.

12.4 Contaminated groundwater

Based on the results of previous investigations, it Is not anticipated that contaminated groundwater would be of concern at the Marina site. Notwithstanding, groundwater may require remediation or management at the Marina site if:

- impacted by leachate produced by anthropogenic fill present on-site; and
- impacted by contaminated groundwater migrating on site.

13 Remediation options evaluation and preferred remediation option

13.1 General

In general, options for remediation include the following, given in the NSW EPA's preferred order (DEC 2006):

- on-site treatment of soil (including HGG producing fill) and dredge pond sediment so that the contaminant is either destroyed or the associated hazard is reduced to an acceptable level;
- off-site treatment of soil (including HGG producing fill) and dredge pond sediment so that the contaminant is either destroyed or the associated hazard is reduced to an acceptable level, after which the soil is returned to the site;
- removal of contaminated soil and dredge pond sediment to an approved site or facility, followed where necessary by replacement with clean fill;
- consolidation and isolation of the contaminated soil and/or dredge pond sediment by on-site containment beneath a properly designed barrier (eg a cap); and
- leave the dredge pond sediment in its current state to avoid disturbance and potential mobilisation of contaminants if additional investigation data indicates the sediment is suitable to remain in situ.

These options were assessed with consideration of the known conditions on the Marina site and the practicality and cost associated with on-site treatment, off-site treatment and wholesale excavation. Where appropriate, the project would aim to retain suitable materials on site to ensure compliance with NSW EPA's waste hierarchy as follows:

- Waste avoidance - including action to reduce the amount of waste generated by households, industry and all levels of government;
- Resource recovery - including re-use, recycling, reprocessing and energy recovery, consistent with the most efficient use of the recovered resources; and
- Waste disposal - including management of all disposal options in the most environmentally responsible manner.

Offsite disposal is the least preferred option whereas waste avoidance is the preferred option.

The RAP has evaluated remediation options for the three main types of contamination that need to be remediated, these being:

- contaminated soil (Section 13.2);
- dredge pond sediment and surface water quality (Section 13.3);
- HGG (Section 13.4); and
- contaminated surface water and groundwater (Section 13.5).

Based on the current concept design and with consideration of the proposed landform for the site north of the Marina site, development of the Marina site will require bulk earthworks to facilitate final landform shaping (including road levels and drains) to proposed design surfaces. Additionally, the proposed design includes removal of some materials currently submerged by the dredge pond as well as backfilling portions of the current dredge pond to create area of reclaimed land. The use of clean and validated soils to achieve design levels at the Marina site will effectively form a cap which can be utilised to address some of the issues posed by contamination at the Marina site and has been considered when evaluating remediation options.

13.2 Remediation options for residual soil contamination

The proposed development will likely involve the regrading of surface levels to accommodate the Marina design and may involve the reuse of suitable materials won from the site during bulk earthworks and landforming and/or the importation of VENM. Options for soil and sediment remediation include:

- Option 1: Do nothing;
- Option 2: Off-site treatment prior to off-site disposal or onsite reuse;
- Option 3: Off-site disposal to landfill;
- Option 4: Containment of the impacted soil on site beneath an engineered barrier or cap; and
- Option 5: On site treatment of contaminated soil (eg ASS liming) and reuse/burial of suitable materials to the extent practical; off-site disposal of hotspot material and other unsuitable materials via targeted excavation and validation, capping of site with clean material to achieve design levels and finished remediated surface.

Table 13.1 Contaminated soil remediation options

Option	Evaluation	Option ranking
Option 1: Do nothing	In the context of the proposed development, significant bulk earthworks and landforming works will be required, therefore this option is not considered appropriate.	Not applicable.
Option 2: Off-site treatment prior to off-site disposal or onsite reuse/burial	There is anthropogenic fill on the Marina site including soil and fill contaminated with ACM, contaminated soil hot-spots and aesthetically unsuitable fill and ASS that needs to be managed. ACM impacted soil, anthropogenic fill and ASS are readily amenable to treatment onsite via screening (ACM and fill) and liming (ASS) and therefore offsite treatment prior to offsite disposal or onsite reuse is considered unnecessary.	Not applicable.
Option 3: Off-site disposal to landfill	This option is achievable and practical for near surface contamination. It is not considered appropriate for deeper (eg >2 m) contamination for economic and sustainability reasons. Excavation could be adopted to facilitate the removal and off-site disposal of hotspots identified during the additional site investigation works and unexpected finds.	Applicable, contingency

Table 13.1 Contaminated soil remediation options

Option	Evaluation	Option ranking
Option 4: Containment of the impacted soil on site beneath an engineered barrier or cap	In the context of the proposed marina development, bulk earthworks and landforming will be required to achieve design levels which will require the reuse of clean and validated onsite materials and/or importation of VENM for use as engineered fill, which can be used as a cap overlying any residual soil contamination that may be present. This option would minimise the requirement for additional investigations and possibly minimise the requirement to remove soil contamination 'hotspots', however the practicalities of this approach would need to be confirmed following completion of the detailed design for the Marina site.	Applicable, contingency
Option 5: On site treatment of ASS and reuse/burial of suitable materials to the extent practical; off-site disposal of hotspot material and other unsuitable materials via targeted excavation and validation, capping of site with clean material to achieve design levels and finished remediated surface	There is anthropogenic fill on the Marina site including soil and fill possibly contaminated with ACM, contaminated soil hot-spots and aesthetically unsuitable fill due to the presence of a high proportion of anthropogenic material and ASS that needs to be managed. An intrusive investigation program to refine the understanding of these hotspots is proposed as part of preliminary works at the site, which is discussed in Section 8. Residual contamination hotspots will be remediated via targeted excavation for offsite disposal and subsequent validation to confirm the hotspot has been appropriate removed. Excavation/scraping and hen-picking of residual asbestos fragments for off-site disposal of ACM and unsuitable fill material to a licensed facility followed by validation sampling. Excavation and on-site treatment of ASS or placement below water table. Screening and disposal of anthropogenic materials may also have a secondary benefit of reducing concentrations of HGG. The screened anthropogenic waste material would be disposed off-site and the remaining materials returned to the excavation. Capping of impacted soils using either site-won materials validated as suitable for use on-site, or imported VENM can be achieved as part of the earthworks required to reach final site design levels. Additionally, buildings and hardstand cover, such as pavements, can be used as capping methods.	Preferred approach

13.3 Remediation options for dredge pond sediment and surface water quality

Construction of the Marina would require bulk earthworks to shape and stabilise the marina basin and foreshore areas. Some areas within the existing basins will be infilled to reclaim areas for the proposed landside development (eg Maritime Building) while other areas will be excavated to become part of the future marina basin.

An earthworks plan will be developed by the successful contractor to provide detailed earthworks design, plans of excavation and fill areas, construction methods and material management procedures. The following provides an indicative high-level approach to the marina construction for the purposes of the RAP.

Remediation planning for the appropriate management of the dredge pond sediment and associated surface water quality will involve the management of contaminated surface water runoff entering the Marina site from the north, flowing into the dredge pond and resuspension of dredge pond sediment caused by construction and land forming works.

Options for dredge pond sediment and surface water remediation include:

- Option 1: Detailed investigation with the data justifying adoption of a do nothing approach;

- Option 2: Construction of diversion drains to prevent runoff from the site to the north;
- Option 3: Capping or removal of contaminated dredge pond sediment by placement of rip rap or sand;
- Option 4: Use of silt curtains; and
- Option 5: combination of options 1–4.

The evaluation of remediation options for the dredge pond sediment and surface water quality management is outlined in the following table.

Table 13.2 Dredge pond sediment remediation and surface water quality management options

Option	Evaluation	Option Ranking
Option 1 Detailed investigation with the data justifying adoption of a do nothing approach	Further assessment of sediment and surface water quality is required to obtain sufficient data to support the do nothing approach in the dredge pond.	Possible
Option 2: Construction of diversion drains to prevent runoff from the site north of the Marina site entering the Marina site	Diversion drains could help to intercept surface water runoff but would not address the remediation of dredge pond sediment or management of existing water quality within the dredge basins.	Applicable contingency
Option 3: Capping or removal of contaminated sediment	Removal or capping of fine-grained sediments to reduce the potential for resuspension when the marina basin is opened to the Georges River.	Applicable contingency
Option 4: Use of silt curtains	Silt curtains are a fundamental component of suspended sediment control in waterways and would be integrated into the construction process, although alone they would not address all issues of water and sediment quality in the dredge basins or Georges River.	Applicable contingency
Option 5: Combination of applicable options 1–4 (subject to investigations outcomes)	A combination one or more of the above sediment and water management approaches would provide the best solution for the remediation of fine-grained sediments within the dredge basins and the management of water quality within the basins and in adjacent areas of the Georges River.	Preferred approach

During construction, surface water in the Georges River would be prevented from entering the marina basin construction area until the landforming works, and other marina infrastructure have been finalised. The existing riparian landform that separates the basins from the river would be retained until the end of the marina construction, and enhanced with additional barriers, such as coffer dams and/or silt curtains, if needed. These barriers would be removed carefully when flooding of the marina basin is undertaken.

Final details of the method for barrier removal will be included in the contractor's earthworks plan; however, barrier removal would aim to manage unintentional movement of sediment and/or turbid water between the marina basin and the Georges River. Silt curtains would be installed prior to barrier removal to reduce the movement of suspended sediments between the two water bodies. If a cofferdam has been installed across the marina entrance, the land barrier behind the cofferdam would be excavated and the edges of the entrance channel stabilised with rock armour prior to the staged removal of the cofferdam and associated silt curtains.

13.4 Remediation options for HGG

HGG monitoring data to date indicates that there is a potential for low concentrations of HGG to be present at the Marina site associated with buried anthropogenic fill material and adjacent offsites sources. Consequently, there is

a risk of the migration of HGG into structures associated with proposed Marina site development if not managed. The options for HGG remediation at the Marina site have been prepared with consideration to the measures proposed in DP (2017) to manage HGG on the adjacent Benedict north site.

Options for HGG remediation include:

- Option 1: Detailed investigation of HGG to demonstrate that HGG is below NSW EPA trigger values and justify adoption of a do nothing approach;
- Option 2: Complete removal of the HGG source;
- Option 3: Partial removal of the HGG source (partial solution that would need to be coupled with Option 4 or Option 5). Partial removal would involve either:
  - removal of pockets of fill with high organic content; or
  - removal of pockets of fill with high organic content and screening a proportion of the organic material out of the fill prior to its re-use to backfill excavation(s).
- Option 4: Engineered HGG mitigation measures for the entire site (eg drainage blanket across the entire site likely coupled with active HGG extraction system);
- Option 5: Engineered HGG mitigation measures (passive) for each structure (eg venting and/or gas resistant membranes beneath concrete slabs); and
- Option 6: Engineered HGG mitigation measures (passive and active) for each structure (eg active venting and/or gas resistant membranes beneath concrete slabs).

Table 13.3 Remediation options for HGG

Option	Evaluation	Option ranking
Option 1: Do nothing	Further assessment of HGG is required to obtain sufficient data to support the do nothing approach.	Possible
Option 2: Complete removal of the HGG source	There is a significant quantity of fill (ie a possible source of HGG) on the Marina site. Complete removal of the fill is not considered to be feasible or practical. This option is not considered appropriate.	Not applicable
Option 3: Partial removal of the HGG source	There is a significant quantity of fill (ie the primary source of the gas) on the site. Partial removal of 'unacceptable' gas generating fill may lower the CGS for the site and would be undertaken as part of the contaminated soil remediation works outlined in Table 13.1.	Preferred if option 1 is not available

Table 13.3 Remediation options for HGG

Option	Evaluation	Option ranking
Option 4: Engineered HGG mitigation measures for the entire site	Previously reported HGG concentrations are generally low. An active HGG mitigation system may not be suitable for residential land because effective long-term operation may not be feasible and is not warranted given the low reported concentrations.	Not applicable.
Option 5: Engineered HGG mitigation measures (passive) for each proposed structure	Given the low concentrations previously reported, the passive management option is considered both feasible and practical.	Preferred if option 1 is not available
Option 6: Engineered HGG mitigation measures (passive and active) for each proposed structure	This option is not considered to be feasible or practical due to the incorporation of active measures that would require ongoing maintenance.	Contingency.

13.5 Remediation options for contaminated surface water and groundwater

The condition of surface water and groundwater at the Marina site is not considered likely to require further remediation but will be subject to further monitoring during site remediation and construction. The scope of monitoring will be defined in the remediation works plan (RWP). In the event that surface water and groundwater monitoring shows a decline in conditions and consistent with the approach developed for the Benedict north site, remediation options could involve the following:

- additional surface water and groundwater monitoring with data justifying adoption of a do nothing approach;
- selective source removal including removal of onsite fill that has an elevated leachate generation potential; and
- short term monitoring to demonstrate a continued decrease in key contaminants emanating from the Marina site (as represented by water quality in the dredge pond with a contingency for groundwater investigation if considered necessary).

Source removal is the preferred strategy in combination with ongoing monitoring to confirm concentrations of CoPC in groundwater are acceptable.

13.6 Summary of preferred remediation options

Preferred remediation options are summarised below:

- Soil – On site treatment of ASS and reuse/burial of suitable materials to the extent practical; off-site disposal of hotspot material and other unsuitable materials via targeted excavation and validation, capping of site with clean material to achieve design levels and finished remediated surface.

- HGG – Do nothing (subject to the results of additional HGG investigations) or implementation of passive engineered HGG mitigation measures for proposed building structure if results of detailed HGG investigations indicate it is required.

- Dredge pond sediment – Subject to the outcome of additional sediment sampling, a combination of removal of contaminated sediment, completion of bulk earthworks and/or marina basin landforming including placement of infrastructure (eg piles and riprap).

- Groundwater and surface water – monitoring of dredge pond and Georges River water quality during remediation and construction (for a period of 12 months from the date of this RAP) to demonstrate that groundwater impacts are not occurring at the nearest sensitive receptor and that trends in improved water quality, since dredging ceased, continue and are thus not likely to impact water quality when the marina is opened to the Georges River.

- General:

    - removal of surficial ACM and unacceptable anthropogenic fill (based on exceedances of the RAC);

    - removal of buried services that may contain asbestos/wastes;

    - remove pockets of timber and other types of biodegradable waste; and

    - remove rubbish/oversize material that is geotechnical unsuitable for use as controlled fill.

The RAP has assumed that the preferred remediation strategy is to be applied across the whole site. Following completion of the detailed and additional site investigations, an RWP would be prepared for each development area (eg roads and infrastructure, open space, residential and commercial and marina basin areas documenting the specific requirements for each individual area. The establishment of whether any groundwater and/or surface water remediation is required (considered unlikely) will be evaluated as part of the proposed validation surface water monitoring programme.

14 Staged remediation works overview

14.1 General works program overview

The planning process (see Section 15) will need to be completed prior to commencement of the Marina site remediation works for each stage.

The detailed design for the marina, buildings and landscaped areas have not been prepared.

It is understood that the proposed constructions work will be completed immediately following remediation of each area. As such, the requirements for the placement of VENM may be mitigated based on the requirements of the proposed construction.

14.2 Project schedule

The remediation works have been organised into tasks that will allow the work to be undertaken in a practical and efficient manner that will be protective of human health and the environment. The preliminary task breakdown structure involves:

1. Obtain site auditor approval of the RAP by means of an interim advice letter;
2. Approvals process, including concept, project and development approval;
3. Completion of additional intrusive investigations (refer to Section 8);
4. Preparation of RWP's which would be informed by the findings of the additional investigations (refer to Section 14.5);
5. Site establishment, installation of environmental protection measures and environmental monitoring;
6. Establishment of the access road (with consideration of future vehicle movements), diversion drains for surface water management and set-down areas for use during the remediation and early works programme;
7. Decommissioning or appropriate protection of existing groundwater monitoring wells across the Marina site;
8. Removal of residual infrastructure (if any) in all areas of the Marina site incorporating appropriate environmental management measures (refer to Section 19).
9. Removal of all hotspots identified as an outcome of the site investigation scope;
10. Sorting, scraping and excavation of all unsuitable fill material including ACM for offsite disposal;
11. Hen-picking of scraped areas for any residual ACM;
12. Remediation oversight during bulk earthworks and landforming works (including the dredge basin) to ensure any materials remaining onsite are suitable for the proposed Marina site landuse;
13. Tracking of all excavated materials in accordance with the Materials Tracking Procedure (refer to Section 16.4);
14. Validation sampling to demonstrate compliance with the requirements of this RAP;

15. Excavation of any additional hotspot material exceeding the RAC (if encountered during validation) and then validation of additional excavations;

16. Backfilling of Marina site to design levels (as required) with suitable site-won materials and/or imported and validated VENM (refer to Section 17.2.4);

17. Decommissioning and demobilisation;

18. Reporting – preparation of a Validation and Remediation Report;

19. Preparation of a Section A Site Audit Statement confirming that the Site is suitable for the marina development;

20. Post-remediation surface water and groundwater monitoring (if required); and

21. Implementation of an ongoing long-term environmental management plan (if required).

Further refinement of the task breakdown structure will occur as part of detailed design and during the appointment and coordination of the work with the remediation/bulk earthworks contractor.

14.3 Remediation works overview

A summary of the proposed remediation works to be completed is provided in Table 14.1.

Table 14.1 Remediation works overview

Development Area	Remediation Process Summary
Area 1 Road and Infrastructure corridor	1) Initial screening of unsuitable fill materials for offsite disposal 2) Excavation and off-site disposal of all identified hotspots exceeding 250% of the adopted RAC 3) Excavation, scraping and hand picking of surficial ACM 4) Excavation and treatment of ASS (based on bulk earthworks and landforming requirements) 5) Validation sampling and analysis (including HGG monitoring) 6) Chasing out residual RAC exceedances and re-validation 7) Backfilling and compaction of the excavations to design levels with certified and validated VENM 8) Sealing of all road surfaces with hardstand
Area 2 Open space	1) Initial screening of unsuitable fill materials for offsite disposal 2) Excavation and off-site disposal of all identified hotspots exceeding 250% of the adopted RAC 3) Excavation, scraping and hand picking of surficial ACM 4) Excavation and treatment of ASS (based on bulk earthworks and landforming requirements) 5) Validation sampling and analysis (including HGG monitoring) 6) Chasing out residual RAC exceedances and re-validation 7) Backfilling and compaction of the excavations to design levels with certified and validated VENM 8) Post-remediation surface to be turfed or seeded and area fenced off and not utilised until development
Area 3 Commercial lots (marina buildings)	1) Excavation and off-site disposal of identified hotspots exceeding 250% of the adopted RAC. 2) Excavation, scraping and hand picking of surficial ACM 3) Excavation and treatment of ASS (based on bulk earthworks and landforming requirements) 4) Validation sampling and analysis

Table 14.1 Remediation works overview

Development Area	Remediation Process Summary
	5) Chasing out residual RAC exceedences and re-validation 6) Backfilling of the resultant excavation with validated VENM 7) Post-remediation surface to be turfed or seeded and area fenced off and not utilised until development
Area 4 Marina basin	1) Excavation and off-site disposal of identified hotspots exceeding 250% of the adopted RAC. 2) Excavation, scraping and hand picking of surficial ACM in areas that are not submerged 3) Bulk earthworks to obtain marina basin landform including removal of contaminated sediment 4) Validation of excavated materials to evaluate suitability for reuse or disposal 5) Excavation and treatment of ASS (based on bulk earthworks and landforming requirements including piling locations, other ground disturbance locations excavated for the construction of marina building) 6) Validation sampling and analysis of final marina basin landform 7) Chasing out residual RAC exceedences and re-validation 8) Backfilling of the resultant excavation with validated VENM where required to achieve design levels 9) Opening of channel to allow Georges River inflows into the remediated and validated marina basin

Further refinement of the task breakdown structure will occur as part of detailed design and during the appointment and coordination of the work with the remediation/bulk earthworks contractor and will be presented in the RWP prepared for each development area.

14.4 Hold points

Hold points following the completion of each individual work phase will be implemented. A hold point is a mandatory verification point beyond which work cannot proceed without approval by the designated authority, typically the site auditor, environmental consultant and geotechnical engineer. Work cannot proceed until receipt of a hold point release issued by the person(s) whom inspected the work. The purpose of the hold points is to provide assurance that the scope of assessment and remediation works as outlined in the RAP and detailed in the RWP's prepared for each development area have been appropriately completed and verified.

Specific hold points have been detailed below:

1. removal and validation of all hotspots identified as an outcome of the site investigation scope;

2. completion of sorting, scraping and excavation of all unsuitable fill material including ACM for offsite disposal and hen picking of scraped areas for ACM;

3. completion of capping;

4. completion of marina basin and site land forming works; and

5. completion of validation sampling.

For each of the above, the inspection and documentation of these processes would constitute hold point before further related works are contemplated. Hold point compliance would include the following:

- written confirmation of that all identified hotspots and potentially contaminated buried services have been removed from the area, validated by the environmental consultant and appropriately backfilled;

- the Site Auditor has inspected and confirmed the suitability of the work conducted at each hold point; and
- written confirmation of geotechnical suitability of site condition by a certified geotechnical engineer.

Specific details of hold point inspections will be provided in the RWP's prepared for each development area following completion of the detailed design.

14.5 Remedial work plans

Following completion of the detail design for the Marina site, RWP's will be required for each development area. The RWP's will not include any further information (not already in this RAP) regarding confirmation that the Marina site can be made suitable for the proposed land uses as these conclusions are solely provided within this RAP.

The RWP will provide a technical and staging specification for Benedict and its Remediation Contractor to assist in delivery of the remediation works, including required excavation and sampling plans.

15 Site establishment

15.1 Work to be completed prior to establishment

Prior to site establishment, all plans, programs, licences, certificates and other documents necessary for the commencement of work will be completed. These documents will include, but not be limited to the following:

- community consultation activities prior to the commencement of remediation work (refer Section 22).
- management Plans and Work Procedures for the remedial program addressing:
  - Occupational Health and Safety (OH&S);
  - Environmental Management;
  - Project Management;
  - Quality Management; and
  - Emergency Response and Contingency.
- detailed work program and logic diagram.
- all necessary licences and approvals from regulatory authorities, including:
  - State Environmental Planning Policy (SEPP) No. 55 – Remediation of Land, relates to the decision-making process for conducting remediation activities and making planning decisions regarding contaminated land. Category 1 remediation works require development consent while Category 2 remediation works do not. The proposed works at the Site are considered to be Category 2 works under SEPP 55, which require:
    - notification to Council at least 30 days prior to works commencing; and
    - at least 14 days prior to works commencing, provide copies of investigations reports and a remediation action plan, including contact details, to Council.
  - Submission of all SafeWork NSW notifications.
- structural and geotechnical engineer's reports where required.
- pre-dilapidation surveys.
- commissioning and mobilisation of plant.
- utilities.

15.2 Site preparation and installation of environment protection measures

The risks to the environment posed by the remediation and bulk earthworks program have been assessed as part of remediation environmental management planning (refer Section 19). Environmental protection measures required by the plan will be installed and commissioned at the beginning of the project during the site establishment stage and then operated and maintained throughout the period of the remediation and bulk earthworks. Work to be undertaken prior to remediation works include:

- establishment of site offices;
- demolition of existing structures and removal of concrete pavements, where required;
- establishment of exclusion zones; and
- establishment of the plant as required.

15.3 Site facilities and procedures

Site facilities required for the remediation works will be established in compliance with the relevant regulations. These facilities will be connected to appropriate utilities as required. All connections and reticulations will be carried out by licensed and qualified personnel in accordance with statutory requirements and standards.

Activities for the set-up of site offices, fencing, decontamination stations, environmental control measures and other associated facilities include:

- wheel wash zones at the entrance and exit points to the remediation area;
- stores, work sheds, lunchrooms and changing areas for the use of subcontractors and consultants;
- temporary site sheds, first aid and emergency facilities, bathroom facilities and decontamination units; and
- any additional facilities required to facilitate work in other areas of the Marina site, or in areas requiring additional safety measures.

It is noted that existing Marina site and adjacent buildings and infrastructure owned or leased by Benedict may be utilised for the remediation works.

15.4 Exclusion zones

Exclusion zones, if required, are areas of the Marina site that will be outlined in the occupational health and safety (OH&S) plan that either require additional protective measures or may require the adoption of additional OH&S requirements and work practices. Exclusion zones may also include other areas affected by emissions from the works being undertaken at any point in time. All Exclusion zones will incorporate a buffer area along the boundary of the zone.

The boundaries of the Exclusion zones will be defined by fencing and safety signs erected at regular intervals around each exclusion zone warning of the boundary of the exclusion zone, the nature of the hazard associated with it and access restrictions that apply for entry into the zone. Access of personnel into and out of the Exclusion Zones, will be controlled at a Decontamination Station, and will depend on the personnel classification. The location and extent of Exclusion Zones will be detailed in the OH&S plan and outlined in the site-specific safety induction.

15.5 Site access and security

15.5.1 General

Only authorised personnel and equipment will be allowed into the exclusion zones and other areas associated with the remediation works. Access will be strictly controlled throughout the course of the remediation works using the following procedures.

15.5.2 Working hours

It is anticipated that remediation works hours would be between the hours of 7 am and 6 pm Monday to Friday, and 7 am to 1 pm Saturdays. No remediation works would occur on Sundays and public holidays without prior approval from relevant authorities.

15.5.3 Site haul roads and parking areas

Existing roadways will be utilised as haul roads to the extent practicable. Traffic movements on-site will be directed around areas that are the subject of remediation works. Traffic travelling to and from the commercial areas to the east of the Marina site will be diverted along temporary access routes as required throughout the remediation works.

15.5.4 Site access

The primary access route to the Marina site will be via Brickmakers Drive or Newbridge Road. The entry point will control access to and around the Marina site during the remediation works.

All site personnel entering and leaving the Remediation works will be required to pass through the clean/dirty zone and the decontamination station.

15.5.5 Signage

Signage will be installed at the Marina site entrance detailing the location of:

- the Marina site offices;
- remediation works areas;
- decontamination units;
- first aid facilities; and
- parking.

Traffic restrictions will be installed to limit access into the Marina site and to ensure the safety of site visitors. Signage at the main gate will include after- hours contact details. As detailed in Section 15.5.5, additional signage will be erected along Exclusion Zone boundaries to restrict access to these areas to authorised personnel only.

15.5.6 Fencing

Security fencing may be required around the remediation works areas in the event that the Marina site is accessible. Additional fencing will be erected where necessary to secure portions of the Marina site.

15.5.7 Control of site entry and exit

Entry to any designated remediation works areas will be controlled through the use of a sign-on/sign-off log system at the main gate. Only authorised personnel will be allowed into the remediation works area.

Personnel will gain access to the remediation works area only after they have:

- attended and completed a site safety induction briefing (applicable to all site workers and visitors);
- are wearing all applicable PPE as detailed in the OH&S Plan; and
- been inducted into the OH&S Plan.

All construction vehicles and delivery vehicles will enter the Marina site through the nominated main gate.

In the event of an emergency on-site and the need for emergency services personnel to access the site works, the site access process may be expedited. In these situations, which require the need to minimise delays in accessing injured site personnel, prior arrangement will be made for special site access procedures. However, given the nature of the remediation works, all PPE and decontamination protocols will remain in effect at all times.

An Emergency Response Plan will be developed prior to site establishment detailing the specific procedures relating to site emergencies.

16 General remediation excavation and materials management

16.1 Excavation planning

The materials to be excavated comprise anthropogenic fill materials, natural soils and dredge pond sediment. Prior to commencement of excavations, detailed excavation plans will be prepared outlining the anticipated classification of materials and the results of the site investigations.

All remediation excavation works will be undertaken in accordance with the following procedures, in sequence:

- prior to commencement of excavations on each work shift, all necessary environmental, OH&S measures and related equipment will be established and all worker PPE and respiratory controls will be checked to ensure they are in full working order in accordance with the OH&S Plans;
- all excavation plant operators, haulage operators and supervisors will be made familiar with the excavation strategy, and all workers will be made aware of their responsibilities prior to the commencement of each shift;
- stockpile areas will be prepared with adequate capacity to receive the contaminated materials after excavation prior to the commencement of excavation;
- exclusion zones will be set up around the active remediation works areas and as required;
- all truck haulage roads will be made suitable for transportation and haulage of the excavated materials; and
- all haulage trucks will be covered prior to exiting the exclusion zone/excavation area and will be decontaminated at the end of each shift of haulage operations in accordance with the environmental management plan (EMP). All haulage trucks will be fitted with liquid seals which will be inspected daily to ensure their integrity.

All personnel, vehicles and equipment leaving the excavation enclosure will be properly decontaminated in accordance with the EMP outlined in Section 19.

16.2 Excavation operations

Excavations will be regularly inspected by a suitably experienced environmental engineer or scientist to confirm that the visual and olfactory characteristics of the excavated materials are consistent with expectations. These regular inspections will also serve to identify additional hotspots that may not otherwise have been identified by the previous site investigations. As required by the RAC, materials must also meet aesthetic requirements (ie no odours or discolouration in soils such as staining).

16.3 Water management

16.3.1 Subsurface water management

Water management is critical to successful remediation and reduction of cross contamination issues. Subsurface water from areas of the Marina site in which contaminated materials have been identified will be assumed to be impacted. Impacted surface water that may accumulate in a remediation area will be contained prior to being tested and where required, disposed of at a licensed waste facility.

A number of existing groundwater monitoring wells fall within the proposed bulk earthworks footprint and may require decommissioning prior to excavation. The wells should be decommissioned in accordance with the Minimum Construction Requirements for Water Bores in Australia (NUDLC 2012).

16.3.2 Surface water management

Surface water from remediated and undisturbed areas of the Marina site will be considered clean. Undisturbed surface water runoff will continue to follow existing drainage patterns, unless diversion from work areas is warranted. Surface water drainage will also be arranged so that surface water run-off from disturbed or contaminated areas does not enter remediated or undisturbed areas or the Georges River.

16.3.3 Measures to protect the Georges River

Specific measures that will be adopted to protect water quality within the Georges River include the preparation of a detailed erosion and sediment control plan (ESCP). The SESCP will be developed based on the requirements outlined in The Blue Book - Managing Urban Stormwater: Soils and Construction (Volumes 1 and Volume 2). The ESCP will incorporate the following minimum requirements:

- one or more drawings or maps (typically 1:500 to 1:1000 scale) showing the layout and details of erosion and sediment control measures;
- approach for connecting the Marina basin to the Georges River, including presentation of a detailed methodology of how water quality impacts will be mitigated. This should include, but not limited to, the use of physical water quality management measures such as floating siltation booms and provision of oil absorbent booms to address any accidental spillage, etc; and
- supporting commentary or construction notes containing explanatory text, calculations and diagrams as necessary.

Where applicable, the ESCP map should show detail the following activities:

- access and haulage tracks;
- stockpile and storage areas (if required, noting that that requirement for stockpiling is to be minimised;
- temporary work areas;
- materials processing areas;
- crossings (road and creeks);
- compound areas, such as the contractor's and the principal's facilities; and

- any other activities that might affect water quality.

The ESCP should be prepared with consideration to achieving compliance with the Georges River Water Quality and River Flow Objectives (https://www.environment.nsw.gov.au/ieo/georgesriver/report-02.htm) and must be revised whenever the construction program, scope of work or work methods change, whenever the work methods and control structures are found to be ineffective, or if so directed by the relevant regulatory authority.

More detailed information is provided regarding Environmental Management controls are provided in Section 19.

16.4 Materials handling

16.4.1 Materials tracking

All materials handled during the remediation works will be tracked in order to allow verification of the correct movement and handling. The system will track materials from cradle-to-grave, and will provide detailed information on the location and quantity of all material movements both on and off-site, so that the material being handled can be identified and accounted for. The tracking system shall include accurate tracking of stockpiles throughout the entire material handling stage and will included confirmation of stockpile locations via registered survey. This is to reduce the risk of cross-contamination between stockpiles.

Plans will be made with respect to the extent of each excavation. A register of all analytical results for stockpiles and excavations will be maintained throughout the validation works.

Standard forms shall be prepared as part of the Materials Tracking Procedure. The forms and their function shall include, but not be limited to:

- **Off-site Transport/Disposal Form** - Providing a record of materials removed from the Marina site and including the material type, quantity, origin, shipping destination and an approval by the environmental consultant that the material meets the disposal requirements.

- **Imported Fill Form** - Providing a record of materials imported to the Marina site including the date, material type, quantity, point of origin, intended use and the suitability of the material for use as backfill at the Marina site.

- **Material Excavation Form** - Providing a record of excavated materials for each excavation on the Marina site including the date, material type, excavated quantity, origin and intended destination.

- **Material Stockpiling Form** - Provides a record of all materials placed in stockpiles. The form will include the date, material type, stockpiled quantity, origin and intended end use.

Each form shall be completed on a weekly basis and collated into a cumulative log for each process on a weekly basis.

16.4.2 On-site transportation of material

Materials at the Marina site will be excavated, handled, moved, treated and stockpiled in a manner designed to minimise exposure to the environment. The following materials handling requirements will be developed for trucks transporting materials within the Marina site:

- Trucks carrying excavated materials will be covered and decontaminated in the wheel wash facility within the excavation area before exiting the area.

- Trucks will proceed directly to the soil stockpile area, as appropriate, along the predetermined haul roads.

- Trucks carrying contaminated materials will not be permitted to drive over areas of the Marina site which have previously been excavated, validated or reinstated.

- Empty trucks will return directly to the excavation are along predetermined haul roads.

- The validated excavation will be effectively isolated from contaminated areas of the Marina site by the use of physical means such as the placement of clean material bunds, temporary fences and by use of signage.

16.4.3 Off-site transportation of materials

The following materials handling requirements will be developed for trucks transporting materials away from the Marina site:

- Trucks carrying excavated materials will be covered and decontaminated in the wheel wash facility before exiting the excavation area and exiting the Marina site.

- Trucks carrying contaminated materials will be covered prior to exiting the Marina site and will remain covered until authorised to unload at the destination.

- Trucks will be fitted with seals to ensure that the movement of potentially saturated materials is undertaken appropriately. The integrity of the seals will be inspected and tested prior to commencement of each day's haulage works.

- Trucks will exit the Marina site through predetermined exit points and will follow a predetermined transport route to the destination (landfill or other).

16.4.4 Stockpiling of materials

Stockpile Locations

Given the proximity of the Marina site to the Georges River, and to minimise contaminated soil loss in the event of heavy rainfall or flooding, no permanent stockpiling of contaminated material (including soil, fill and waste materials) will be permitted. Soils that are contaminated or not suitable for reuse at the Marina site should be classified in-situ, or in the event of hotspots requiring characterisation temporarily stockpiled in bunded elevated areas for characterisation, then loaded directly onto trucks for expedited disposal. Soils that are contaminated but can reused at the site (based on the results of additional investigations and validation sampling) should be classified/validated in-situ wherever possible, then excavated and placed in the final location. Material movements will be tracked via registered survey as part of the Materials Tracking System.

For clean material, stockpiling will be minimised to the extent practical with material temporarily stockpiled in designated stockpile areas located on elevated ground and not flood prone areas. All stockpiling works of clean material should be temporary in nature (<24 hrs) with placement subject to consideration of up to date Bureau of Meteorology forecasts.

Stockpile Area Preparation

During site establishment, stockpile areas will be prepared using the following methods:

- works will be undertaken initially to clear the area of rubbish, rubble and vegetation;

- where possible, all material will be managed to limit stockpiling to minimise environmental hazards (such as flooding and erosion hazards) and reduce the requirement for validation sampling after the stockpile is removed;

- diversion drains and bunds will be constructed around the perimeter of the stockpile areas to minimise the potential for erosion. Additional sediment and erosion control measures including silt fencing and hay bales will be installed where necessary;
- signs will be erected at the entrance to the stockpile area and at locations around the stockpile specifying individual stockpile numbers and the type of materials stored; and
- buffer zones will be established around each stockpile area to enable access to the stockpiles and minimise impacts of the stockpile area on the surrounding facilities.

Stockpile Construction and Maintenance

The drainage, sediment and erosion control measures installed within stockpiling areas at the commencement of the project will be maintained, repaired and replaced where necessary for the duration of the stockpiling activities. All stockpiles will be maintained in a tidy and safe condition with stable batter slopes.

16.5 Material fate

Where possible, materials won from the screening of excavated materials will be assessed for their recycling suitability as follows:

- steel materials will be transported to appropriate off-site steel recyclers;
- concrete, brick and rock may be crushed to create fill for use in other areas of the development (as required) and for construction of haul roads or recycled off-site; and
- timber will be recycled off-site, where possible.

16.5.1 Waste classification

i General solid waste

Where off-site disposal is required, materials classified as General Solid Waste in accordance with the NSW EPA (2014) Waste Classification Guidelines will be transported off-site and disposed of at a landfill licensed to accept General Solid Waste

ii Restricted solid waste

Where off-site disposal is required, materials classified as Restricted Solid Waste in accordance with the NSW EPA (2014) Waste Classification Guidelines will be transported off-site and disposed of at a landfill licensed to accept Solid Restricted Waste.

If treatment of excavated material is required to facilitate off-site disposal, an Immobilisation Approval will be sought from the NSW EPA prior to off-site disposal.

iii Documentation

Waste disposal dockets and other relevant other waste documentation must be recorded and provided as required for any disposed waste.

16.6 Imported Soil

Soils to be imported to the Site to be used for the reinstatement of excavations or for constructing new land required by the Marina are to be VENM or excavated natural material (ENM) that has been obtained from reputable sources approved by the Site Auditor, tested and certified in accordance with NSW EPA requirements.

17 Waste containment and capping strategy

The overarching strategy for fill management at the Marina site is designed to ensure that no residual waste or existing anthropogenic fill materials remain at the surface, and any residual waste or fill materials that do remain are appropriately capped and covered to mitigate any human health and environmental risks and aesthetic issues. The strategy for waste containment and capping at the Marina site includes the following:

- prior to placement of any capping materials, the environmental consultant should visually confirm areas where existing residual waste materials are present;
- confirm that visually identified areas of residual waste requiring capping are consistent proposed landuse plans as outlined in the detailed design plans and RWP prepared for each development area;
- evaluate the contamination status of VENM/ENM source material prior to importing to the site;
- confirm that the VENM/ENM source material complies with the requirements of this RAP and the RWP prepared for each development area;
- once VENM/ENM suitability has been confirmed, commence importing VENM/ENM;
- place VENM/ENM in accordance with the specification outlined in the RWP's for each development area as informed by data obtained during additional investigations completed prior to remediation;
- maintain records of fill movement, importation and placement across the Marina site in accordance with the RWP requirements to provide to the environmental consultant to include in the final site validation report;
- the environmental consultant should inspect construction of each development area where capping is to be placed throughout construction at an initial frequency not less than once per week and record the inspection findings in the site inspection field record prepared in the field at the time of the site inspection. Inspection frequency can be reduced to coincide with the completion of specified completed areas once the suitability of any particular VENM/ENM source is established. A photographic record of site conditions should also be maintained; and
- the Site Auditor should inspect the capping layer when it has been completed in each applicable development area and before the commencement of other work in the area.

Imported VENM/ENM will be progressively validated as set out in the RWP for each area. Validation of the final surface of the capping materials will be undertaken by the environmental consultant via grid based sampling as detailed in the RWP's prepared for each development area. The analytical suite will be the same as set out in the RWP for each development area.

Minimum requirements for the containment and/or capping of buried contaminated soil in an area within the Marina site include the following:

- documented approval from the geotechnical engineer on the geotechnical suitability of proposed imported VENM/ENM;

- geotechnical confirmation that the proposal burial area is geotechnically suitable and subgrade meets all geotechnical requirements, certified in writing by a suitably qualified geotechnical specialist;

- the environmental consultant has certified in writing that all existing buried services have been removed from the area subject to burial and capping, validated by the environmental consultant and area backfilled in accordance with the geotechnical requirements;

- the environmental consultant has certified in writing that no underground services will be constructed in an area of buried and capped waste materials;

- the environmental consultant has certified in writing that the cap has been appropriately constructed with appropriate materials and validated in accordance with the RAP; and

- the Site Auditor has inspected the completed cap and confirmed suitability of the capped area for ongoing development in accordance with detailed design plan for the proposed land use.

It is noted the waste containment and capping approach outlined may not be required and is included in the RAP as a contingency measure only. Environmental risks associated with containing and/or capping contamination soil at the site would be managed by a long-term EMP prepared by the environmental consultant and would require approval by the Site Auditor and Council and attached to a Section A2 site audit statement (SAS).

18 Validation strategy

18.1 Validation principles

The validation principles that apply to the Marina site are listed below.

- Soils remaining on Marina site must comply with the soil RAC as detailed in Section 9.
- Soils to be imported to the Marina site to be used for the reinstatement of excavations or for constructing new land required by the Marina are to be VENM or ENM that has been obtained from reputable sources approved by the Site Auditor, tested and certified in accordance with NSW EPA requirements.
- Soils to be imported to the Site to be used for reinstatement of excavations must be validated VENM/ENM.
- Topsoil to be imported to the Site must comply with the human health-based soil RAC detailed in Section 9.

18.2 Soil validation

18.2.1 Hotspot excavations (RAC exceedences)

Following the completion of additional investigations to confirm the specific remediation requirements in each development area, hotspot excavations will be required where materials that exceed the RAC extend beneath the proposed general bulk earthworks removal level.

Validation samples will be collected from the walls and base of these hotspot excavations at a minimum rate of 1 sample per each wall and one sample per base. Where excavation walls are greater than 10 linear metres samples will be collected at rate of one sample per 10 metres of wall. Where the area of the base of the excavation exceeds 25 m^2, then samples will be collected at a rate of one sample per 25 m^2 of base.

Where there is a layer of fill and natural material on the walls, validation samples will be collected and analysed from both the fill and natural material for each wall.

Samples will be analysed for heavy metals (As, Cd, Cr, Cu, Hg, Pb, Ni and Zn), TPH/BTEX, asbestos (presence/absence), OCPs and PCBs and PAHs.

Excavated hotspot material will be temporarily stockpiled (whilst laboratory analytical results are pending) and tracked using a Materials Tracking Register. Samples will be collected at the following minimum rates for characterisation:

1. one sample per 25 m^3 for stockpiles less than 100 m^3.
2. four samples plus one sample per 100 m^3 for stockpiles greater than 100 m^3.

Samples will be analysed for heavy metals (As, Cd, Cr, Cu, Hg, Pb, Ni and Zn), TPH/BTEX, asbestos (presence/absence), OCPs and PCBs and PAHs (Total and TCLP) for characterisation prior to off-site disposal.

18.2.2 Validation strategy for existing fill remaining onsite

The validation strategy for existing fill remaining onsite will comprise the following:

- collection of in situ validation samples at a frequency of one sample per 500 m^3 calculated on a grid basis with scope to adjust the frequency to one sample per 1,000 m^3 depending on the consistency of the results. The sampling frequency is considered appropriate because there will be a considerable amount of data resulting from the completion of the detailed site investigations completed across each remediation development area prior to the commencement of remediation and validation works and this sampling frequency will provide a supplementary data set. Furthermore, imported VENM/ENM landscaping or hardstand will be placed above the existing fill limiting access;

- the stockpile soil sampling frequency of one sample per 500 m^3 for all contaminants of concern shall not be adjusted without prior written approval of the Site Auditor. A lower stockpile frequency for some analytes may be justified after the collection and testing of not less than 50 in situ validation samples;

- analysis of validation samples for metals, TRH, BTEX, PAH, OCP, OPP, PCB, Phenols and asbestos (10 L sample for ACM and 500 mL sample for FA and AF) Neutral leachate tests for heavy metals and PAHs should be undertaken at a frequency of not less than 10% of validation samples;

- the environmental consultant should inspect each stockpile during or following completion of the stockpile formation and again during its removal and placement and will record the inspection findings in the site inspection field record prepared in the field at the time of the site inspection;

- maintenance of a photo record of site conditions should also be taken;

- auditor inspection should take place as required by the auditor;

- collection and analysis of QA/QC samples as per Section 18.3.2;

- soil samples should be representative of the materials being validated and also target any suspect materials based on physical appearance; and

- the environmental consultant will undertake the validation sampling.

18.2.3 Visible asbestos across excavated surfaces

The validation strategy for visible asbestos will comprise the following:

- no visible asbestos is permitted to remain on excavated surfaces;

- following completion of excavations an appropriately trained environmental consultant or occupational hygienist will undertake a grid based inspection of the excavated surface and provide a written and photographic record confirming that no visible asbestos was present on the inspected excavated grounds surface;

- should visible bonded ACM be encountered during the inspection, the visible fragments should be removed (via hand picking) by an appropriately trained environmental consultant or occupational hygienist and appropriately disposed to a suitably licensed facility. All disposal records will be maintained for inclusion in the final validation report prepared for the Marina site; and

- inspected and cleared excavation locations and the date of clearance will be recorded and marked on a plan for inclusion in the final validation report prepared for the Marina site. A cleaned certificate will be issued for each cleared area by a suitably qualified occupational hygienist.

18.2.4 Validation strategy for sediment in the dredged sediment basin

The validation strategy for sediment in the detention basin will comprise the following:

- collection of in situ validation samples on a grid basis from the base of the detention on an indicative 50m x 50m grid basis with scope to adjust the sampling density based on the results of additional investigations conducted in the detention basin (which will be considered when calculating the sampling density). The detailed validation sampling approach methodology will be informed by the preferred construction methodology for marina basin works and recorded in the RWP. The validation sampling frequency shall not be adjusted without prior written approval of the site auditor;

- the indicative sampling frequency is considered appropriate given there will be a considerable amount of data resulting from the completion of the detailed site investigations completed within the dredged sediment basin prior to the commencement of remediation and validation works and this sampling frequency will provide a supplementary data set. Furthermore, imported VENM/ENM landscaping or hardstand will be placed above the existing fill limiting access;

- analysis of validation samples for metals, TRH, BTEX, PAH, OCP, OPP, PCB, Phenols, asbestos and PFAS. Neutral leachate tests for heavy metals and PAHs should be undertaken at a frequency of not less than 10% of validation samples;

- maintenance of a photo record of sediment validation samples for inclusion in the validation report;

- inspection to take place as required by the site auditor;

- collection and analysis of QA/QC samples as per Section 18.3.2;

- soil samples should be representative of the materials being validated and also target any suspect materials based on physical appearance; and

- the environmental consultant will undertake the validation sampling.

18.2.5 USTs and fuel lines

It is not anticipated that USTs or fuel lines will be encountered during the bulk earthworks program. If USTs or fuel lines are encountered, validation samples for UST excavations should be undertaken in accordance with the NSW EPA (April 2014) guidelines as follows:

- UST excavation: samples are to be collected from each wall at a minimum rate of 1 sample per 10 m length and be collected from the base at a rate of one sample per 25 m^2;

- Fuel lines: samples are to be collected from the beneath fuel lines at a minimum of 1 sample per 10 m;

- Fuel dispensing pump: one sample is to be collected and analysed from beneath the former fuel dispensing pump location (if located); and

- Samples from UST excavations should be analysed for Lead, TPH, BTEX and PAHs.

18.2.6 Imported VENM/ENM and landscaping materials

The following validation process for VENM will be required prior to delivery of the VENM/ENM and landscaping materials to the Marina site:

- a desktop review of readily available information of the VENM source site history such as current aerial photographs, NSW EPA register of contaminated sites, published geological and soil maps by a suitably qualified environmental consultant;
- a site inspection and collection of representative samples of VENM from the VENM source site by a suitably qualified environmental consultant;
- preparation of a letter by a suitably qualified environmental consultant that certifies the material as VENM; or
- acquisition of VENM from a certified source or quarry.

Following delivery to the Site, the VENM will be validated by the following process:

- visual inspection of the VENM for observations of potential contamination and screening of subsamples with a photo-ionisation detector (PID);
- collection of one sample per 1,000 m^3 of VENM unless it is from a continuous source such as a tunnel; and
- analysis of each sample for heavy (As, Cd, Cr, Cu, Hg, Pb, Ni and Zn), TPH, BTEX, PAHs, OCPs, OPPs and PCBs.

Each VENM sample collected will be described in accordance with Section 17.3 and VENM delivery dockets will be kept for inclusion in the validation report.

18.2.7 Imported topsoil

Imported topsoil will be stockpiled before use and validation samples collected prior to spreading on the Site. Validation samples will be collected at the following minimum rates:

- one sample per 25 m^3 for stockpiles less than 100 m^3; and
- four samples plus one sample per 100 m^3 for stockpiles greater than 100 m^3.

Sub-samples will be collected for VOC screening with a PID and each topsoil sample collected will be described in accordance with 17.3.

Samples will be analysed for heavy metals, TPH, BTEX, PAHs, OCPs, OPPs and PCBs. Copies of topsoil delivery dockets will be kept for inclusion in the validation report prepared for the Marina site.

18.3 Soil sampling methodology

18.3.1 Sample collection

The sampling methodology to be used during soil validation is detailed below.

Table 18.1 Methodology for validation soil sampling

Activity	Details
Soil Sampling Excavations	a) Soil samples will be collected using an excavator. b) The excavator bucket will scrap an excavator bucket full of material from the wall or base and will penetrate the wall or base by a minimum of 0.3 m c) A sample will be collected from the centre of excavator bucket that has not made contact with the sides of the excavator bucket d) A new pair of nitrile gloves will be used for the collection of each sample e) Sampling implements such as trowels or hand augers will be decontaminated between each sample collection
Soil Sampling Stockpiles	a) Soil samples will be collected in grid pattern across stockpiles and also target any areas of concern b) Soil samples will be collected from a minimum of 0.2 m below the stockpile surface c) Soil samples will be collected with a decontaminated sampling implement such as a trowel or hand auger where practical and safe or using an excavator d) Where an excavator bucket is used, the sample will be collected from the centre of excavator bucket that has not made contact with the sides of the excavator bucket e) A new pair of nitrile gloves will be used for the collection of each sample
Asbestos inspections	a) Soils in test pits and across excavated surfaces should be inspected by the environmental consultant or occupation hygienist for visible asbestos b) If no visual asbestos is identified the location will be cleared (via issue of a clearance certificate prepared by an occupational hygienist) and recorded as having no visually identifiable asbestos present c) If asbestos is visually identified, it should be appropriately packaged by suitably trained personnel for disposal to a facility licensed to receive that type of waste
Sample Containers	a) Sampled materials will be placed in new laboratory supplied glass jars with Teflon lined lids b) Sample jars will be filled with no headspace c) Samples collected for volatile analysis will not be homogenised
Soil logging	a) Soil logging will be undertaken in accordance with the Unified Soil Classification System. Samples information will be recorded in the field (e.g. soil/rock type, colour, grain size, inclusions, moisture conditions, staining and odour, etc)
Sample Nomenclature	a) Each sample will be labelled with a unique field sample identification number, the sample date, sampler and job reference number
Surveying	a) The extent of Area and hotspot excavations will be surveyed following validation and provided on a Site Survey for inclusion in the validation report
Field Screening	a) Duplicate soil sub-samples are to be collected in snap-lock plastic bags and the vapour headspace screened in the field for volatile organic compounds (VOCs) using a calibrated Photoionisation Detector (PID) equipped with a 10.6 eV lamp

Table 18.1 Methodology for validation soil sampling

Activity	Details
Decontamination	1. Equipment decontamination will be undertaken as described below. The following equipment will be needed for the detergent wash and water rinse decontamination process: a) laboratory (phosphate-free) detergent, Decon 90 or Liquinox b) tap water and deionised water c) buckets or tubs (sufficient for size of equipment to be cleaned) d) stiff brushes for cleaning. 2. The equipment is to be scrubbed with the detergent solution until gross contamination is removed and then rinsed in potable water and then deionised water before sampling use. 3. Equipment that cannot be thoroughly decontaminated using the detergent wash and water rinse should be steam cleaned, or if a steam cleaner is not available, not used for further sampling (and marked clearly "not decontaminated") or discarded. Equipment decontaminated using the high pressure steam cleaner will be further decontaminated as described above

18.3.2 Field quality control samples

The quality control (QC) samples to be collected as part of the field quality control procedures are listed below.

Table 18.2 Field quality control samples

QC Sample Type	Description	QC Sample Collection Rate
Intra-Laboratory Duplicates	Are identical to field samples, but both samples are sent anonymously to the primary laboratory. Blind duplicates provide an indication of the analytical precision of the main testing laboratory, but may also be affected by sampling techniques and inherent heterogeneity in the sample medium	Collected at a rate of approximately 1 in 20 soil samples and analysed for the full analyte suite. At least one blind duplicate sample will be included in each batch of samples.
Inter-Laboratory Duplicates	Are identical to blind duplicates, but the duplicate sample is sent to the second (check) laboratory. Split duplicates provide an indication of the accuracy of the main testing laboratory	Samples will be collected at a rate of approximately 1 in 20 soil samples and analysed for the full analyte suite. At least one split duplicate sample will be included in each batch of samples.
Equipment Blanks	Are prepared in the field (at the sampling site) using empty bottles and the distilled water used during the final rinse of sampling equipment. After completion of the decontamination process fresh distilled water is poured over the sampling equipment and collected. The distilled water is exposed to the air for approximately the same time the sample would be exposed. The collected water is then transferred to an appropriate sample bottle and the proper preservative added, if required. Equipment blanks are a check on equipment decontamination procedures.	One equipment blank of soil sampling equipment will be collected for every day of sampling and analysed for full analyte suite.
Trip Blanks/Spikes	Are samples of soil or water prepared by the laboratory with either zero or known anolyte concentration. Trip blanks/spikes are a check on the sample contamination originating or lost from sample transport and handling, and shipping. One Trip Blank/Spike will be analysed per sample batch	One Trip Blank/Spike will be analysed per sample batch

Procedures for duplicate sampling will be identical to those used for routine sampling and duplicate samples will be despatched for analysis for the same parameters using the same methods as the routine sample. Duplicate soil samples will be collected from directly adjacent to original samples. No homogenisation of samples will occur to reduce the loss of volatile compounds.

18.3.3 Laboratory quality control and quality assurance

The laboratories will undertake the analyses utilising their internal procedures and their test methods (for which they are NATA, or equivalent, registered) and in accordance with their quality assurance (QA) system which forms part of their registration.

Table 18.3 Laboratory quality control and quality assurance

QC Sample Type	Description
Laboratory Duplicate Samples	These are sub-samples taken from one sample submitted for analytical testing in a batch. A laboratory duplicate provides data on analytical precision. The rate of duplicate analysis will be according to the requirements of the laboratory's accreditation but will be at least one per batch. Results of the QC analyses for both laboratories will be reported with each batch.
Matrix Spiked Samples	The purpose of the matrix spike is to monitor the performance of the analytical methods used, and to determine whether matrix interferences exist. A sample is spiked by adding an aliquot of known concentration of the target analyte (s) to the sample matrix prior to sample extraction and analysis. A spike documents the effect of the sample matrix on the extraction and analytical techniques. These will be analysed at a rate of approximately 5% of all analyses. At least one per batch will be reported.
Laboratory Blank	This is usually an organic or aqueous solution that is as free of analyte as possible and contains all the reagents in the same volume as used in the processing of the samples. The reagent blank must be carried through the complete sample preparation procedure and contains the same reagent concentrations in the final solution as in the sample solution used for analysis. The reagent blank is used to correct for possible contamination resulting from the preparation or processing of the sample. Blanks will be analysed at a rate of once per process batch, and typically at a rate of 5% of all analyses.
Laboratory Control Samples	These comprise either a standard reference material or a control matrix fortified with analytes representative of the analyte class. Recovery check portions should be fortified at concentrations that are easily quantified but within the range of concentrations expected for real samples. These will be analysed at a rate of one per process batch, and typically at a rate of 5% of analyses.
Surrogates	Surrogate spikes are known additions to each sample, blank and matrix spike or reference sample analysis, of compounds which are similar to the analytes of interest in terms of: • extraction; • recovery through clean-up procedures; and • response to chromatography or other determination; but which: • are not expected to be found in real samples; • will not interfere with quantification of any analyte of interest; and • may be separately and independently quantified by virtue of, for example, chromatographic separation or production of ions of different mass in a GC/MS analyser.
Surrogate spikes	Surrogate spikes are added to the analysis before extraction. The purpose of surrogates is to provide a means of checking, for every analysis that no gross errors have occurred at any stage of the procedure leading to significant analyte losses. Other internal laboratory quality control procedures, as required for NATA, or equivalent, registration, will also be performed.

19 Remediation environmental management plan

This section assesses the risks to the environment posed by the remediation and bulk earthworks programme and outlines how these risks will be mitigated.

19.1 Potential remediation/construction impacts

19.1.1 Potential impacts on existing sources from project construction activities

The construction phase has the potential to disturb existing contamination (where present) through the exposure pathways and receptors enabled by various activities, particularly the excavation and management of construction spoil.

Excavated material would be transported to disposal/reuse sites following classification and confirmation of suitability for the proposed land use.

Construction activities which require consideration of potential contamination are primarily related to excavation works (surface and trenching works), and may include the following:

- temporary stockpiling of spoil on land;
- cut and fill;
- laydown and storage of materials (including dangerous goods);
- delivery of materials, plant and equipment; and
- excavating, filling and rehabilitation of disturbed areas to the final approved landform.

19.1.2 Potential introduced sources from project activities during construction

Additionally, new sources of contamination may be introduced through construction. These include and are not limited to spills/leaks of chemicals or waste generation associated with:

- ancillary utility works;
- storage of petroleum, diesel, chemicals and other hydrocarbons (including dangerous goods), etc;
- establishment of site offices, amenities and temporary infrastructure; and
- construction of permanent project infrastructure.

There is the potential for exposure of human and ecological receptors to contamination as a result of the inappropriate management of waste, including potential leaks and spills from equipment and plant (generated by construction activities). Typical examples would include spills of hydrocarbons while refuelling or lubricants used by machinery, and generation of construction waste. If managed appropriately, potential impacts to human and environmental health can be minimised.

19.2 Environmental management plan principles

This section of the RAP describes the minimum standards to be adopted to protect the environment during the Remediation Works. The Remediation Contractor will develop and implement a suitable Environmental Management Plan (EMP) in compliance with legislative and regulatory requirements. The EMP will detail the appropriate information and mitigation measures necessary to conduct the remediation works in a manner that will minimise the risk to the environment, as outlined below.

All Site workers and visitors will be inducted so as to be aware of potential environmental risks and management procedures at the Site. As part of the Site induction, all employees, sub-contractors and visitors will be made aware of the specific protocols for management of asbestos and acid sulfate soils.

19.3 Water management

Water management is critical to successful remediation and reduction of cross contamination issues. The EMP for the works will include general procedures for the management of surface and groundwater during the works including those outlined below.

19.3.1 Surface water

Impacted surface water that may accumulate in a remediation area will be contained prior to being tested and where required, disposed of at a licensed waste facility. Surface water from remediated and undisturbed areas of the Marina site will be considered clean. Undisturbed surface water runoff will continue to follow existing drainage patterns, unless diversion from work areas is warranted. Surface water drainage will also be arranged so that surface water run-off from disturbed or contaminated areas does not enter remediated or undisturbed areas or the Georges River.

19.3.2 Groundwater

Subsurface water from areas of the Marina site in which contaminated materials have been identified will be assumed to be impacted.

The following management measures will be implemented if groundwater is intersected in excavations:

- where practicable, sumps will be created at the base of the excavations to collect groundwater;
- groundwater will be sampled and classified to facilitate appropriate off-site disposal prior to the collection of the validation samples from the floor and walls of the excavation pits;
- sediment control measures will be implemented to mitigate potential runoff off-site;
- a discharge to stormwater licence will be sought from the Liverpool Council, provided the sample analysis indicates compliance with Council criteria;
- if the sampled groundwater does not comply with council criteria, a licence to discharge to the sewer as trade waste will be sought from Sydney Water; and
- if the sampled groundwater does not comply with Sydney Water criteria then the groundwater will be pumped and disposed off-site at an appropriate licenced treatment facility.

19.3.3 Flooding

The risk of flooding from the adjacent Georges River and subsequent mobilisation of contaminants is to be mitigated by not stockpiling contaminated soils on the Site and assessing them in-situ as outlined in Section 19.6. Additionally, essential and unavoidable stockpiling should be temporary in nature (<24 hours) with placement subject to consideration of up to date Bureau of Meteorology forecasts.

Specific measures that will be adopted to protect water quality within the Georges River include the preparation of a detailed erosion and sediment control plan (ESCP) as outlined in Section 16.3.3.

19.3.4 Spills and leaks

A spill response plan will be developed and implemented as part of the ERP detailing the procedures for responding to spills and leaks. The procedures outlined in the plan will be aimed at minimising the impact of any contaminant releases that may occur during the works.

The following actions will be taken in preparation for spills or leaks:

- Training of site personnel in appropriate spill response techniques.
- Allocation of spill response materials and equipment on-site (such as oil absorbent pads, booms and bio-dispersants). Specifically, spills are to be mitigated by the provision of oil absorbent booms to address any accidental spillage (eg from heavy machinery) in the dredge pond or western drainage channel as a measure to protect the Georges River.
- Containment of all storage tanks and drums inside bunded areas with a capacity of 110% of the largest container, or 25% of the total volume of all containers, whichever is greater.
- Initial assessment of the spill.
- Notification of the appropriate authorities if necessary.
- Following a spill or leak, an investigation to determine the root cause of the incident will be undertaken.
- Corrective and preventative actions implemented to prevent future incidents.

19.4 Air quality management

19.4.1 Odours

Odour management is recognised as a critical aspect of site environmental management and will need to be given high priority in the planning of all excavation and stockpiling of contaminated soil at the Site. Odours are expected to be minimal during the soil excavation; however, management procedures will need to be developed within the EMP to address odour issues during the remediation works.

Primarily, odours at the Site will be associated with the removal of buried fill materials and potentially marine sediment. Odour generation at the Site will be influenced by weather conditions, the extent of open excavations stockpiles, and the quality of material exposed.

A detailed odour management system will be developed as part of the EMP incorporating the use of various management options as deemed appropriate for particular areas. The odour management system will include the following options:

- investigation as to the source of odours including odour monitoring;
- minimisation of the quantity or surface area of exposed odorous materials;
- implementation of odour management response procedures (as specified in the EMP);
- implementation of progressive contingency measures (as specified in the EMP);
- excavation (odorous soils);
- stockpiling (odorous soils);
- covering of exposed odorous materials progressively or at the completion of each work period;
- apply odour suppressant sprays or foams to excavation surfaces; and
- undertake activities during favourable weather conditions.

Selection of the appropriate management and mitigation measures, including those summarised above will be based on consideration of:

- the quantity of odorous materials that require remediation;
- the duration of the required remediation works and associated management of odorous materials;
- the proximity of the proposed remediation works to sensitive receptors;
- the prevailing and forecast weather conditions; and/or
- other activities being undertaken at the Site in parallel with the remediation work.

Should unacceptable levels of fugitive emissions be detected at the Marina site boundaries or in the surrounding area during the remediation works, an investigation will be conducted to determine the source of the emissions, and to evaluate the appropriate measures to be implemented.

These measures may include the following:

- Alteration in the remediation works program to minimise in the extent of disturbed open areas.
- Prompt removal and treatment of heavily contaminated materials that have been exposed and are identified to have caused the emissions.
- Use of fine mist sprays around the Remediation Area.
- Conducting the work in more favourable weather conditions.
- Use of alternate work practices to minimise the period of impact of the emissions.
- Use of additional features to control emissions from plant and equipment.
- Use of alternate work practices such as using modified equipment.

- Relocation of offending plant and equipment to less sensitive on-site areas.
- Reducing the number of plant and equipment items on-site.
- Use of a deodorant within water sprays at locations on-site and at Site boundaries provided the chemicals do not pose a contamination or OHS hazard.

19.4.2 Dust

Care should be taken to manage wind-blown (aeolian) dust at the Site during excavation and earthworks activities. Dust can be generated through a range of means and activities:

- Wind action - exposed soil surfaces will generate dust during winds.
- Agitation and movement - excavation, mixing and placement of soil will generate dust.
- Vehicle Movements - vehicles' wheels on exposed soil surfaces (such as unsealed roadways) will generate dust and transfer of soil in uncovered trucks may also result in dust generation.

Appropriate management of dust is required to ensure that it is minimised and/or prevented. Dust management will include the following:

- Covering surfaces.
- Minimising exposed/excavation areas.
- Wetting down.
- Dust monitoring.

Should unacceptable levels of dust be detected during the remediation works, an investigation will be conducted to determine the source of the dust, and evaluate the appropriate measures to be implemented.

These measures may include the following:

- Increased use of a water cart or water sprays to suppress dust in open areas.
- Installation of temporary sheeting to cover localised exposed areas and stockpiles.
- Installation of dust screens around the Remediation Area.
- Covering stockpiles of contaminated soil which will remain on the Site for more than 24 hours (where practical).
- Alteration of the works program to minimise the extent of disturbed open areas.
- Consolidation of material stockpiles.
- Use of chemical dust-suppressants provided the chemicals do not pose a contamination or health and safety hazard.
- Use of alternative coverings such as hydromulch to stabilise the surface of open disturbed areas.

- Use of additional dust suppression features on items of dust generating plant and equipment.
- Securely covering all loads entering or exiting the Site.
- Use of alternate work practices such as modified equipment to minimise dust generation.

Due to the identified presence of asbestos at the site, an asbestos dust management plan is outlined below. Further details relating to asbestos management are included in Section 19.9 and Appendix A.

Table 19.1 Asbestos management - dust

Objective(s)	**To ensure the impacts of dust on contractors and surrounding areas are minimised.**		
Management Strategy	Dust issues managed principally by emission controls at source, and administrative controls during works.		
		Responsibility	**Timing**
Control(s)	Area to be disturbed minimised. Clearance lots to be approved by Project Manager. Where dust is identified as an issue, dust control measures will be implemented. These will primarily involve the use of water carts, but may include surface treatments. Vehicle movements controlled and kept to established tracks and haul roads. Dust awareness issues in environmental induction process.	Site Manager	Immediate
Performance Indicator(s)	No complaints from adjacent commercial premises and/or community.	Site Manager	Immediate
Monitoring	Daily inspection of works sites to occur, including: • visual check for dust crossing the site boundaries; and • visual check of high potential dust areas, such as haul roads, stockpiles and operational areas.	Site Manager	Immediate
Reporting	Any complaints or incidents to be reported to Site Manager.	Site Manager	Immediate
Corrective Action(s)	• Investigate cause of excessive dust. • Implement controls immediately (eg water carts). • Implement corrective measures prior to the recommencement of site works. • Implement administrative controls if required, such as rescheduling of dust generating activities to more favourable weather conditions.	Site Manager	Immediate

19.5 Noise and vibration management

An assessment of noise and vibration impacts potentially generated during the remediation works will be prepared in consultation with the NSW EPA. The assessment will be prepared in accordance with the Interim Construction Noise Guideline DECC (2009), Noise Policy for Industry (NSW EPA 2017) and NSW Road Noise Policy (DECCW 2011) and Assessing Vibration: A Technical Guide (DEC 2006).

The potential for noise and vibration impacts from the remediation works will result from:

- works associated with preparation of the Marina site;

- movement of construction vehicles around the Marina site; and
- operation of plant and activities on the Marina site.

Should unacceptable noise and/or vibration levels be detected during the remediation works the following measures may be implemented:

- Modify the works program to minimise the impact of noisy or vibratory operations, including:
  - modify the timing of the works to appropriate times of the day; and
  - accelerate the works program to complete the works quickly and minimise the period of disturbance.
- Install additional noise suppression features on plant and equipment.
- Construct additional noise attenuation measures such as stockpile barriers, works area enclosures.
- Use of different items of plant and equipment that generate less noise or vibration.

19.6 Erosion and sediment control

19.6.1 General controls

Erosion and sediment control measures will be in place during the remediation works in accordance with Managing Urban Stormwater, Soils and Construction, 4th edition (Landcom 2004). A detailed erosion and sediment control plan (ESCP) will be developed based on the requirements outlined in The Blue Book - Managing Urban Stormwater: Soils and Construction (Volumes 1 and Volume 2). The ESCP will incorporate minimum requirements as outlined in Section 16.3.3.

General erosion and sediment control measures may include:

- installation of silt fencing and bunding as appropriate for the site;
- silt fences must be installed upright and securely fixed. Accumulated sediments behind silt fences must be periodically removed to maintain the retention capacity of the fencing;
- inspections of the control measures in place must be completed daily during the remediation works or immediately following heavy rainfall events to confirm the measures are in good condition; and
- the surface area of exposed soils at a given time should be minimised by adopting a controlled sequence of works and progressive approach to excavations.

19.6.2 Safeguarding the Georges River

Potential escape of sediment/siltation into the Georges River is to be mitigated by not connecting the Marina basin to the Georges River until after remediation work has been completed and towards the end of the bulk earthworks construction program, in addition to the use of floating siltation booms.

Specific measures that will be adopted to protect water quality within the Georges River include the preparation of a detailed ESCP. The ESCP is outlined in Section 16.3.3.

19.7 Stockpile management

Given the proximity of the Marina site to the Georges River, and to minimise contaminated soil loss in the event of heavy rainfall or flooding, no stockpiling of contaminated material (including soil, fill and waste materials) will be permitted, unless absolutely unavoidable, and any stockpiling should be temporary in nature (< 24 hours). Soils that are contaminated or not suitable for reuse at the Marina site should be classified in-situ, then excavated and loaded directly onto trucks for disposal. Soils that are contaminated but can reused at the site (based on the results of additional investigations and validation sampling) should be classified/validated in-situ, then excavated and placed in the final location. Material movements will be tracked via registered survey as part of the Materials Tracking System.

For non-contaminated ('clean') material, stockpiling will be minimised to the extent practical with material temporarily stockpiled in designated stockpile areas located on elevated ground and not flood prone areas. All stockpiling works of clean material should be temporary in nature (<24 hours) with placement subject to consideration of up to date Bureau of Meteorology forecasts.

Any temporary stockpiles are to be appropriately located and tracked to avoid mixing of difference classes of material (eg soil types, evidence of contamination). Bunding and sediment controls will be installed as appropriate to minimise runoff from stockpiles to surrounding areas. All stockpiles should be formed in a manner that reduces the potential for erosion.

19.8 Soil haulage

Soil tracked off the site due to vehicles and plant should be avoided. The following measures are to be adopted to minimise the risk of tracking soils off-site:

- the number of vehicles and plant on-site should be minimised where practicable;
- the frequency of vehicles and plant entering and exiting the site should be minimised where practicable;
- equipment and plant should be washed down before leaving the site; and
- covers should be used on vehicles transporting soils for off-site disposal.

19.9 Asbestos management

During the remediation works, ACM may be encountered and will require management and disposal to an off-site landfill licenced to receive 'Special Waste – Asbestos' under the Waste Classification Guidelines (NSW EPA, 2014). Additional health and safety measures will be provided in the health and safety plan developed of the remediation works.

Detailed management and mitigation measures are contained within the Asbestos Management Plan (AMP) in Appendix A.

Asbestos dust management is outlined in Section 19.4.2.

19.10 Acid sulfate soils management

During the remediation works, ASS/PASS may be encountered and will require management, treatment and/or disposal to an appropriately licenced off-site landfill under the Waste Classification Guidelines (NSW EPA, 2014).

Detailed management and mitigation measures are contained within the Acid Sulfate Soils Management Plan (ASSMP) in Appendix B.

19.11 Environmental monitoring program

A program of environmental monitoring will occur for the duration of the remediation and bulk earthworks period. The program would be conducted in addition to the additional site investigation (refer to Section 8) and would include the following:

19.11.1 Air quality and dust

Air quality monitoring programs should be designed to include the regular measurement and testing of dust, odours or atmospheric concentrations of pollutants, on-site and at site boundaries, to ensure that workers and the community are not at risk of adverse health effects. Dust monitoring should be undertaken monthly from at least four locations along the site boundary at minimum. Monitoring methodology should be based on the *Approved methods for sampling and analysis of air pollutants in NSW* (NSW EPA 2007) which reference to Australian Standard (AS) 3580.10.1-1991 as the method for measuring deposited particulate matter.

Asbestos fibre monitoring must be undertaken by a suitably qualified occupational hygienist as required for asbestos related works, from at least four locations along the site boundary and within the work area(s) as required for health monitoring for occupational exposure (refer to Section 20 and Appendix A).

19.11.2 Noise and vibration

Vibration from fill compaction or rock/concrete excavation may cause a nuisance to nearby residential receptors and needs to be monitored in accordance with legislative requirements outlined in Section 19.5. It is noted that the NSW EPA's Interim Construction Noise Guideline (ICNG) is the principal guidance for the assessment and management of construction noise in NSW.

19.11.3 Landfill gas and methane

Monthly monitoring of landfill gas concentrations using a portable landfill gas analyser (eg GA5000) with triggers to install monitoring wells to allow flow measurements. Methane surface monitoring in accordance with the Environmental Guidelines Solid Waste Landfills (2nd Edition) 2016 (NSW EPA 2016) can also be undertaken monthly and as required when each fill area is completed.

19.11.4 Groundwater and surface water

The HGG and groundwater/surface water monitoring programmes outlined in Section 8 and associated reports will form part of the final site validation report. The primary constraint to the collection of data for these monitoring programmes at the current time is the activities on site which limit the ability to install and maintain monitoring points for the respective media.

In addition to the programmes outlined in Section 8, monthly sampling of surface water at least two locations in both the Georges River and dredge pond should be undertaken. The western drainage channel may also be considered for inclusion in regular monitoring when remediation works may affect water quality in that area.

19.12 Long term environmental management plan

Following finalisation of the detail design and earthworks staging for the Marina site, a long-term environmental management plan (LTEMP) would be prepared if required. The LTEMP will document in specific detail the staging and procedures for the long-term (post construction) management of contamination that will remain at the Marina site with consideration to site elevation, flood levels and surface water ingress.

Consistent with the LTEMP proposed to be prepared for the Bendict north site, the LTEMP will document:

- contamination that remains at the Marina site including HGG and buried wastes;
- flood level and surface water management considerations;
- long term ownership of the contamination;
- any restrictions that the contamination may place on the future use of the land;
- tasks that will need to be undertaken as part of the long term management of residual contamination at the site;
- how the LTEMP will be made legally enforceable;
- reporting protocols and requirements;
- a mechanism for progressive improvement and monitoring of compliance with the LTEMP;
- compliance auditing of LTEMP implementation;
- end points that would need to be achieved before the LTEMP could be terminated;
- contingency measures; and
- triggers for defining when contingency measures would need to be implemented.

A draft version of the LTEMP would be prepared by the Environmental Consultant, reviewed by the Site Auditor and approved in writing by Liverpool City Council prior to the commencement of Marina development works. This will allow issues of concern to stakeholders to be flagged and addressed prior to the commencement of site work.

The LTEMP would be prepared in accordance with NSW EPA endorsed guidelines. The Environmental Consultant is to notify the Site Auditor during the remediation work of any significant changes that may need to be made to the preliminary version of the LTEMP. The Site Auditor would review any such proposed changes and advise Council of their acceptability.

20 Remediation occupational health and safety

20.1 General

This section of the RAP describes the minimum standards to be adopted to protect the health and safety of all persons involved in the remediation works. The Remediation Contractor will develop and implement a suitable Health and Safety Management System in compliance with legislative and regulatory requirements. A site-specific Occupational Health and Safety Plan (OHSP) will be developed prior to commencement of the works. The OHSP will detail the appropriate health and safety information necessary to conduct the remediation works in a safe manner.

20.2 Occupational Health and Safety

The purpose of the Site-specific OHSP is to present all relevant health and safety information for the works. The information presented in the OHSP will include:

- assignment of responsibilities for management personnel and workers;
- an outline of the existing site conditions;
- details of all work to be conducted;
- an evaluation of hazards and risks;
- details of the proposed measures to be implemented to manage the identified hazards and risks;
- establishment of personnel protection standards and mandatory safe work procedures;
- establishment of OHS monitoring protocols;
- training requirements for emergency team members;
- communication protocols and training procedures;
- evacuation procedures, emergency contacts and emergency drills to be implemented; and
- provision for contingencies and changes in work practices.

20.3 Responsibilities

The responsibilities and duties of the Remediation Contractor in relation to OHS will include:

- ensuring all work undertaken is performed in accordance with relevant legislation and regulations, and directions issued by regulatory authorities;
- developing and documenting safe working practices for all employees and subcontractors;
- ensuring workers are adequately trained to undertake their work tasks using the adopted work practices;

- ensuring that work is performed in strict adherence to the adopted work practices;
- appointing a suitably qualified and experienced Site Safety Officer (SSO) to supervise and control safety matters;
- supplying and maintaining first aid kits, first aid facilities and ensuring first aid attendants are present in accordance with statutory requirements;
- ensuring that all workers are inducted prior to their commencement of work. This will include Site-specific training in regard to the site conditions, works procedures, emergency and evacuation procedures, first aid procedures, decontamination procedures and other relevant matters detailed in the OHSP;
- ensuring that copies of the OHSP are readily available;
- establishment and maintenance of a record of all hazardous substances on the Site including provision of Material Safety Data Sheets (MSDSs);
- ensuring that all personnel who work with contaminated materials undergo a medical examination prior to and at the completion of their work on-Site;
- reporting all site incidents and accidents to SafeWork NSW;
- ensuring that the SSO is on-site during all site works to monitor compliance with the OHSP;
- ensuring that regular documented OHS inspections are conducted, including the use of a documented follow-up system to monitor improvements and measures introduced to rectify any observations made;
- supplying and maintaining the required personal protective equipment (PPE);
- ensuring all workers are trained in the use of the PPE and correctly use PPE; and
- ensuring that all electrical equipment, plant and tools comply with appropriate statutory requirements and are maintained in a good, serviceable and safe condition.

20.4 OH&S Legislation, regulations and standards

The remediation works will be conducted in compliance with applicable OH&S legislation, regulations and standards. In addition, the remediation works will comply with relevant industry codes of practice, guidelines and other publications that have been developed by the WorkCover Authority. These may include:

- the Work Health and Safety Act 2011 and Regulation 2011;
- the Dangerous Good Act 1975 and General Regulation 1999;
- Guide for Riggers (November 1995);
- Electrical Practices for Construction Work (February 1992); and
- Exposure Standards for Atmospheric Contaminants in the Occupational Environment (May 1995).

A number of Australian Standards have been identified relating to OH&S issues for the works proposed at the Site. These standards include:

- AS 1319 -1994 Safety Signs for the Occupational Environment;
- AS 1336 -1997 Recommended Practices for Occupational Eye Protection;
- AS 1470 -1986 Health and Safety at Work - Principles and Practices;
- AS 1715 -1994 Selection, Use and Maintenance of Respiratory Protective Devices;
- AS 1716 -2003 Respiratory Protective Devices;
- AS 1801 -1997 Occupational Protective Helmets;
- AS 1885.1 -1990 Measurements of Occupational Health and Safety Performance - Describing and Reporting Occupational Injuries and Disease (known as the National Standard for Workplace Injury and Disease Recording);
- AS 2161 - 2000 Occupational Protective Gloves;
- AS 2210 - 2000 Occupational Protective Footwear;
- AS 2436 -1981 Guide to Noise Control on Construction, Maintenance and Demolition Sites;
- AS 2601 -2001 The Demolition of Structures;
- AS/NZS 2865-2001 Safe Working in a Confined Space;
- AS 2986 -1987 Workplace Atmospheres - Organic vapours - Sampling by Solid Adsorption Techniques;
- AS/NZS 3012 -1995 Electrical Installations – Construction and Demolition Sites;
- AS 3640 -1989 Workplace Atmospheres - Method for Sampling and Gravimetric Determination of Inspirable Dust; and
- AS/NZS 4576 -1995 Guidelines for Scaffolding.

20.5 Risk assessment

A hazard analysis should be conducted prior to site establishment to identify the OHS hazards expected during the course of the remediation works. A Safe Work Method Statement (SWMS) will be developed to identify hazards associated with each work activity required by the proposed remediation works, evaluate the associated risks and determine the necessary measures to reduce or mitigate those risks. This section of the RAP outlines some of the hazards expected over the course of the remediation works. Hazard identification and risk assessment will be conducted and documented on an ongoing basis as the remediation works proceed.

20.5.1 Chemical hazards

Based on the information provided in previous investigations at the Site, the presence of, heavy metals, TPH and PAHs has been confirmed within soils on the Site. The hazard posed by these materials will be evaluated and the associated risks assessed in the SWMS.

20.5.2 Atmospheric Exposure Limits and Recognition Qualities

The exposure limits and recognition qualities of the chemicals likely to be encountered in the remediation works will be taken from the following guidelines (listed in order of precedence) and detailed in the OHSP:

- NOHSC, Exposure Standards for Atmospheric Contaminants in the Occupational Environment, 1995. The most up-to-date Australian exposure standards are located on the Safe Work Australia Hazardous Substances Information System (http://hsis.ascc.gov.au/SearchHS.aspx); and
- National Institute for Occupational Safety and Health (NIOSH) 2007, Pocket Guide to Chemical Hazards. Also refer to http://www.cdc.gov/niosh/npg/.

20.5.3 Additional hazards and risks

The OHSP will identify and describe a range of other hazards anticipated during the remediation works. These hazards will include:

- heat stress;
- explosive atmospheres in areas dealing with contaminated materials;
- oxygen deficient atmospheres and confined spaces (as defined under AS/NZS 2865 - 2001 Safe Working in a Confined Space);
- underground utilities;
- underground pipelines, pits, and other obstructions;
- above ground electrical and utility hazards;
- traffic hazards;
- instability of excavation batters and stockpiled material; and
- physical hazards such as trip hazards and mobile plant.

Specific minimum standards for these hazards will be outlined within the SWMS.

20.6 Work zones

The Marina site will be divided into work zones as follows:

- Exclusion Zones – active works areas within the Remediation Area where there is a potential for occupational exposure to contaminants; and
- Support Zones – the Site office and Site facilities areas within the Remediation Area.

Movement of personnel and equipment between these zones will be minimised and restricted to specific access control points and decontamination stations to prevent cross contamination to clean areas.

20.6.1 Decontamination stations

The decontamination stations will be the only entry and exit points to Exclusion Zones. The stations will be located to minimise the transportation of contaminants between the various areas of the Site, and to ensure that the support zone does not become contaminated or affected by other hazards.

Clean and dirty zones will be established at all decontamination stations. All workers will be required to pass through the decontamination stations when entering and exiting the exclusion zones.

These stations will also house the PPE stock rooms and change rooms, so that when entering the Exclusion Zones workers are able to apply the necessary PPE.

20.6.2 Support Zone

The support zone refers to the site office and other support facilities involved in administering the remediation works. Site personnel may wear normal work clothes within this zone, leaving any potentially contaminated clothing, equipment and materials in the decontamination station until decontaminated or appropriately disposed of.

In the event of an emergency, support zone personnel are responsible for alerting the correct authorities. All emergency telephone numbers, evacuation route maps, vehicle keys and site safety information would be held within the support zone.

21 Contingency planning

21.1 Approach

The purpose of this contingency plan is to outline procedures for the identification and management of unexpected issues or events that may occur during the remediation works.

A number of unexpected issues or events that may occur during the remediation works, which may include, but not be limited to:

- increased volumes of contaminated material – to be mitigated by additional off-site disposal and use on an on-site containment and/or capping strategy;
- unknown chemical contamination – to be mitigated by stop work, additional investigation, options assessment then remediation in accordance with NSW EPA requirements;
- flooding; and
- emergencies – to be mitigated by preparing an emergency response plan as described in Section 21.3.1

21.1.1 Chemical contamination

The range of contaminants analysed in previous site investigations is considered appropriate. However, there is the potential for occurrence of as-yet unidentified contaminants and for variation to the concentration or distribution of known contaminants. Should any significant changes to the nature or types of contaminants be identified during the works, a variation to the RAP may be required. Variations will be issued to the Site Auditor for review and approval.

21.1.2 Asbestos contamination

ACM has not been identified in fill in previous investigations within the Marina site, however due to the presence of fill there is a potential for ACM to be encountered during excavation works. Should asbestos be uncovered the following process should be undertaken:

- the material is not to be further disturbed and an exclusion zone created around the affected area to prevent access by site workers or visitors;
- the material and the soil immediately surrounding the suspected ACM should be wetted down;
- a suitably qualified environmental consultant or occupational hygienist should inspect and test the suspected ACM for asbestos;
- an Occupational Hygienist should be engaged to implement necessary controls and/or monitoring of the asbestos removal works;
- soils containing bonded ACM may be excavated and disposed off-site to an appropriately licensed landfill by a contractor with a minimum “Class B” asbestos removal license in accordance with the NSW DECC (2009) Waste Classification Guidelines as Special Waste (Asbestos) or as per the advice of the occupational hygenist; and

- soils containing friable asbestos should be excavated and disposed off-site to an appropriately licensed landfill by a contractor with a minimum “Class A” asbestos removal license in accordance with the NSW EPA (2014) Waste Classification Guidelines as Special Waste (Asbestos).

21.2 Increased volumes of contaminated material

The remediation works strategy is to undertake excavation and off-site disposal of all impacted fill material such that the Marina site is suitable for mixed open space, residential and commercial/industrial (marina) land uses. In addition to those completed, additional environmental site investigations will be conducted to further characterise material within the Marina site as part of the remediation programme which will help to minimise the risk of increased volumes of contaminated material requirement management during the remediation works.

Excavated materials will be disposed to landfill and tracked using the Materials Tracking System described in Section 16.4. The quantities of materials excavated will be regularly compared to the estimated quantities.

In addition to unanticipated increased volumes of contaminated material, increased volumes of foreign materials in the form of steel reinforcement, scrap steel and pipe work may have the potential to adversely impact on the remediation works. Depending on the magnitude of the changes of anticipated volumes of excavated materials, and the extent of contamination, changes to the depth of excavation and to the final reinstatement levels may be made during the remediation works.

21.3 Operational contingencies

21.3.1 Emergency response plan

An Emergency Response Plan (ERP) will be prepared prior to the commencement of the site remediation works. The plan will outline the process for identifying possible emergency situations and detailing the procedures necessary to ensure the safety of both on-site and off-site personnel in the event of an emergency.

The ERP should include the following general information:

- assignment of responsibilities to nominated key personnel;
- assessment of the potential on and off-site impacts of hazards;
- emergency reporting procedures including on-site reporting and reporting to the appropriate authorities;
- emergency response procedures including, but not limited to, the following:
  - on-site fires or explosions;
  - chemical spills;
  - rupture of buried services;
  - hazardous gas releases and emissions;
  - confined spaces situations;
  - traffic accidents both involving the transportation of "Dangerous Goods";
  - first aid for injured personnel;

- evacuation of on-site personnel; and
- managing unknown/uncertain situations;

- incident investigation procedures to determine the root cause of the incident, and to identify the appropriate corrective and preventative actions to prevent future incidents.

22 Community engagement

Community engagement prior to and during remediation is an integral component of successfully delivering the remediation works. The strategy includes processes for communicating with the local community on the remediation works, discussing potential short-term impacts and mitigation measures relating to the remediation.

Table 22.1 Summary of community consultation strategy

Communication channel	Purpose
Marina site Concept Plan Website	This is the central portal for information about the proposed development. It contains information for the community and stakeholders regarding the remediation works including electronic copies of notifications, press releases and links.
Newsletters	To provide ongoing updates about the planning process and progress of works on site. This will be a key means of ensuring information transparently flows to the community and stakeholders about the remediation works.
Community Information Sessions	Used to convey key messages to the local stakeholders and proactively work to address specific concerns.
Stakeholder one-on-one briefings	To discuss concerns raised by key stakeholders face-to face and provide more detailed information and assurances about the project.
Notifications	To ensure all residents and businesses potentially impacted by Site works are informed in advance of key work commencing. Notifications will be used to inform the community of key issues such as the timing of noisy work, out of hours construction and traffic impacts.
Signage	To inform the community about who is responsible for the Site activities and the contact details for further information about the work.
Commercial Property Notice Boards	When appropriate, general information about the overall project will be included on the notice boards in commercial properties.

23 Key personnel

23.1 Contractual framework

The contractual framework of delivery of the remediation works has not yet been determined by Benedict as it does not have a Consent for the Marina. Potential contractual structures may include:

- turn-key delivery of the remediation works by a remediation contractor or Benedict personnel;
- supervision of the remediation works by a superintendent and validation team engaged separately for the remediation contractor; and
- a variation on the above.

Notwithstanding the contractual framework initially adopted, the key roles and responsibilities associated with the remediation works are as discussed following. Depending on the contract structure the various roles and responsibilities may be discharged by one or more entities.

23.1.1 Project Director

The Project Director is responsible for ensuring that the remediation works undertaken on-site are in accordance with this RAP, the EMP, the OHSP and other relevant documentation, and that the objectives stated within the RAP are ultimately met. The Project Director will generally also be responsible for ensuring that the remediation works occur within the timeframe nominated, within the financial budget allocated, and is completed safely. The Project Director assumes ultimate responsibility for the project.

23.1.2 Project Manager

The Project Manager is responsible for daily operations and directs the site operations to ensure effective planning, verification, documentation and management of operational and environmental and safety issues in accordance with this RAP. This includes maintaining a liaison with regulatory authorities to ensure that all necessary work is undertaken to satisfy the NSW EPA and NSW EPA Accredited Site Auditor that the remediation achieves the objectives of this RAP.

The Project Manager is responsible for the implementation of all Project Plans including the RAP, EMP, OHSP Plan, Quality Plan and other relevant contractual documents associated with the remediation works. This includes responsibility for:

- any design that may be required during the remediation work;
- implementation and scheduling of the remediation works in accordance with the abovementioned documents; and
- ensuring compliance with relevant legislation and regulations.

The Project Manager is also responsible for ensuring that human health and the environment are protected at all times, including the provision of training and site inductions to all appropriate subcontractors and workers.

The Project Manager will be a primary community contact and the first point of contact for subcontractor issues.

23.1.3 Remediation and validation works team

A suitably qualified environmental consultant will undertake the supervision and validation of the remediation works under the direction of a Validation Project Director (VPD). The VPD is responsible for ensuring that all required validation systems are fully functional, and that personnel are trained in the requirements of the validation requirements as detailed Section 17 of this RAP.

Daily validation management will be from an on-site project office. A site-based administrative system will be established to ensure that the remediation works are fully documented. A daily fieldwork summary will be prepared and filed. All project-related incoming and outgoing communications will be logged in a register.

Decisions related to validation will be made in accordance with relevant guidelines endorsed by the NSW EPA and NSW EPA Accredited Site Auditor. Copies of relevant guidelines will be made available and accessible on-site as required (electronic versions are acceptable).

All remediation site work will be directed by qualified environmental engineer(s)/scientist(s) with experience working on contaminated sites. A member of the environmental consultant's field team will be the Site Validation Manager (SVM) responsible for making all validation decisions and directing all routine site fieldwork. Prior to commencement of the project, the SVM will prepare a project manual containing all required procedures and forms. The manual will be updated, in conformance with the VP, on an as needed basis. It is the responsibility of the SVM to ensure that the validation requirements detailed in Section 17 are followed.

Site meetings will be convened, as required, to discuss fieldwork procedures. At least one meeting per week will be held with the SVM and the Project Manager to plan work for the following week and to resolve outstanding issues.

Where, because of an unforeseen circumstance, the SVM considers that a departure from the validation requirements is required, this must be discussed with the VPD and NSW EPA Accredited Site Auditor before any other related action is taken. If the departure is approved, it will be documented in site files. If urgent action is required, the VPD will be responsible for deciding the particular issue. The NSW EPA Accredited Site Auditor will be sent written confirmation as soon as practicable, but in any case within 5 working days of the reasons for making the changes to the validation procedures detailed in Section 17 feedback and endorsement of the changes will be requested in writing from the NSW EPA Accredited Site Auditor.

23.1.4 Site Foreman

The Site Foreman implements day-to-day operations as directed by the Project Manager.

23.1.5 Safety and Quality Officer

The Safety and Quality Officer is responsible for implementation of the quality and safety management systems. This person assists the Project Manager with day-to-day tasks that arise, reports activities undertaken, directs the subcontractors, maintains accurate records of works such as safety checklists, and maintains a photographic record of works undertaken. This will include review and update of the OH&S Plan and EMP plus health and safety manuals, rules and procedures.

The Safety and Quality Officer ensures personnel and visitors to the site are inducted and has responsibility for emergency response and training in accordance with the Emergency Plan. The Safety and Quality Officer has the authority and independence to require reasonable steps to be taken to avoid or minimise unintended or adverse work safety impacts, and can direct relevant actions to be ceased should any adverse impact on worker safety be likely to occur.

The Safety and Quality Officer ensures all health and safety monitoring devices are operating in accordance with the RAP, EMP and OHSP and also keeps the incident and accident register up to date with notification given to Work Cover NSW as necessary.

The Safety and Quality Officer will provide advice and recommendations, when appropriate, with regards to:

- legal requirements;
- changes in legislation;
- dealings with Work Cover New South Wales;
- prevention of injury or damage;
- accident and injury investigations and reports;
- work methods, equipment, or materials which could reduce risk; and
- selection, suitability and application of safety equipment.

The Safety and Quality Officer will be responsible for holding regular 'toolbox' safety meetings with all site personnel and will ensure meeting minutes are appropriately documented.

23.1.6 Subcontractors

All work will be undertaken, as specified by the Project Manager, and per the requirements stated within this RAP and the EMP, the OHSP and relevant management plans.

Subcontractors will be advised of required work procedures through induction, training, and meetings provided by the Contractor. Maintenance of subcontractor equipment will be the responsibility of the subcontractors.

The Subcontractor is responsible for ensuring that all works executed by the subcontractor complies with relevant SafeWork NSW as necessary.

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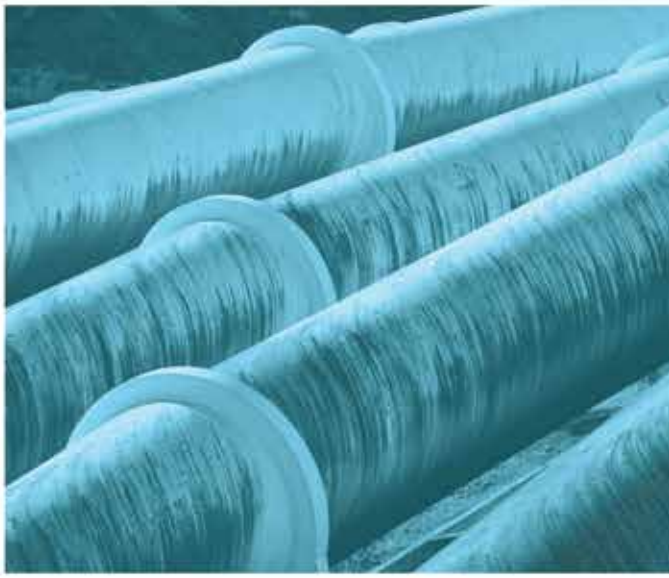
Appendix A

Asbestos Management Plan


Georges Cove Marina

Asbestos Management Plan

Prepared for Benedict Industries Pty Ltd
March 2021

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Georges Cove Marina

Asbestos Management Plan

Report Number

J180179 RP8_AMP

Client

Benedict Industries Pty Ltd

Date

26 March 2021

Version

v2 Final

Prepared by

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Environmental Scientist
26 March 2021

Approved by

Anthony Davis
Associate Director
26 March 2021

Contents

Appendices

Tables

Figures

1 Introduction

EMM Consulting Pty Limited (EMM) was engaged by Benedict Industries Pty Ltd (Benedict) to prepare an Asbestos Management Plan (AMP) for the proposed Georges Cove Marina development located at 146 Newbridge Road, Moorebank NSW (the Marina site). The Marina site has an approximate area of 12.357 ha situated on the southern part of the Benedict Sand & Gravel Moorebank site (Benedict site).

This AMP should be read in conjunction with the overarching Remediation Strategy and Remedial Action Plan (RAP) developed for the site (EMM 2021).

1.1 Background

Benedict intends to develop the Marina site for mixed land use, including a marina, commercial and residential apartment buildings. The Marina site (as part of the larger Benedict site) has a history of agricultural land use up to the mid-1980s. The land use subsequently changed to industrial when a sand quarry was established on the site. Sand dredging ceased in 2016.

Much of the Marina site has been covered with fill during the period of sand extraction. The fill typically comprises a mixture of silty sand or clay with gravel and fragments of mixed refuse (including plastic, pipe, bricks, concrete, plastic, tyres, glass, tiles, wood, asbestos containing material (ACM), metal, charcoal, and terracotta). The average depth of fill was reported as 2.5 m but it is known to extend to at least 4 m at some locations (EMM 2016).

An investigation undertaken by Douglas Partners (DP 2018) identified fragments of bonded ACM in fill obtained from two test pit locations. No free asbestos fibres were detected (DP 2018).

These observations have led to the development of this AMP to inform the conduct of future civil works at the Marina site.

1.2 Objectives

The purpose of this AMP is to ensure that all practicable steps are taken to prevent or minimise the risk of exposure to ACM for all workers and visitors at the site and on neighbouring properties. This approach is guided by legislative requirements and is achieved through two primary objectives:

1. identify asbestos related risks at the Marina site based on available information, including previous investigation reports for the site and surrounding properties; and

2. provide a summary of management controls needed to mitigate risks during future development works at the site, including engineering and administrative controls.

The AMP will help identify risks from ACM and presents management controls to be included in relevant health, safety and environmental management plans for civil works undertaken at the Marina site.

1.3 Regulatory framework

This AMP has been developed in general accordance with the following guidelines/codes:

- Safe Work Australia (2020a) Model Code of Practice: How to manage and control asbestos in the workplace;

- Safe Work Australia (2020b) Model Code of Practice: How to safely remove asbestos;

- WorkCover NSW (2014): Managing asbestos in or on soil;
- *Work Health and Safety Act 2011*;
- Work Health and Safety Regulation 2011;
- Western Australian (WA) Department of Health (DoH) (2009): Guidelines for the assessment, remediation and management of asbestos-contaminated sites in Western Australia; and
- National Environment Protection Council (NEPC), National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended in 2013 (ASC NEPM) (NEPM 2013).

2 Health risks posed by asbestos

2.1 Asbestos and health impacts

Asbestos is a naturally occurring mineral fibre which due to its excellent heat and sound insulation was widely used in building products generally between the 1940s and 1980s. Such materials include cement sheeting and fencing, drainage pipes, roofing, guttering and flexible building boards. In 2003, a total ban on the manufacture, use, reuse, import, transport, storage and sale of all forms of asbestos came into force.

Asbestos poses a potential health risk when asbestos fibres are inhaled. Long term health effects can include asbestosis, lung cancer and mesothelioma, that are typically, but not always, associated with higher exposures over a long period of time (WA DoH 2009).

Bonded asbestos in good condition does not pose a health risk although if damaged (for example, through weathering or by cutting, drilling or grinding), the asbestos fibres (AF) can be released into the air where they could be inhaled. In contrast, friable asbestos (FA), that can be easily crumbled or pulverised into powder, is more likely to release inhalable fibres and poses a greater health risk than bonded asbestos.

2.2 Management principles

If an ACM or suspected ACM is discovered or damaged, the *Managing asbestos in or on soil* flowchart from WorkCover NSW (2014) (Figure 2.1) should be consulted in conjunction with Section 4 of this AMP.

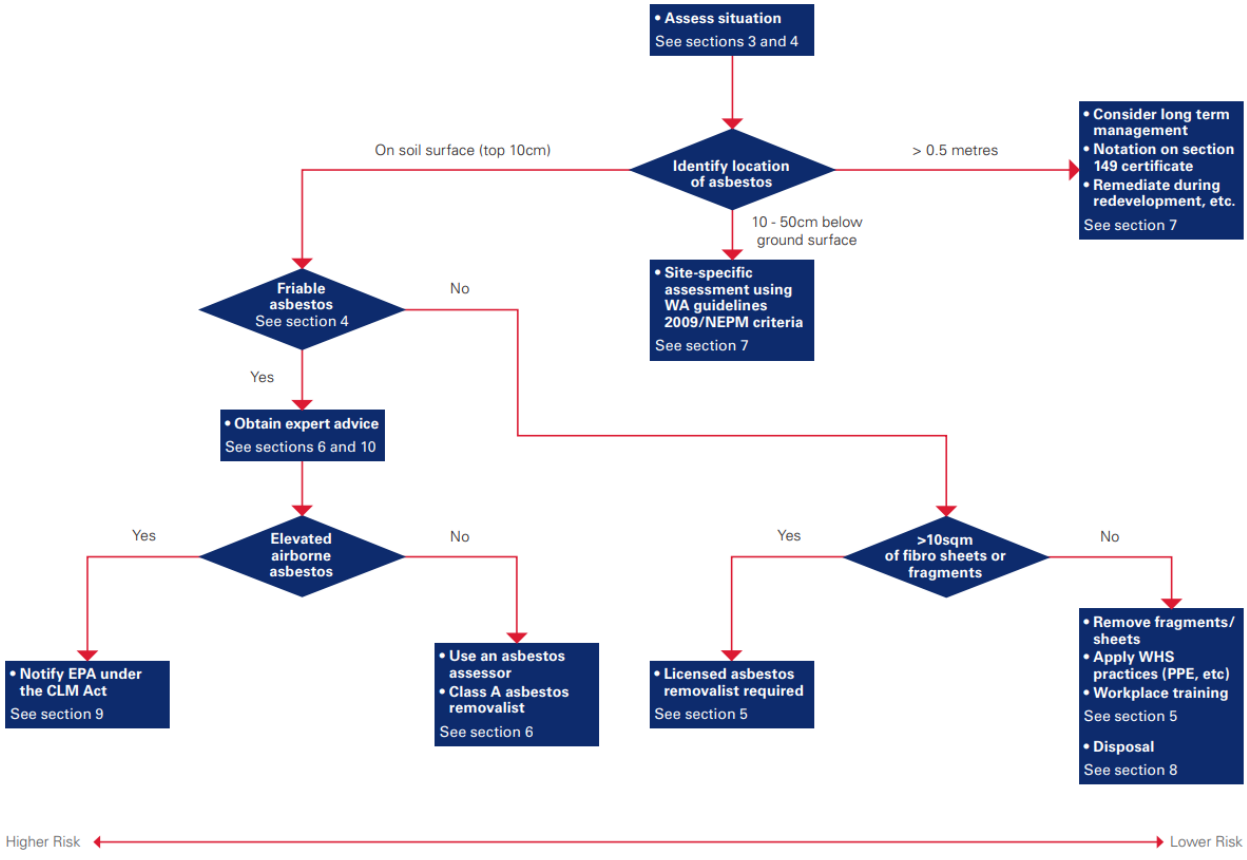


Figure 2.1 Flowchart for managing asbestos in or on soil (WorkCover NSW 2014)

3 Environmental setting

3.1 Site conditions

The Marina site will be zoned RE2 'Private Recreation' and is proposed to be developed for a marina, commercial and apartment buildings, with a Marina basin connected to the Georges River.

The Marina site currently comprises open space and a large water-filled dredge pond (abandoned sand dredging pond), stockpiles, and lightly vegetated and unvegetated foreshore areas on the west bank of the Georges River. There is a layer of fill material in parts of the Marina site (notably, adjacent to material recycling activities on the northern site boundary, along the western site boundary and to the immediate south of the dredge pond). The fill averages about 0.5 m thick, and anthropogenic debris is reported in the fill profile (EMM 2019).

Areas of fill and stockpiles containing fill material are potential areas of concern for ACM at the Marina site. Further investigations will be undertaken to confirm the extent of fill at the Marina site prior to the commencement of remediation works.

Soil excavated from test pits typically comprised fill overlying brown to light grey, moderate plasticity clay and dark sandy loam. The presence of anthropogenic fill is consistent with historic land filling practices on the Marina site. Road base and debris, including plastic and pipe fragments, were present in places in the fill layer as well as light brown organic matter. The location and thickness of fill and organic matter appears to vary widely across the site (EMM 2019).

A small quantity of virgin excavated natural material (VENM) was used to assist in restoring landforms on the Marina site. The source and the exact location of fill is unknown. It is understood that one to two metres of topsoil has also been stripped and sold from the site.

3.2 Asbestos contamination

Various site investigations have occurred at the Marina site, with two investigations including assessment of asbestos in soils:

- EMM (2015) – no evidence of ACM at the Marina site during a preliminary investigation of soil quality.
- Douglas Partners (2018) - excavated two test pits (TP101 and TP102) to a depth of 3.0 m and collected soil samples from regular depth intervals (Figure 3.1). Fragments of bonded asbestos were identified in fill from both test pits. No free asbestos fibres were detected.

  The test pits contained silty sand, clayey sand and clay filling with some gravel to a depth of at least 3.0 m below ground level (mbgl). Anthropogenic inclusions were brick, glass, tile, wood, and fragments of fibre cement. Fragments of fibre cement tested positive for chrysotile and amosite asbestos.

All areas of fill on the Marina site could potentially contain ACM and it is expected that fragments of bonded asbestos may be randomly scattered across the ground surface. Some fill that contains ACM is likely to be unsuitable in its present form to remain at shallow depths where it is potentially accessible to future users of the site.

Figure 3.1 Locations of bonded asbestos fragments reported at the Marina site

3.3 Remediation strategy

The proposed remedial strategy for soil at the Marina site includes:

- Removal of surficial ACM and unacceptable anthropogenic fill if they exceed the remediation acceptance criteria (RAC).
- Removal of buried services (such as pipes) that may contain asbestos.
- On site treatment of ASS and reuse/burial of suitable materials to the extent practical; off-site disposal of hotspot material and other unsuitable materials via targeted excavation and validation, capping of site with clean material to achieve design levels and finished remediated surface.

4 Asbestos management at the Marina site

No friable asbestos or asbestos fibres (FA/AF) have been found at the Marina site and this AMP is focused on managing potential concerns from the presence of bonded ACM fragments in fill. Based on investigations to date, the concentration of asbestos in fill materials would be acceptable for the proposed land use(s), although further investigations may be required to quantify the concentration of asbestos in fill in accordance with the ASC NEPM (2013).

To prevent weathering or damage of ACM and the release of fibres, and to address aesthetic issues, visible asbestos will be removed from the final ground surface of the Marina site or will be capped by validated clean fill. Some fill excavated from the Marina site may be reused onsite provided appropriate controls are implemented to manage aesthetic and contamination issues associated with any bonded asbestos fragments.

Typical remedial options for asbestos impacted soils include:

- hand-picking ACM fragments and disposal to landfill, accepting risk from potential residual contamination beneath the soil surface;
- excavation of asbestos impacted soils and disposal on-site beneath a cap or other appropriate separation layer; and
- excavation of asbestos impacted soils and disposal to licensed landfill.

As implied by the ASC NEPM (2013), leaving contaminated material in situ may be acceptable, providing there is no immediate danger to the environment or community and the site has appropriate controls in place. Total removal of asbestos from an impacted site typically incurs extensive investigative and confirmatory sampling. This is often not effective or necessary, and management of asbestos in situ may be preferred to avoid excessive and unnecessary soil disturbance (WA DOH 2009).

The management of asbestos in situ includes covering impacted soil with clean fill and/or other protective or warning layers (for example, a geofabric marker layer).

An assessment of remedial options has been undertaken in the RAP (EMM 2021), with the preferred options for asbestos impacted soil comprising:

- surface clearance to remove visible ACM fragments in areas where the concentration of asbestos in soil/fill meets the ASC NEPM acceptance criteria for the proposed land use; or
- containment of asbestos impacted materials beneath a capping layer and management with a long-term environmental management plan in areas where the concentration of asbestos exceeds the ASC NEPM acceptance criteria for the proposed land use.

Management principles to guide remediation works to mitigate risks to human health and the environment from ACM are outlined below.

4.1 Removal

An asbestos removal control plan would be developed once the extent of asbestos contamination at the Marina site is confirmed. All asbestos work areas will be defined by perimeter fencing and internal barriers, with prominent signs indicating an asbestos work area.

All workers involved in ACM clearance will be suitably trained and inducted in asbestos awareness and handling procedures prior to commencing work. Workers will wear appropriate PPE (such as P2 dust masks, steel-cap boots, hard hat, safety glasses and coveralls).

SafeWork NSW must be notified at least 5 working days prior to commencing asbestos removal work.

4.1.1 Hand picking of bonded ACM

Small pieces of visible bonded ACM would be removed from the surface of fill areas by hand-picking.

Hand-picking would involve two passes by two or more workers walking parallel along a grid, with 90-degree direction change between each pass. The ground surface may be lightly raked to assist with the identification of buried ACM fragments, if appropriate. The location and size of picked ACM would be recorded to allow calculations of ACM density in different areas of the site and to inform any need for additional ACM management.

Picked ACM would be securely bagged and labelled for disposal ion accordance with the waste management procedures discussed in Section 4.3.

4.1.2 Other asbestos contamination

If areas of heavily asbestos contaminated fill are found or if friable asbestos or large amounts (>10 m^2) of ACM are discovered, asbestos removal must be undertaken by a licensed asbestos removal contractor, holding a Class A/B licence for non-friable (or bonded) asbestos or a Class A licence for friable asbestos (FA/AF asbestos).

The licensed asbestos removal contractor would establish site-specific protocols for the asbestos removal, including delineation and signage of the asbestos site, site access restrictions, required PPE, and decontamination procedures. Asbestos waste would be loaded into bins or trucks that are double lined with plastic, and appropriately sealed before leaving site.

The presence of FA/AF would also require advice from a SafeWork NSW licensed asbestos assessor (LAA) with respect to the need for air monitoring. If required, monitoring for airborne asbestos fibres would be undertaken by a hazardous materials (Hazmat) specialist who is independent of the asbestos removal contractor. Air monitoring would be undertaken at the boundaries of asbestos work areas prior to removal works (background levels) and during removal works (management compliance).

Once the licensed asbestos removal work has been completed, a clearance (validation) inspection is carried out and a clearance certificate issued by an independent LAA or an independent competent person (eg occupational hygienist).

4.2 Dust management

Management of dust from sites where ACM is known or suspected is important to avoid the potential spread of airborne asbestos fibres. An overview of dust management is provided in Table 4.1.

Table 4.1 Asbestos management - dust

Objective(s)	**To ensure the impacts of dust on contractors and surrounding areas are minimised.**		
Management Strategy	Dust issues managed principally by emission controls at source, and administrative controls during works.		
		Responsibility	**Timing**
Control(s)	Area to be disturbed minimised. Clearance lots to be approved by Project Manager. Where dust is identified as an issue, dust control measures will be implemented. These will primarily involve wetting of surfaces using water from water carts but may include surface treatments. Vehicle movements controlled and limited to established tracks and designated haul roads. Dust awareness issues covered in the environmental induction process.	Site Manager	Immediate
Performance Indicator(s)	No complaints from adjacent commercial premises and/or community.	Site Manager	Immediate
Monitoring	Daily inspection of works sites to occur, including: • visual check for dust crossing the site boundaries; and • visual check of high potential dust areas, such as haul roads, stockpiles and operational areas.	Site Manager	Immediate
Reporting	Any complaints or incidents to be reported to Site Manager.	Site Manager	Immediate
Corrective Action(s)	• Investigate cause of excessive dust. • Implement controls immediately (eg water carts). • Implement corrective measures prior to the recommencement of site works. • Implement administrative controls if required, such as rescheduling of dust generating activities to more favourable weather conditions.	Site Manager	Immediate

4.3 Waste management

Asbestos waste must be managed in accordance with the *NSW Protection of the Environment Operations (Waste) Regulation 2014*, Part 7 'Transportation and management of asbestos waste'. Asbestos waste must be contained and labelled before being removed. Other asbestos waste management requirements include:

- Do not dispose of ACM within normal waste streams.
- Securely package and label non-friable asbestos while awaiting disposal.
- Seal friable asbestos in labelled containers while awaiting disposal.
- Do not stockpile asbestos waste, process and dispose promptly.
- Wet down asbestos-contaminated soil during excavation, screening/processing, transport and backfilling.
- If disposing asbestos waste off-site, only use an appropriately licensed waste facility.

- Only transport asbestos off-site in secure containers (bonded asbestos) or sealed containers (friable asbestos).
- Prevent asbestos waste in any form from being re-used, recycled or illegally dumped.

4.4 New ACM finds

If asbestos is found on site that has not been previously reported and/or is not listed on the asbestos register, the following course of action must be taken:

- All work must cease.
- The Marina site supervisor is notified.
- The Marina site supervisor must assess the asbestos and put control measures in place to address the identified risk.
- Update asbestos register to reflect each find and continue the asbestos removal work to reflect the amount and type of asbestos involved.

If new finds of more than 10 m^2 of potential bonded asbestos (for example, asbestos piping or conduit) or suspected friable asbestos (FA/AF) are observed on or below the ground surface, the protocol outlined in Figure 4.1 would be followed. The Marina site manager is responsible for training site workers in the protocol.

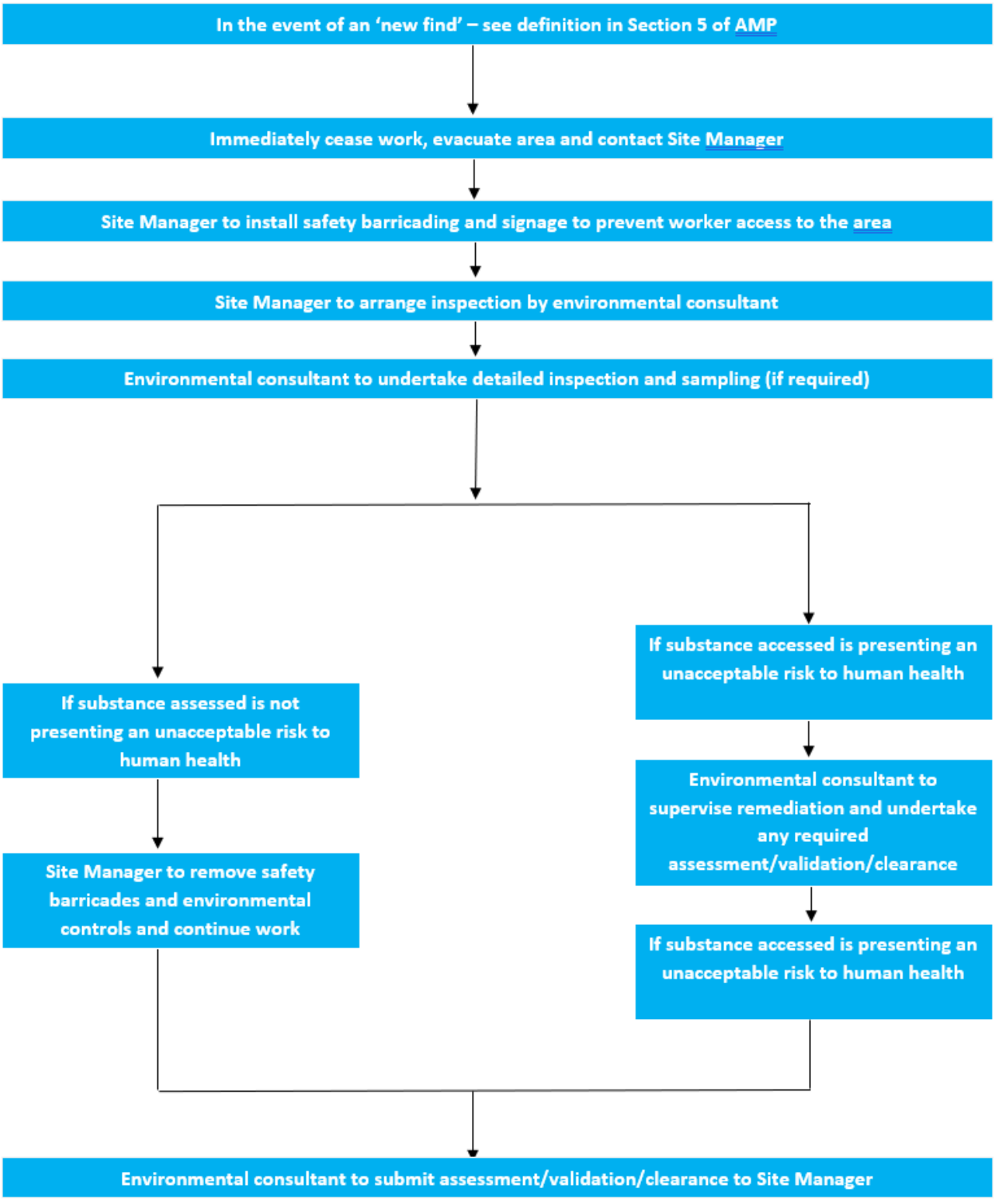


Figure 4.1 New ACM finds protocol

4.5 Emergency procedures - Asbestos

If ACM or a material suspected of containing asbestos is discovered or damaged on the site without appropriate controls in place, the emergency procedure outlined in Figure 4.2 should be followed to manage risks to health and safety. The Marina site manager is responsible for training site workers in the emergency process.

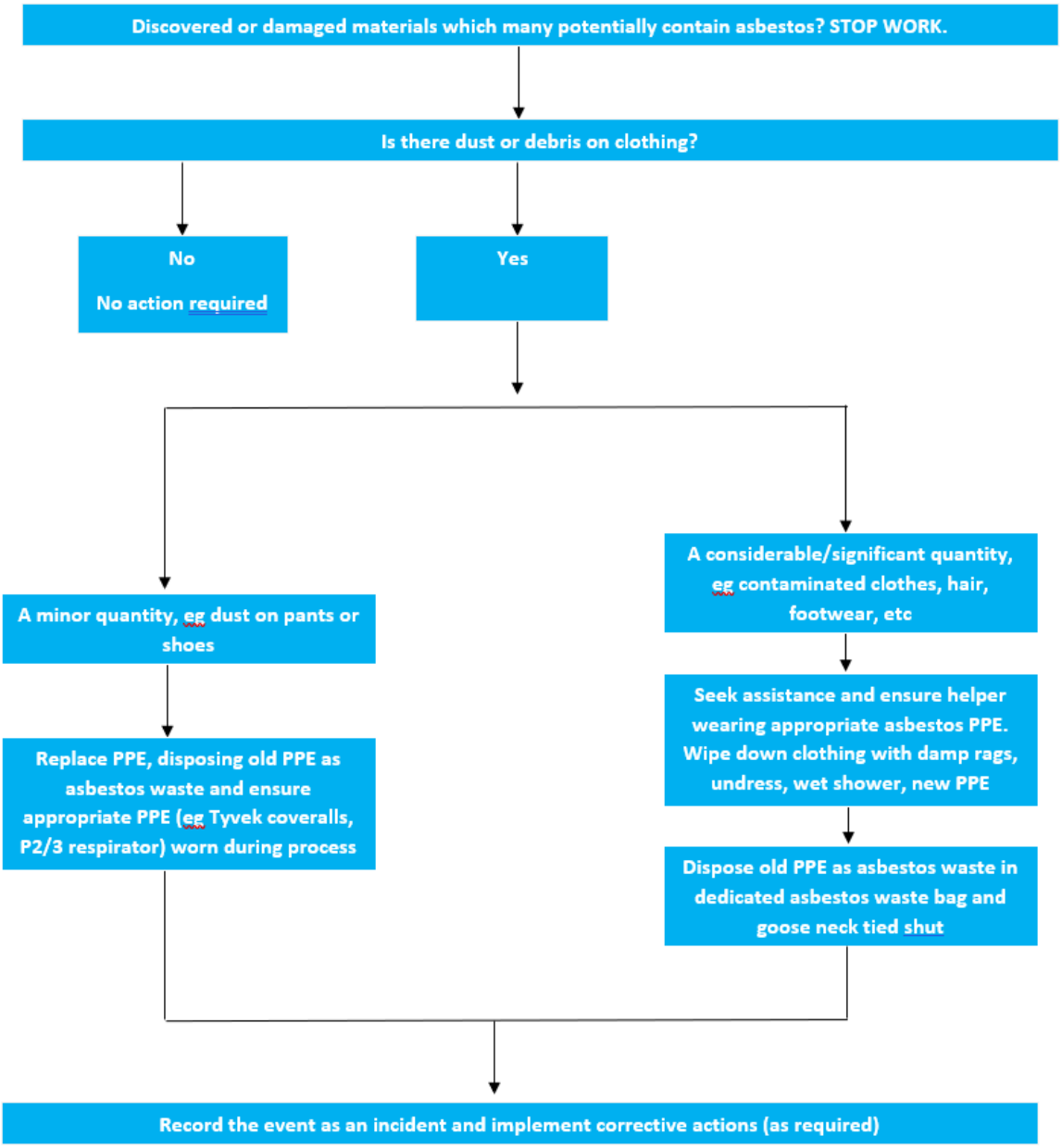


Figure 4.2 Emergency procedure - asbestos (health and safety)

5 Asbestos register

An asbestos register is required for a site when asbestos has been identified or is likely to be present from time to time. In accordance with SafeWork NSW guidance, the asbestos register must:

- Record any asbestos that has been identified or is assumed to be present at the workplace.
- Record the date when the asbestos was identified.
- Record the location, type and condition of the asbestos.
- Be maintained to ensure up to date information.
- State if no asbestos has been identified.
- Be given to the person conducting the business or undertaking (PCBU) when there is a change of management or controller of the workplace.

The construction manager or their onsite representative (specific names to be nominated) is responsible for maintaining the asbestos register.

An outline of an asbestos register is included in Appendix A.

6 Compliance management

6.1 Monitoring, reporting and review

In accordance with SafeWork NSW guidance, this AMP must be maintained with up-to-date information and reviewed at least every five years or when requested by a health and safety representative (HSR) or when asbestos is removed, disturbed, sealed or enclosed, or when changes to a control measure are made or when the plan is no longer adequate.

WA DoH (2009) guidance on reporting further investigations should be adhered to, including hand-picking, screening, soil bores/test pits/trenches and air quality monitoring.

6.2 Information and training

- Prior to commencing any works onsite, contractors are to read, understand and sign the site-specific Safe Work Method Statements (SWMS) after reading a hard copy of the AMP.
- Prestart meetings will be completed with the Marina site manager with all workers (including contractors) each day prior to site works commencing. The meetings must discuss the procedures documented in the AMP prior to beginning work and need to be acknowledged and signed onto by all personnel working on the site.

6.3 Safety management

- Intrusive soil works with excavators, drillers or using tools (spades etc) are to be undertaken only while wearing the following personal protective equipment (PPE):
  - nitrile gloves;
  - dust masks – to be worn by all personnel; and
  - long sleeves and long pants will be worn to prevent soil from contacting skin during site works.
- Additional PPE including Tyvek suits may be considered appropriate in the event of any unexpected finds of asbestos.
- PPE, including gloves that are suspected of being contaminated with asbestos, must not be removed from the work area used for the activity unless the clothing is decontaminated or contained before removal.
- All vehicles onsite must be operated with windows shut and air conditioning set to recycled air.
- Segregate all used disposable consumables (including nitrile gloves) from general waste.
- Ensure all PPE items that are used and any associated packaging are collected and removed from site as potentially asbestos contaminated materials.
- All ACM that is excavated from the site is to be placed within dedicated plastic lined skip bins provided and clearly labelled as asbestos waste.

- Stockpiled soil is to be assessed, managed or removed only under the direction of a suitably qualified environmental consultant, occupational hygienist, licenced asbestos assessor or asbestos removalist.

- If construction activities result in an increase in dust at the site, the Site Manager must follow the asbestos management from dust protocol detailed in Section 4.2. Air monitoring requirements are also considered in the removal procedure in Section 4.1.

References

Douglas Partners 2018, Preliminary Site Investigation, Proposed Rezoning (Area 1) and Georges Cove (Area 2), 146 Newbridge Road, Moorebank

EMM 2015, Preliminary Investigation of Contamination, Proposed Georges Cove Marina

EMM 2016, Supplementary Preliminary Investigation, Proposed Georges Cove Marina

EMM 2021, Georges Cove Marina, Remediation Strategy and Remedial Action Plan (RAP)

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

Safe Work Australia 2020a, Code of Practice, How to manage and control asbestos in the workplace

Safe Work Australia 2020b, Code of Practice, How to safely remove asbestos

WorkCover NSW 2014, Managing asbestos in or on soil

Work Health and Safety Act 2011

Work Health and Safety Regulations 2011

Western Australian (WA) Department of Health (DoH) 2009, Guidelines for the assessment, remediation and management of asbestos-contaminated sites in Western Australia

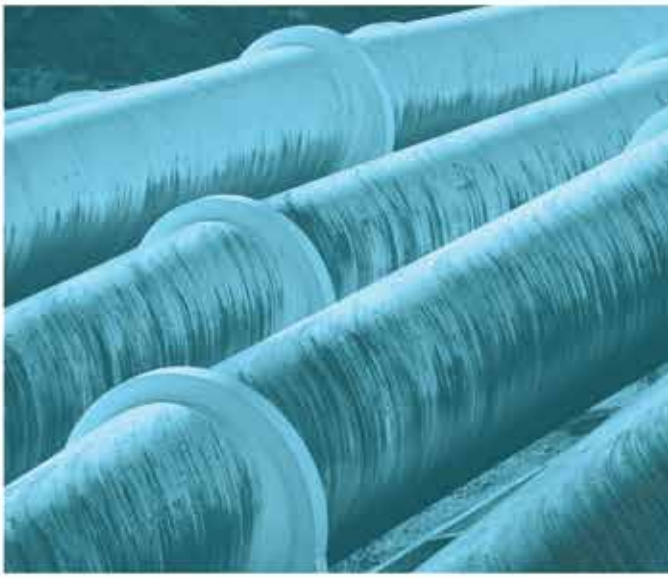
Appendix A

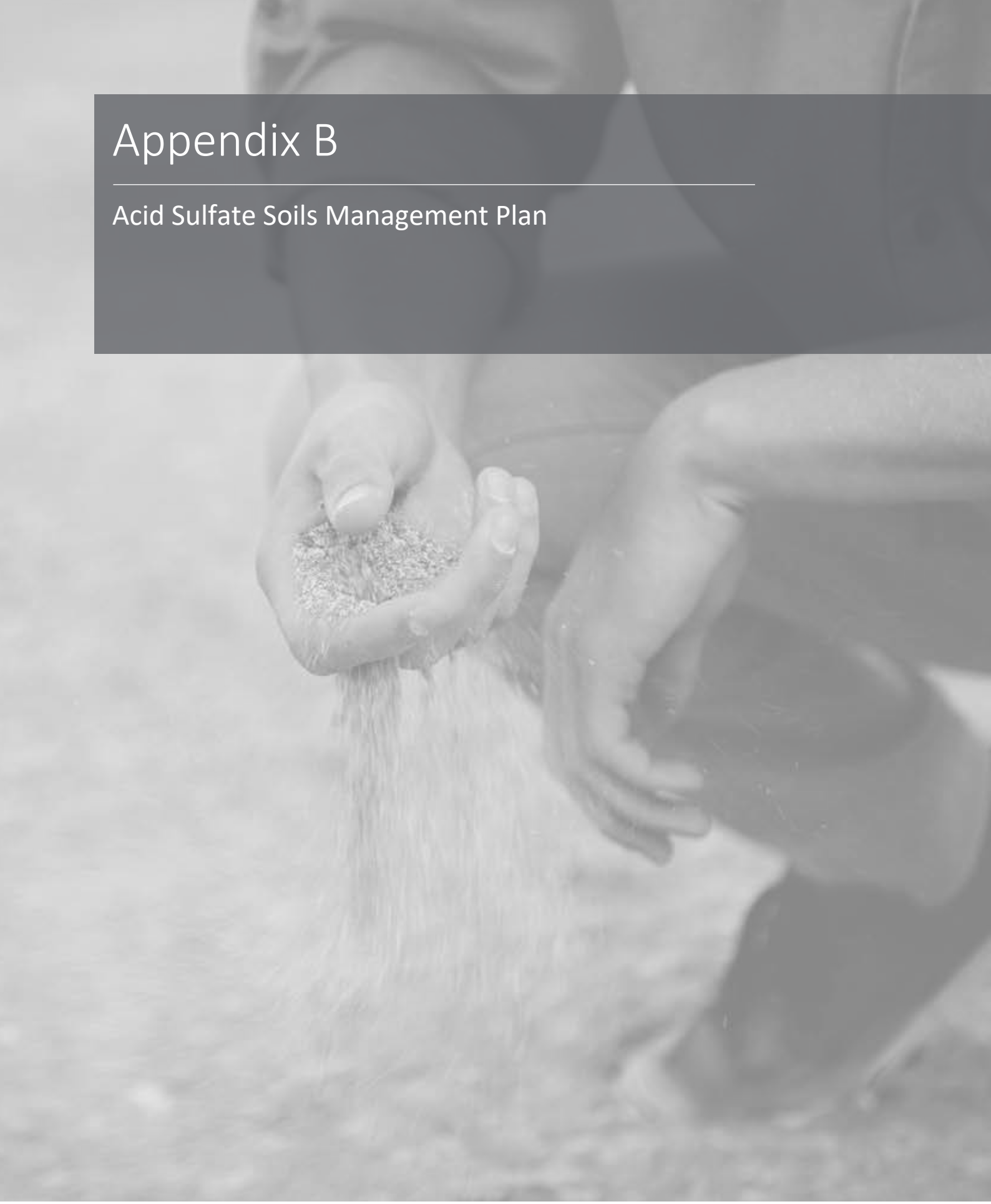
Asbestos register

Asbestos Register

Workplace Address: Conducted by:

Type of Asbestos	Specify	In this area inaccessible	Source of unfixed or uninstalled asbestos	Friable or non-friable?	What is its condition?	Likely to sustain damage or deteriorate?	Activities that may disturb the asbestos	Date of identification





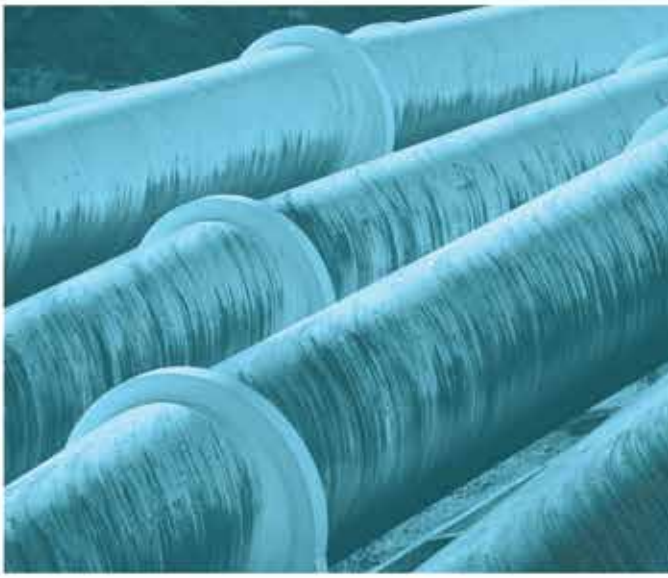
Appendix B

Acid Sulfate Soils Management Plan


Georges Cove Marina

Acid Sulfate Soils Management Plan

Prepared for Benedict Industries Pty Ltd
March 2021

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Georges Cove Marina

Acid Sulfate Soil Management Plan

Report Number

J180179 RP8_ASSMP

Client

Benedict Industries Pty Ltd

Date

26 March 2021

Version

v2 Final

Prepared by

Lachlan Lewis
Environmental Scientist
26 March 2021

Approved by

Anthony Davis
Associate Director
26 March 2021

Table of Contents

Figures

1 Introduction

EMM Consulting Pty Limited (EMM) was engaged by Benedict Industries Pty Ltd (Benedict) to prepare an Acid Sulfate Soils Management Plan (ASSMP) for the proposed Georges Cove Marina development located at 146 Newbridge Road, Moorebank NSW (the Marina site). The Marina site has an approximate area of 13 hectares (ha) and comprises a parcel of land situated on the southern part of the Benedict Sand & Gravel Moorebank site ('Benedict site') at the abovementioned address.

This ASSMP should be read in conjunction with the overarching Remediation Strategy and Remedial Action Plan (RAP) for the Marina site (EMM 2021).

1.1 Background

EMM understands that Benedict intends to develop the Marina site for mixed land use, including a marina, commercial and residential apartment buildings. The Marina site (as part of the larger Benedict site) has a history of agricultural land use up to the mid-1980s, which included a dairy farm. The land use then changed to industrial, when it was used as a sand quarry that involved a dredging operation.

The project area is identified on the Liverpool LEP (2008) acid sulfate soils (ASS) map, and reference to the Atlas of Acid Sulfate Soils indicates there is a high probability for ASS to occur. In addition, approximately 1000 tonnes of potential acid sulfate soils (PASS) have been disposed of on-site (pers comms Mark Morris, Production Manager, 29 May 2015). The marina site is currently licensed for the disposal of ASS as well as VENM.

Civil earthworks at the Marina site will disturb areas of fill and natural soils that could contain PASS and/or ASS and connecting the dredge pond and the Georges River will require removal of existing soils that are likely to be ASS.

Consequently, fill and soils that are excavated from the Marina site will require testing and management in accordance with this ASSMP to reduce the risk of acid generation that could impact water quality on and off site and aquatic health of the Georges River.

1.2 Objectives

The objectives of the ASSMP are to:

- identify acid sulfate soil (ASS) risks at the Marina site based on available information including previous investigations undertaken at the Marina site and on surrounding properties;
- minimise the duration of exposure of disturbed ASS/potential ASS (PASS) materials and excavations to minimise oxidation and resultant acid production;
- ensure that soils identified as ASS or PASS are treated to ensure adequate neutralisation and prevent adverse environmental impacts; and
- provide a summary of the controls that will need to be put in place to mitigate environmental impacts during future remediation works.

The overarching purpose of this ASSMP is to ensure that all practicable steps are taken to prevent or minimise the risk of ASS/PASS exposure as guided by legislative requirements and achieved through the identification of ASS related risks and the implementation of appropriate control measures.

1.3 Regulatory framework

The key guidelines, specifications and policy documents for ASS in NSW are:

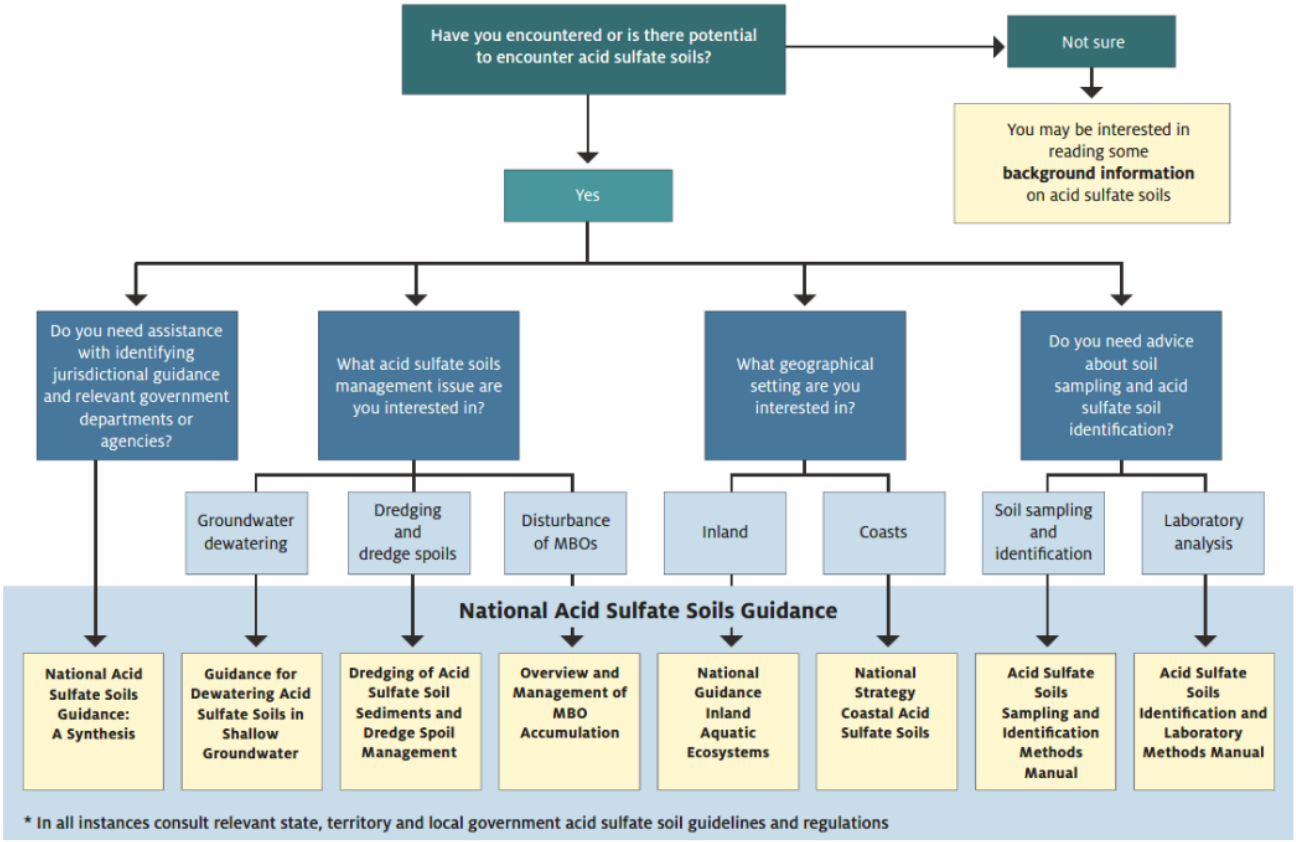
- Acid Sulfate Soil Manual (NSW Acid Sulfate Soil Management Advisory Committee (ASSMAC) 1998); and
- Acid Sulfate Soils Assessment Guideline (ASSMAC 1998).

National guidance documents from the Australian Government Department of Agriculture, Water and the Environment have also been developed to address the following ASS assessment and management aspects:

- soil sampling and identification;
- laboratory methods;
- dewatering groundwater;
- dredging and dredge spoil management; and
- management of monosulfidic black oozes (MBOs).

This national guidance, as outlined in Figure 1.1, supplements but does not replace the NSW Acid Sulfate Soils Manual (1998). The national guidance documents relevant to the Marina site include:

- National Acid Sulfate Soils Sampling and Identification Methods Manual (Commonwealth of Australia, 2018);
- Guidance for the Dewatering of Acid Sulfate Soils in Shallow Groundwater Environments (Commonwealth of Australia, 2018); and
- Overview and Management of Monosulfidic Black Ooze (MBO) Accumulation in Waterways and Wetlands (Commonwealth of Australia, 2018).



Source: Commonwealth of Australia (2018)

Figure 1.1 Selecting the right national guidance on acid sulfate soils

Under the *Protection of the Environment Operations (POEO) Act 1997 (NSW)*, it is a requirement to identify and manage acid sulfate soils to prevent pollution of waters and to lawfully dispose of acid sulfate soil waste.

The NSW EPA 2014 Waste Classification Guidelines - Part 4: Acid sulfate soils apply to acid sulfate soils that need to be transported and treated offsite.

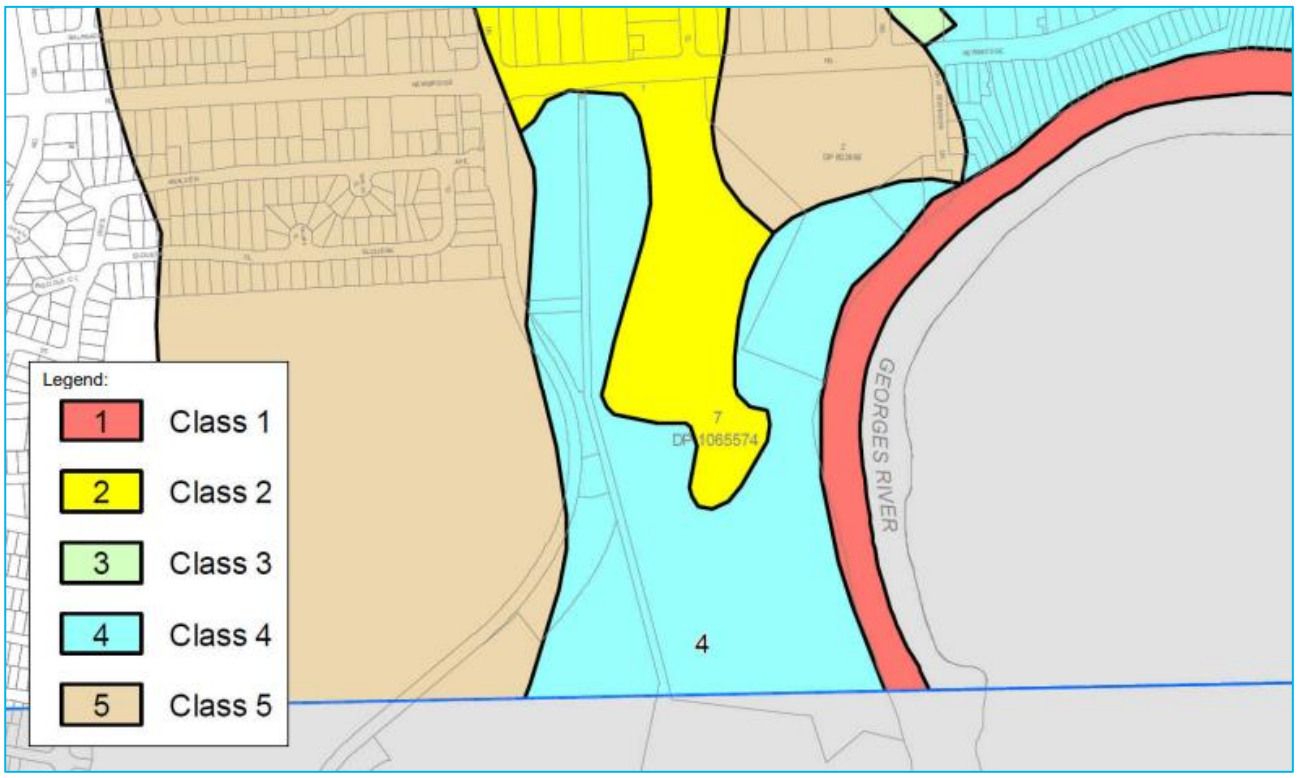
2 Environmental setting

2.1 Database information summary

The project area was identified on the Liverpool LEP (Liverpool City Council 2008) ASS map and dominated by Class 4 ASS as shown in Figure 2.1.

Reference to the Atlas of ASS indicated that there was a high probability for ASS (EMM 2015). The ASS Atlas is a dataset of available national ASS mapping and ASS qualification inferred from surrogate datasets, prepared by CSIRO Land and Water.

The Section 149 Certificate for the Benedict site identified the site includes Class 1, Class 2, Class 4 and Class 5 ASS (EMM 2015).



Source: Liverpool City Council (2008)

Figure 2.1 Liverpool LEP 2008, Acid sulfate soil map – sheet ASS-014 and sheet ASS-015

2.2 Previous investigations summary

2.2.1 Environmental Investigation Services (EIS) 2013, Stage 1 Environmental Site Assessment for Proposed, Residential Development at 146 Newbridge Road, Moorebank, NSW

As outlined by Douglas Partners (2017), the EIS (2013) Environmental Site Assessment (ESA) was limited to the subsurface soil profile and encompassed the Benedict site rather than the Marina site. The objectives included identifying widespread soil and groundwater contamination issues and the potential for the occurrence of ASS.

Of the eight (8) samples that were analysed for Suspension Peroxide Oxidation Combined Acidity and Sulphur (SPOCAS), five (5) from fill layers and three (3) of natural material), all samples were within the acidic to very acidic range.

The adopted S_{POS} criterion of 0.03% was exceeded for samples of both fill and natural soils, suggesting that some PASS may have been used to fill the Benedict site, as discussed below in the EMM 2015 Preliminary Investigation (PI).

The calculated preliminary liming rate required for neutralisation ranged from 2 kg Ca3/tonne to 15 kg Ca3/tonne.

2.2.2 EMM 2015, Preliminary Investigation of Contamination, Proposed Georges Cove Marina

A Preliminary Investigation (PI, EMM 2015) report was prepared to satisfy the requirements of clause 7(2) of SEPP 55 at the site. The PI was undertaken in May to July 2015 and encompassed a desktop review of all available historic information, a site inspection and a limited field investigation program assessing soil, dredge pond sediment and dredge pond surface water.

The report stated that Scheduled Activities under the POEO Act 1997 undertaken at the Benedict site included PASS for backfilling the sand quarry. A license variation was issued (Notice Number 1046512) to Benedict in 2005 permitting storage/disposal of Virgin Excavated Natural Material (VENM), including PASS underwater, on the Benedict site. It is understood that approximately 1,000 tonnes of PASS has been disposed on the Benedict site.

The report noted the following findings relating to the assessment of ASS risks:

- reference to the LEP and ASS map indicated that the Benedict site is considered to have a high probability for acid sulfate soils; in addition PASS had been disposed in the dredge pond on the Marina site;
- actual ASS could be present based on historically acidic groundwater results; and
- there was no visual confirmation of ASS during the PI sampling program. This will need to be considered during the construction phase when there is greater potential for soil oxygenation.

EMM (2015) recommended that:

- if required, the soils immediately adjacent to the proposed dredge pond opening and any soils displaying potential for ASS should be treated for ASS or replaced to prevent the long-term drainage of acid from soils. Management would typically be applied to river banks and possibly stockpiles, and could comprise covering soil to reduce oxygen availability, controlling water movement, and/or increasing alkalinity via the introduction of lime; and
- ASS characterisation is warranted in accordance with Section 7.7 of the Liverpool LEP 2008, and if necessary, a detailed ASS management plan should be prepared as part of the Construction Environmental Management Plan (CEMP).

2.2.3 Douglas Partners Pty Ltd 2016, Detailed Site Investigation, Proposed Residential Development, 146 Newbridge Road, Moorebank

A Detailed Site Investigation (DSI) was undertaken by Douglas Partners Pty Ltd (Douglas Partners) for a proposed residential development at 146 Newbridge Road, Moorebank, known as the northern portion of the Benedict site.

Whilst no ASS sampling was undertaken during the DSI, previous sampling data and analytical results from the EIS 2013 ESA was reviewed. Based on this review, Douglas Partners concluded that the natural soils below the water table were likely to pose a much greater risk in terms of potential acid generation considering:

- the two highest SPOS results recorded by EIS (2013) were from natural soils; and
- much of the fill was located above the water table, which meant it had been exposed to oxygen for many years that would have caused the partial oxidation of any PASS if present.

The Douglas Partners DSI recommended that excavation work undertaken at the Benedict site would need to include procedures for managing disturbance to ASS if there was a requirement for deep excavation work to occur at the Benedict site, particularly into the natural soils underlying the fill layer.

2.2.4 Douglas Partners 2017, Remediation Action Plan, Proposed Residential Development, 146 Newbridge Road, Moorebank

A RAP outlining the remedial strategy for the proposed residential development at 146 Newbridge Road, Moorebank, known as the northern portion of the Benedict site, was undertaken by Douglas Partners in 2017. The report also details results from trial remediation excavations.

The report stated that iron staining at the base of the trial remediation excavation was observed. The staining may be indicative of the oxidation of naturally occurring acid sulphate soils beneath the fill. It was recommended that testing of the soils and water at the base of the excavation is undertaken to evaluate whether:

- PASS soils are being oxidised;
- the pH and dissolved metal concentrations in the dewatered fluid is being affected by the generation of sulphuric acid; and
- liming of the excavation base should occur to neutralise the acid generating capacity (AGC) of any exposed PASS (if present).

Based on analytical results from the trial remediation excavation, Douglas Partners concluded that:

- one of the two samples collected from the base of the excavation was PASS;
- the water sample (field filtered) collected from the ponded water at the base of excavation had relatively low concentrations of dissolved metals compared to those detected in groundwater wells in the vicinity of the excavation;
- the results indicate that while PASS may be exposed at the base of the excavation, it was unlikely to be having a significantly adverse effect (ie mobilisation of dissolved metals) on water quality; and
- a significant component of the coarse material used to backfill the base of the excavation contained crushed concrete (which contains lime) that would assist to buffer any acid generation that may have occurred whilst the excavation remained temporarily dewatered.

2.3 Potential areas of concern

The Marina site has been identified has being situated within an ASS risk area. Areas where PASS has been imported to the Marina site (understood to be within the dredge pond) and areas where excavation will be required beneath the water table to achieve the desired design levels are considered to be areas of concern. However, it is expected that natural soils underlying the fill layer would be the most likely material to be classified as PASS or ASS and therefore any excavation of natural soils at the Marina site should consider the potential for ASS or PASS risk.

3 Potential impacts

3.1 Construction activities

ASS impacted material is most likely to be contained within the natural subsurface layer underlying fill material across the Marina site. This is because it would generally not be expected to encounter ASS forming conditions within fill material.

The average depth of fill material at the Marina site is understood to be approximately 2.5 m. Therefore, it is anticipated that the key construction activity with the potential to cause ASS impact is deep excavations (greater than the current depth of fill material below the ground surface).

Aspects of the project that also have the potential to cause ASS related environmental impacts may include:

- shallow excavations;
- excavation of dredge pond sediments, including to open the dredge pond to the Georges River;
- dewatering; and
- diverting small open drainage lines.

3.2 Potential ASS disturbance impacts

Potential ASS/PASS impacts from anticipated construction activities, including consequential transport mechanisms and exposure pathways, may include:

- alternations to surface run-off or uncontrolled surface runoff in excavation areas of exposed ASS, causing the release of acid into the environment;
- leaching of acid into the underlying ground surface in areas of stockpiling/ASS treatment; and
- exposure of PASS to ambient air, causing oxidisation and conversion to ASS.

4 Mitigation and procedures

Based on a review of the environmental setting (refer to Section 2), the Marina site is situated within an ASS risk area. Excavation work undertaken during remediation will need to include procedures for managing disturbance to ASS if there is a requirement for deep excavation work to occur, particularly into the natural soils underlying the fill layer.

4.1 ASS identification and testing regime

All ASS assessments must be undertaken by a suitably qualified environmental consultant and in accordance with the NSW Acid Sulfate Soil Manual (ASSMAC 1998) and other national guidance where relevant (refer to Section 1.3).

Testing for the presence of ASS must be directed by the nominated consultant and shall apply the following general methodology:

- excavate boreholes or test pits to the extent of proposed excavation, collecting samples and conducting ASS screen tests on material from each location at regular and representative depths throughout the soil profile (including samples from fill material); and
- submit samples to a National Association of Testing Authorities (NATA) accredited laboratory for SPOCAS analysis plus additional suites of tests on the two most acidic ASS screen test samples.

4.2 General works impact avoidance

Works undertaken in any areas identified as potentially containing ASS should adopt the following basic principles:

- divert surface runoff away from areas of potential or known acid sulfate material (including ASS treatment areas);
- appropriately manage surface runoff contaminated by exposure to acid sulfate material, including testing for pH and appropriately treated (if required) prior to discharge; and
- remediate and validate excavations where acid sulfate material has been removed.

4.3 ASS treatment area

ASS/PASS material will be treated onsite as soon as possible after being excavated. The optimum location for the treatment area will be identified in consultation with the project's environmental consultant but would:

- avoid low-lying areas which may be susceptible to flooding;
- not be used for storage of non-acid producing materials; and
- be situated within an area of low ground permeability (eg on a hardstand).

The ASS treatment area will include bunds of at least 0.5 m high that are made from non-PASS or treated PASS soils. The base and bund batters shall be limed (with fine agricultural lime) at a rate of 10 kg/m^2 to prevent migration of acidic conditions outside the bund. Any runoff from the treatment area would be captured and diverted to a basin for monitoring and treatment to neutralise acid.

4.4 Treatment regime

Soils shall be treated according to their acidity classification:

- **Non-acidic soils** may be handled and disposed of without specific treatment or management.
- **naturally acidic soil**s are to be treated with lime should be placed in a prepared treatment area where it will be mixed with lime applied at the appropriate rate by discing or rotary hoeing. The rate of lime application can be determined based on Titratable Actual Acidity (TAA), with a minimum liming rate of 10 kg/m^3 required for soils assessed as acidic.
- **ASS and PASS** are to be similarly placed in a prepared treatment area with the soil spread in layers up to 300 mm thickness. This is followed by application of lime at an appropriate rate and mixed with the soil via discing or rotary hoeing. The rate of lime application shall be as determined as TAA plus the acidity equivalent of the measured chromium reducible sulphur (Scr) and residual acidity (Sras) with a factor of safety of 1.5.

The base of all reclamation areas or excavations where treated PASS/ASS are to be placed shall be treated with 5 kg/m^3 (or as otherwise recommended by the environmental consultant) of fine agricultural lime per metre depth of fill prior to emplacement of the soil used as fill.

4.5 Haulage and disposal

Transport of ASS/PASS material will be undertaken by haulage vehicles with adequate tailgates and load coverings to prevent spillage of material onto public or construction access roads. Haulage routes will be monitored routinely with any identified spills documented and cleaned up immediately.

In accordance with the 2014 NSW EPA Waste Classification Guidelines Part 4: Acid sulfate soils, potential ASS must be kept wet at all times during excavation and subsequent handling, transport and storage, until they can be disposed of safely. They must be received at the proposed disposal point within 16 hours of being dug up.

PASS may be disposed of in water below the permanent water table, provided:

- this occurs before they have had a chance to oxidise, ie within 24 hours of excavation;
- the material meets the definition of VENM under the POEO Act 1997, even though they contain sulfidic ores or soils;
- the disposal facility must be a landfill licensed by the EPA to dispose of potential ASS below the water table; and
- documentation must be provided to the occupier of the landfill for each truckload of potential ASS received, indicating that the soil's excavation, transport and handling have been in accordance with the NSW Acid Sulfate Soil Manual (ASSMAC 1998), thus preventing the generation of acid.

It is noted that where soil is identified as ASS, or PASS cannot be classified as VENM or a suitable underwater disposal site at a landfill is not available, the soil must be treated as documented in this ASSMP in accordance with the neutralising techniques in the NSW Acid Sulfate Soil Manual (ASSMAC 1998). After treatment the soil can be assessed against the 2014 NSW EPA Waste Classification Guidelines and disposed of to a landfill that can lawfully accept the determined classification of waste provided by the nominated environmental consultant.

4.6 Discharge of water

No uncontrolled discharge is permitted from the Marina site. This can be managed through bunding excavations with any water collected monitored for pH, oil and grease and suspended solids prior to any release. The pH of water to be released must be within the range 6.5 to 8.5, with no visible oil or grease and suspended solids must be less than 100 mg/L (or as otherwise recommended by the environmental consultant).

4.7 Post-treatment

Treated/neutralised ASS may be incorporated into the works and emplaced at depth, except in the following locations:

- verges or drainage layers;
- Rip Rap or rock linings in drains; or
- within the upper zone of formation, the top 400 mm of general fill or within the top 0.5 m of a drainage layer.

The base of all reclamation areas or excavations where treated PASS/AASS are to be placed shall be treated with 5 kg/m^3 (or as otherwise recommended by the environmental consultant) of fine agricultural lime per metre depth of fill prior to emplacement of the soil used as fill.

5 Validation and monitoring

5.1 Validation testing

Validation testing of treated soils shall be undertaken as specified in this ASSMP. A minimum liming rate of with 5 kg/m^3 of lime shall be used for any soils assessed to be AASS or PASS.

Treated PASS/ASS shall be subject to validation testing at a frequency of 1/250 m^3 of treated soil but not less than 4 samples and include the following analyses:

- soil pH;
- soil pH post peroxide oxidation (pHox);
- TAA;
- Sras;
- Scr; and
- ANC.

Soil can be considered to have been effectively treated if pH and pHox are greater than 6.5 and the ANC is greater than the sum of the acidity (TAA+Sras+Scr) by a factor of at least 1.5.

5.2 Water quality monitoring

Any water encountered through excavation shall be tested daily for pH during site works and follow the following protocols:

- if the recorded pH of any sample is less than 6.5, it shall be immediately retested;
- if the pH is again below 6.5, the pH shall be adjusted by the application of hydrated lime until it is in the range 6.5 to 8.5; and
- where the pH is less than 4.0, advice from a suitably qualified environmental consultant shall be sought in reviewing the site practices and monitoring results and to recommend mitigation/remedial measures, including preparation of an incident report which details the context and subsequent management actions.

6 Compliance management

6.1 Training

A training session must conducted for all workers involved in the excavation, transport or handling of soils or earthworks on the site. The sessions may take the form of a site induction, or a robust discussion through a prestart meeting or toolbox talk and should be delivered by the Site Manager under the guidance of a suitably qualified ASS consultant. This should be undertaken prior to the excavation of any soils on the site and include a documented record of workers who have acknowledged and signed on to the briefing.

The objective of the training/discussion is to ensure that workers:

- are aware of the potential ASS issues on the Marina site;
- can identify PASS/ASS, including:
  - soil pH of <4;
  - pale yellow surface encrustations or excessive iron staining around water bodies;
  - sulphur odours from blue-grey-green-grey waterlogged soils; and
  - corrosion of concrete and/or steel structures exposed to water on site;
- are aware of responsibilities in managing the PASS/ASS, including relevant procedures as outlined in Sections 4 and 6.2.

6.2 New finds protocol

The remediation/construction contractor must develop a new finds procedure, which can be based off this ASSMP. This contingency plan, consistent with the NSW Acid Sulfate Soils Manual 1998, should outline a simple procedure to follow with the discovery of actual or potential acid sulfate soils. It should include procedures for the investigation, handling, treatment and management of such soils and water seepage which are outlined in Section 4.

6.3 Reporting, audits and review

All assessment and monitoring results should be documented and maintained by the principal contractor so that they can be provided to relevant authorities (eg NSW EPA, Liverpool Council) if required.

Audits (both internal and external) of procedures and compliance with those procedures on-site will be undertaken to assess the effectiveness of the environmental mitigation and management measures employed during the site works, including compliance with this plan and any relevant approvals, licenses and guidelines (if applicable).

References

Acid Sulfate Soil Management Advisory Committee (ASSMAC) 1998, Acid Sulfate Soil Manual

ASSMAC 1998, Acid Sulfate Soils Assessment Guideline

Commonwealth of Australia 2018, National Acid sulfate soils guidance: a synthesis

Douglas Partners 2018, Preliminary Site Investigation, Proposed Rezoning (Area 1) and Georges Cove (Area 2), 146 Newbridge Road, Moorebank

Douglas Partners 2017, Remediation Action Plan, Proposed Residential Development, 146 Newbridge Road, Moorebank

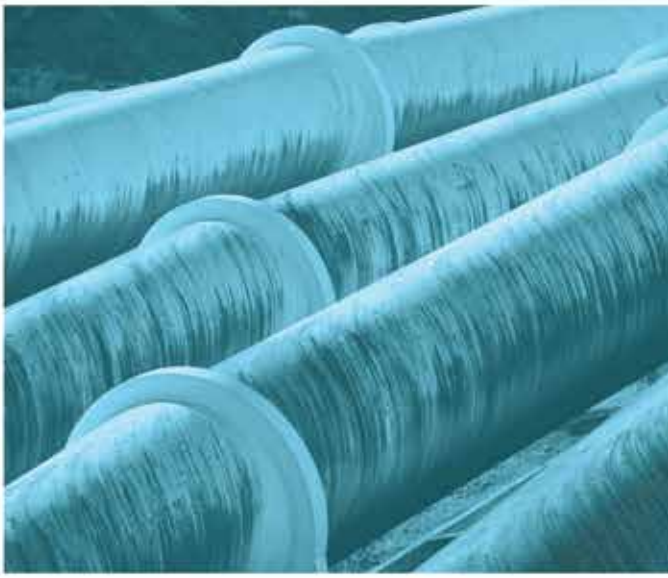
Douglas Partners 2016, Detailed Site Investigation, Proposed Residential Development, 146 Newbridge Road, Moorebank

EMM 2021, Georges Cove Marina, Draft Remediation Strategy and Remedial Action Plan (RAP)

EMM 2015, Preliminary Investigation of Contamination, Proposed Georges Cove Marina

Liverpool City Council 2008, Liverpool Local Environment Plan 2008, Acid sulfate soil map – sheet ASS-014 and sheet ASS-015

NSW EPA 2014, Waste Classification Guidelines – Part 4: Acid sulfate soils



Appendix C

NSW EPA Guidelines for Consultants Reporting on Contaminated Land - Table 2.5

Table 2.5 Remedial action plan

Remedial action plan		
Report section	**Required information**	**Included**
Document control	Date, version number, author and reviewer (including certification details) and who commissioned the report	☑
Executive summary	Background – include a summary of site contamination	☑
	Objectives of the remediation	☑
	Summary of selected scope of remediation works	☑
Objectives	Objectives of the remediation	☑
Scope of work	Summary of the scope of work	☑
Site identification	Site identification and detail items from ASC NEPM Field Checklist 'Site information' sheet	☑
Site history	Site history items from ASC NEPM Field Checklist 'Site information' sheet. A summary is enough if detailed information was included in an available referenced previous report.	☑
Site condition and surrounding environment	Site condition and surrounding environment items from ASC NEPM Field Checklist 'Site information' sheet. A summary is enough if detailed information was included in an available referenced previous report.	☑
Remediation criteria	Table listing all selected remediation criteria and references	☑
	Rationale for the selection of criteria, including assumptions and limitations of the criteria and any deviations from the approved guidelines.	☑
	Rationale for any site-specific remediation criteria developed through a site-specific risk assessment. Refer to ASC NEPM Schedules B4, B5a, B5b, B5c, B6 and B7	☑
	Refer to HEPA (2020) PFAS National Environmental Management Plan (NEMP) or guidance on environmental levels that indicate the need for action.	
Results	A summary is enough if detailed information was included in an available referenced previous report	
	Tabulated previous results relating to the remedial action plan that:	
	• show all essential details such as sample identification numbers and sampling depth	☑
	• show remediation assessment criteria	☑
	• highlight all results exceeding any remediation criteria	☑

Remedial action plan		
Report section	**Required information**	**Included**
	Sample descriptions for all media where applicable (e.g. soil, sediment, surface water, groundwater, biota)	☑
	Site plan showing all sample locations	☑
	Site plan(s) showing the extent of soil and groundwater contamination exceeding selected remediation criteria for each sampling depth, including sample identification numbers and sampling depths of all samples analysed	☑
	Site plan(s) showing the proposed extent of remediation	☑
Site characterisation	A summary is enough if detailed information was included in an available referenced previous report	
	Assessment of types of all environmental contamination	☑
	Assessment of extent of all identified contamination, including off-site areas	☑
Conceptual site model	See Table 2(a)	☑
Remediation Options Assessment and Remediation Strategy	Remediation objectives (these should already be defined under the general objectives and then the criteria derived.)	☑
	Assessment of possible remedial options and how risk can be reduced	☑
	Rationale for the selection of recommended remedial option, in accordance with the preferred hierarchy of site remediation and/or management set out in Key Principles for Remediation and Management of Contaminated Sites of the ASC NEPM Toolbox	☑
	Description of the remediation works to be undertaken	☑
	A validation plan which includes proposed testing to validate the site during/after remediation, including SAQP as per Table 2.2	☑
	Confirmation that waste imported onto the site is lawful Note: materials transported onto site will either need to meet the definition of virgin excavated natural material, or a resource recovery order and resource recovery exemption. In addition, materials imported onto the site must be adequately assessed as being appropriate for the final use of the site, including QA/QC evaluation of any sampling and analysis for material brought to site	☑
	Contingency plan if the selected remedial strategy fails	☑
	Interim site management plan before remediation, including fencing, erection of warning signs, stormwater diversion, etc.	☑
	Site management plan requirements (operational phase):	

Remedial action plan		
Report section	**Required information**	**Included**
	• site stormwater management plan	☑
	• soil management plan, including material tracking	☑
	• noise control plan	☑
	• dust control plan, including wheel wash (where applicable)	☑
	• odour control plan	☑
	• work health and safety plan	☑
	• remediation schedule	☑
	• hours of operation	☑
	• contingency plans to respond to site incidents, to remove potential effects on surrounding environment and community	☑
	Description of regulatory compliance requirements such as licences and approvals or financial assurance	☑
	Names and phone numbers of appropriate personnel to contact during remediation	☑
	Community relations plans (where applicable)	☑
	Staged progress reporting (where appropriate)	☑
	Outline of environmental management plan for ongoing management of contamination at the site (if needed)	☑
Waste management (if applicable)	Waste classification reporting requirements in accordance with EPA Waste Classification Guidelines (see Table 2(d))	☑
	Description of material handling and tracking plan	☑
	Statements regarding materials being disposed via appropriately licenced facility or re-used under an order or exemption	☑
	Waste disposal dockets or other waste documentation for any disposed waste	☑
	Refer to the Site Auditor Guidelines section 4.3.7 Waste management for waste management requirements	
Remediation Technology Pilot Trail (if applicable)	Details and results from treatability trials and Proof of Performance testing, to demonstrate the remediation option chosen was suitable for the site (for major remediation projects). If trials have not been completed, include an indicative scope of the proposed trial.	☑

Remedial action plan		
Report section	**Required information**	**Included**
Conclusions and recommendations	A list summarising the activities and physical changes proposed for the site	☑
	Conclusions addressing the stated objectives	☑
	Assumptions used in reaching the conclusions	☑
	A clear statement as to why the consultant considers the site can be made suitable for the proposed use if the remedial action plan is implemented	☑
	A summary of proposed limitations and constraints on the use of the site post remediation and proposed environmental management plan for long-term management of residual contamination at the site (where applicable)	☑
	Recommendations for further work, if appropriate	☑