AUSTRALIAN
ENVIRONMENTAL AUDITORS

Environmental Audit Report (53V)

Marrara Detention Basin – 226 McMillans Road, Marrara NT

Prepared for:
Department of Infrastructure, Planning and Logistics

Prepared by:
Australian Environmental Auditors Pty Ltd

Date:
13 November 2019

Project Number:
EA0514

EPA Service Order No.:
PRL7574 (NTEPA2018/0007-02-074)

Environmental Audit Report (53V)

Marrara Detention Basin, 226 McMillans Road, Marrara NT

Prepared for:

Department of Infrastructure, Planning and Logistics
Level 5, Energy House
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Prepared by:

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Date of Report:

13 November 2019

Author:

Jean Paul Pearce
Environmental Auditor (Contaminated Land)
(Appointed pursuant to section 53S (1) of the Victorian *Environment Protection Act 1970*)

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EA0514	13 November 2019	FINAL	JPP	• NT EPA, Environmental Audit Unit – Attention Christopher Coombes • Department of Infrastructure, Planning and Logistics • Australian Environmental Auditors Pty Ltd

Executive Summary

This report is in response to a request from Department of Infrastructure, Planning and Logistics (DIPL) to carry out an audit in accordance with section 53V of the Victorian *Environment Protection Act 1970*, to satisfy an NT EPA requirement.

The Audit reported herein is for the property located at 226 McMillans Road, Marrara, Northern Territory (the Site, shown in Figure 1), referred to as Marrara Detention Basin.

This Audit report presents the findings relative to risk of harm and/or detriment to the segments of the environment, land and water. The following summary tables provide site audit details, physical property information in accordance with Vic EPA Publication 1147, and location of audit findings within the Audit Report.

The Site is part of the Marrara Detention Basin project and has undergone redevelopment to create a detention basin to capture water during large rainfall events, to mitigate and reduce the impact of flooding from Rapid Creek on private residential properties in the suburb of Milner. Culverts and drains under Henry Wigley Drive will divert flow into the basin, while culverts along the western boundary will discharge flows towards Rapid Creek.

The soil assessment to support this audit was limited to PFAS as per the audit scope, and in-situ characterisation was conducted prior to disturbance and zones created to determine what was suitable for placement into the embankment of the Detention Basin and what was acceptable for reuse as daily cover within the lined cell at Shoal Bay Waste Management Facility (Shoal Bay). All dry weight results and leachable concentrations of PFAS were below assessment criteria. In total 80,950 m^3 of material was excavated, with 43,693 m^3 reused onsite and 37,257 m^3 sent to Shoal Bay for use as top cover.

Audit Conclusions

Based on the documentation provided to the Auditor and his own enquiries, spoil from the site was transported to the Shoal Bay Landfill for reuse as daily cover or appropriately reused within the detention basis embankment in accordance with the Auditor's and EPA's approvals.

The risks from offsite transport and reuse as daily cover at a lined cell at Shoal Bay Landfill is within acceptable levels.

The risk to human health and the environment from offsite migration of contamination via leaching of contamination from soil or via erosion is within acceptable levels.

The Auditor concludes there is no unacceptable risk to human health (i.e. future site users) or the environment (i.e. onsite and within Rapid Creek) from site derived PFAS contamination provided the integrity of the detention basin is maintained.

Audit Recommendations

No ongoing management is required beyond the need to maintain the integrity of the detention basin.

Read in Conjunction with Audit Report

This Executive Summary summarises the key points of the Audit Report. The Executive Summary must be read in conjunction with the full Audit Report (Service Order No. PRL7574 (NTEPA2018/0007-02-074); Australian Environmental Auditors Pty Ltd, ref. EA0514, *Environmental Audit Report (53V), 226 McMillans Road, Marrara, Northern Territory*).

Figure 1: Audit Site Boundary
(Source: EcOz 2019)

Table 1: Summary of Audit Information

Item	Detail
Auditor	Mr. Jean Paul Pearce
Auditor account number (Vic EPA)	289162
Auditor appointment end date (Vic EPA)	26 November 2022
Audit type	53V
Date EPA notified of audit	17 May 2017
Audit service order number	PRL7574 (NTEPA2018/0007-02-074)
Name of person requesting audit	Mr. Graham Finch of Department of Infrastructure, Planning and Logistics
Relationship of person requesting audit to Site	Senior Director Infrastructure
Name of premises owner	Department of Infrastructure, Planning and Logistics
Date of Auditor engagement	10 May 2017
Completion date of the audit	13 November 2019
Reason for audit	To assess the risk of harm to the environment and human health from reuse and/or disposal of the PFAS impacted soil from the Marrara Detention Basin project.
Audit categorisation	Risk of harm from on-site reuse of PFAS impacted soil in detention basin embankment
Environmental segments	Land and waters within the proposed reuse/disposal area
If the audit was required by an EPA notice, licence or other, please provide EPA reference number	Not applicable
Current land use zoning	Public open space
EPA region	Northern Territory
Municipality	Darwin
Dominant - Lot on plan	Section 4294 Hundred of Bagot from plan(s) S90/178
Additional - Lot on plan(s)	-
Site/premises name:	Marrara Detention Basin
▪ Building/complex sub-unit No	-
▪ Street/Lot – Lower No.	226
▪ Street/Lot – Upper No.	-
▪ Street Name	McMillans
▪ Street type (road, court, etc.)	Road

Item	Detail
▪ Street suffix (North, South etc.)	-
▪ Suburb	Marrara
▪ Postcode	0812
GIS coordinate of site centroid:	
▪ Latitude (GDA94)	-12.396869°
▪ Longitude (GDA94)	130.876701°
Plan of site/premises showing the audit site boundary attached	Yes, refer to Figure 1
Plan of site/premises showing the audit site boundary attached in a spatial data format	No
Members and categories of support team utilised	Dr. Ismail Gulec of EP Risk Management (technical expert risk assessment) for review of risk assessment Ms. Shandel Coleman of AEA for project management and review of assessment reports, construction environmental management plans and closure report and drafting this audit report. Ms. Alyson Macdonald of AEA for assisting with a site inspection during the construction of the detention basin. Ms Lyn Howard of AEA for undertaking editorial review of this audit report.
Further works or requirements	Maintenance of the integrity of the layer of topsoil and embankment (i.e. prevent erosion).
Nature and extent of continuing risk	Provided the integrity of the layer of topsoil and embankment are maintained, the risk from the impacted PFAS material is within acceptable levels.
Outcome of the audit	The management of spoil from the project has been undertaken in accordance with the Auditor's and EPA's approvals. The risk to the environment from residual site derived PFAS contaminated soils is within acceptable levels. The risk to the human health (i.e. maintenance workers and visitors) from residual site derived PFAS contaminated soils is within acceptable levels.

Table 2: Physical Site Information

Item	Detail
Historical land use	Cleared land for possible sporting use or during construction of McMillans Road (further north)
Current land use	Public open space
Surrounding land use – north	McMillans Road then low density residential properties
Surrounding land use – south	Rapid Creek, Charles Eaton Drive then Darwin International Airport
Surrounding land use – east	Henry Wrigley Drive then sporting facilities
Surrounding land use - west	Rapid Creek, Charles Eaton Drive then childcare centre
Proposed land use zoning	Public open space
Nearest surface water receptor - name	Rapid Creek
Nearest surface water receptor - direction	South-west
Groundwater segment	Segment A (e.g. potable quality) in the absence of site-specific groundwater investigation

Table 3: Location of Audit Findings within the Audit Report

Audit Findings	Location in Audit Report
Assessment of Risk of Harm or Detriment to Human Health and the Environment	Section 6
Audit Conclusions	Section 7

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Abbreviations

Abbreviation:	Description
ACM:	Asbestos-containing materials
AF/FA:	Asbestos fines/fibrous asbestos
ASC NEPM:	National Environment Protection (Assessment of Site Contamination) Measure 1999 (as amended 2013)
bfg:	Below final grade
BTEX:	Benzene, Toluene, Ethylbenzene and Xylenes
CSM:	Conceptual Site Model
DQO:	Data Quality Objectives
EAR:	Environmental Audit Report
EPA:	Environment Protection Authority
HDPE:	High-density Polyethylene
HEPA:	Heads of Environmental Protection Agencies
HIL:	Health-based Investigation Level
HSL:	Health-based Screening Level
mbgl:	Metres below ground level
NATA:	National Association of Testing Authorities
NTEPA:	NT Environment Protection Authority
OC/OP pesticides:	Organochlorine /Organophosphate pesticides
PAH:	Polycyclic Aromatic Hydrocarbons
PCB:	Polychlorinated Biphenyls
PFAS:	Per- and poly-fluoroalkyl substances
PFHxS:	Perfluorohexane sulfonate
PFOA:	Perfluorooctane alkyl
PFOS:	Perfluorooctane sulfonate
SMP:	Site Management Plan
SVOC:	Semi-Volatile Organic Compounds
TRH:	Total Recoverable Hydrocarbons
VOC:	Volatile Organic Compounds
WA DoH:	WA Department of Health

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1 Introduction

1.1 Background

This Environmental Audit Report (EAR) was prepared by Mr. Jean Paul Pearce, an employee of Australian Environmental Auditors Pty Ltd (AEA) and an Environmental Auditor (Contaminated Land) appointed pursuant to the Victorian Environment Protection Act 1970 (*Victorian EP Act*).

This EAR was prepared in response to a request from Mr. Graham Finch of Department of Infrastructure, Planning and Logistics (DIPL) on 10 May 2017 to conduct an environmental audit of the Site under section 53V of the *Victorian EP Act* to satisfy an NT EPA requirement.

DIPL contracted EcOz Environmental Consultants (EcOz) to undertake environmental investigations and associated work for the purpose of providing sufficient information to allow this Audit to be completed.

1.2 Site Definition

The Site subject to this environmental Audit is identified as: a portion of the land, known as Marrara Detention Basin, located at 226 McMillans Road, Marrara, Northern Territory (the Site) (Section 4294 on Survey Plan S90/178, Hundred of Bagot) (Figure 1). Further details are provided in Table 1.

The coordinates of the detention basin are provided in Table 4 below and a survey of the detention basin is provided in Appendix A.

Table 4: Detention Basin Coordinates

Location	Coordinates (Zone: 52L)	
	Easting	Northing
NW Corner	704,133	8,628,947
NE Corner	703,525	8,628,959
SE Corner	704,139	8,628,234

The Site is located approximately 8 km north-east of the Darwin central business district, Northern Territory. The site location is shown in Figure 2.

1.3 Proposed Development

The Site was vacant and has undergone redevelopment to create a detention basin.

DIPL is to construct a detention basin to detain the peak of the Q100 floodwater (from the Rapid Creek Catchment) on crown land at the corner of McMillan's Road and Henry Wrigley Drive, Marrara (Section 4294 and 4295) to mitigate flows into Rapid Creek. The construction of the detention basin, embankments and associated drains aim to reduce the impact of flooding on the Rapid Creek floodplain, including private residential properties in the suburbs of Milner and Rapid Creek, to the north of McMillan's Road.

The proposed development includes the construction of a stormwater detention basin by excavating below existing ground level and filling above the existing ground level to form a water retaining embankment up to 4 m high. Water will enter the basin via new drains and culverts located along Henry Wrigley Drive. Water will discharge to Rapid Creek through culverts underneath the western embankment and a spillway if waters exceed design capacity of Q100. Excess material will then be reused as daily cover at Shoal Bay Waste Management Facility (Shoal Bay).

Once complete, the site may be used for public open space, however no plans regarding this potential use are available.

1.4 Reason for Audit

NT DIPL intend to construct a detention basin to store the peak of the Q100 floodwaters on the site, prior to discharge to Rapid Creek. PFAS contamination has been identified by other studies at the Darwin International Airport and within Rapid Creek, which raised the potential for PFAS contamination of the Site.

Sampling across the area indicated that PFAS may be present within the surface soils and in the sediments and waters of Rapid Creek. NTEPA subsequently requested a 53V audit specifically to assess the risks of harm to the environment and human health from the reuse and/or disposal of PFAS impacted soil from the Marrara Detention Basin project.

As this is a 53V audit the Auditor is not permitted to provide a statement of suitability of use. At the request of the client, the Auditor has included an opinion on the risk of using the site for public open space from PFAS in site soils, but this is audit cannot provide a statement of site suitability for that use.

1.5 Independence of the Environmental Auditor

The environmental audit system depends on the Auditor undertaking an independent assessment of the site condition and risks to beneficial uses. Victorian EPA guidelines provide guidance on the Auditor maintaining their independence and avoiding potential conflicts of interest.

Based on Victorian EPA guidance, the Auditor is not aware of any real or perceived conflicts of interest which should prevent the Audit from being completed.

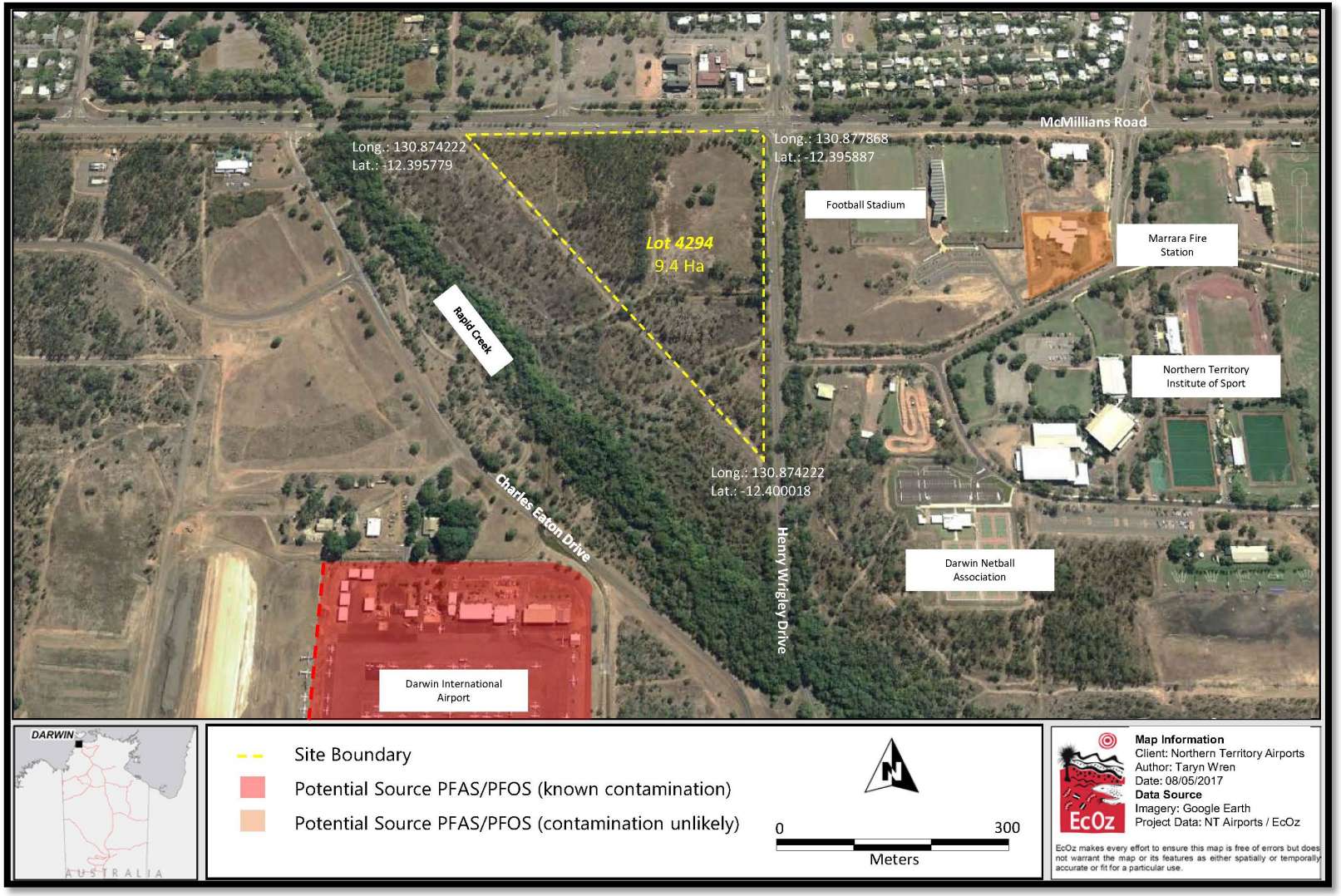

Figure 2: Site Location
(Source: EcOz DSI)

2 Audit Framework and Scope of Works

2.1 General

A 53V audit is an audit '*in relation to the risk of any possible harm or detriment to a segment of the environment caused by any industrial process or activity, waste, substance or noise'*.

A beneficial use is defined in the Victorian *Environment Protection Act* 1970 (Victorian EP Act) as '*a use of the environment or any element or segment of the environment which-*

(a) is conducive to public benefit, welfare, safety, health or aesthetic enjoyment and which requires protection from the effects of waste discharges, emissions or deposits or of the emission of noise; or

(b) is declared in State Environment Protection Policy to be a beneficial use;'.

The assessment of whether a specific beneficial use is precluded or not is undertaken using an assessment of site condition against published qualitative and quantitative assessment criteria. For a 53V audit, the segments and elements which need to be assessed are defined by the audit scope, as detailed in Section 2.4 of this report.

2.2 Legislation, Regulations and Guidelines

Section 68 of the Northern Territory Waste Management and Pollution Control Act 1998 (WMPC Act), Register of qualified persons, specifies that:

(1) The NT EPA must cause to be established and maintained a register of:

(a) persons qualified to perform environmental Audits for the purposes of an environmental Audit program…

It is understood that in early 2011 persons accredited under the NSW Site Auditor Scheme or the Victorian Environmental Auditor Scheme were approved as a class of person suitable to undertake environmental Audits in the Northern Territory.

The Audit was undertaken in accordance with Section 47d of the NT WMPC Act which states that:

An environmental Audit is an evaluation of any of the following:

(d) the likelihood of waste management problems or pollution resulting in environmental harm occurring and the adequacy of safeguards in place to prevent their occurrence or limit their impact on the environment;

(f) the types, amount, distribution or mobility of contaminants or waste present in the environment.

When conducting this environmental audit, the following key pieces of legislation (and subordinate legislation) were considered:

- *Environment Protection Act 1970* (Act No. 8056/1970) Victoria;
- SEPP (State Environment Protection Policy) (1999) *Ambient Air Quality*. Victorian Government Gazette, S19, 9 February 1999;
- SEPP (State Environment Protection Policy) (2001) *Air Quality Management*. Victorian Government Gazette, S240, 21 December 2001;
- SEPP (State Environmental Protection Policy) (2002) *Prevention and Management of Contamination of Land*. Victorian Government Gazette, S95, 4 June 2002; and

- SEPP (State Environmental Protection Policy) (2018) *Waters.* Victorian Government Gazette, S499, 23 October 2018.

Key guidance documents for environmental auditing include, but are not limited to, the following:

- NTEPA, *Guideline for the Preparation of an Environmental Management Plan*, May 2015;
- NTEPA, *Northern Territory Contaminated Land Guideline,* June 2017;
- EPA Victoria Publication 865.12, *Environmental Auditor Guidelines for Appointment and Conduct*, December 2016;
- EPA Victoria Publication 952.5, *Preparation of Environmental Audit Reports on Risk to the Environment*, December 2015;
- EPA Victoria Publication 953.2, *Environmental Auditor Guidelines for Conducting Environmental Audits*, August 2007; and
- EPA Victoria Publication 1147.2, *Environmental Auditor Guidelines – Provision of Environmental Audit Reports, Certificates and Statements*, December 2015.

Additional guidance documents include, but not limited to, the following:

- ASC NEPM (2013) *National Environment Protection (Assessment of Site Contamination) Measure 1999* (ASC NEPM), as amended May 2013, National Environment Protection Council. Australian Government;
- HEPA (2018) PFAS National Environmental Management Plan (NEMP), Heads of EPAs Australia and New Zealand;
- CRC CARE 'Technical Report 16: Safe onsite retention of contaminants Part 2: A risk based approach' (2013); and
- ANZECC (Australian and New Zealand Environment and Conservation Council), *Guidelines for the Assessment of On-Site Containment of Contaminated Soil*, September 1999.

The NTEPA requirements for summary information are provided in the Executive Summary.

2.3 Audit Objectives

The objective of this Audit is to determine the risk of harm to the environment and human health from reuse and/or disposal of the PFOS impacted soil at the Audit Site.

If required, the Audit will propose measures required to identify and reduce potential risks and subsequently maintain risks at an acceptable level for the identified segments, elements and/or beneficial uses.

2.4 Audit Scope

The Audit was conducted under Section 53V of *the Victorian EP Act* and addresses the objectives set out above. The Audit has been completed in accordance with the scope of work provided to the NT EPA, which takes into account written and verbal feedback received from NT EPA, specifically the need for a 53V audit and the approval of the reuse of PFAS impacted material within the embankment walls of the detention basin and reuse as daily cover within the lined cell at Shoal Bay (based on advice from the Auditor).

This EAR is a standalone report, and the Audit has not been conducted as part of a larger environmental audit program.

The key aspects of the scope of the Audit are summarised in Table 5 below.

Table 5: Scope of Work Activities

Aspect	Element
Activity audited	Reuse and/or disposal of the PFAS impacted material at the Audit Site and resultant risks.
Component audited	PFAS impacted material from the Marrara Detention Basin project
Segments audited	The land and waters within the proposed reuse/disposal area.
Elements audited	Soil and waters.
Beneficial uses which were considered	Beneficial uses of Land and Waters.
Risk assessment	The risk assessment will consider risks to human health and the environment from PFAS.
Period of Time	The Audit was commenced in May 2017 and completed in September 2019. The audit findings are applicable to the audit period, with reasonably anticipated future changes discussed where relevant.
Exclusions	The Audit does not include: 1. A total assessment of the Site to determine suitability of part or all of the Site for an intended use as would be conducted under Section 53X of Part IXD of the Victorian Environment Protection Act 1970; or 2. Assessment of risks posed by sources of contamination beyond those directly associated with PFAS.

2.5 Audit Criteria

The criteria for the Audit are found in *the Victorian EP Act* and the relevant policies for land and atmosphere protection. This is a statutory audit conducted under s53V of *the Victorian EP Act*.

The adopted criteria for use in assessing data and other information provided in the course of the Audit are summarised in Table 6 below.

Table 6: Adopted Audit Criteria

Element	Criteria	Comments
Land	CRC Care – human health • Health Screening Levels for public open space (HSL-C) CRC Care – ecological • Ecological Screening Levels for urban residential and public open space (ESL-urpos)	Public open space were deemed to be appropriate for the reuse in a detention basin.
	PFAS NEMP – Human Health Screening values for public open space • PFOS/PFHxS – 1 mg/kg • PFOA – 10 mg/kg PFAS NEMP – ecological direct exposure values public open space • PFOS/PFHxS – 1 mg/kg • PFOA – 1 0 mg/kg PFAS NEMP – landfill disposal • Unlined • Clay/single composite lined • Double composite lined	

Element	Criteria	Comments
Water	PFAS NEMP – aquatic ecosystems • 95% species protection (slightly to moderately disturbed systems)* PFAS NEMP • Interim soil and waste reuse leaching criteria PFAS NEMP – landfill disposal • Unlined • Clay/single composite lined • Double composite lined	NT EPA previously advised that surface water bodies in the vicinity of the site should have a 90% protection level for freshwater ecosystems. In accordance with HEPA NEMP 2018 and ANZECC 2000/2018, the next level protection is to be applied for PFAS due to the bioaccumulative nature of this contaminant, therefore a 95% species protection level is applied.

*Note: When assessing the risk from soil leachate to groundwater and groundwater receptors, a dilution attenuation factor (DAF) is adopted in accordance with USEPA (1996) and EnRisk (2018). A conservative DAF of 20 has been adopted based on distance between the soil source (i.e. contained material) and groundwater.

2.6 Audit Methodology

The methodology of work undertaken for this audit is summarised in Table 7 below.

Table 7: Audit Methodology

Task	Methodology
Task 1: Project familiarisation	This task involved familiarisation with the Site and preliminary review of the available documents. This work involved: • Obtaining copies of documents and data; and • Familiarisation with relevant reports and documents provided by DIPL and advice relevant to the Audit.
Task 2: Stakeholder communication	The Auditor undertook consultation with the stakeholders, NT EPA, the client and the Environmental Consultant (EcOz Environmental), particularly on the scope of the audit.
Task 3: Review of sampling and analysis quality plan (SAQP)	The Auditor reviewed the background information to familiarise himself the Site and the SAQP to determine if the proposed sampling program was suitable. A list of reports is provided in Section 2.8 below.
Task 4: Review of detailed site investigation (DSI)	The auditor reviewed the DSI to ensure the investigation completed was undertaken in accordance with the approved SAQP.
Task 5: Site inspections and verification	An initial inspection of the Site was undertaken by the Auditor on 12 February 2018 to become familiar with site layout and infrastructure and geographic setting.
Task 6: Review of the design construction documentation	The Auditor reviewed the detention basin construction documentation ensuring that the design met the requirements set out by NT EPA for reuse of PFAS impacted material.
Task 7: Endorsement of proposed reuse of PFAS material	The auditor provided advice to NT EPA detailing the PFAS characterisation, proposed construction design, risk assessment and suitability for reuse onsite and at Shoal Bay. NT EPA provided approval of the reuse of material within embankment wall of detention basin and as daily cover at Shoal Bay, subject to a CEMP.
Task 8: Review the Environmental Management Plan (EMP) and Construction EMP	The Auditor reviewed the EMP and CEMP to ensure that the proposed management measures were suitable to ensure the movement and placement of PFAS impacted soils was adequate and suitable in perpetuity.
Task 9: Site inspection during construction	A follow up site inspection was completed by the Auditor on 31 July 2018 and the Auditor's Assistant on 27 September 2018 during construction of the detention basin.

Task	Methodology
Task 10: Review of containment cell design	Asbestos Containing Material (ACM) was identified during the excavations onsite. The client decided that the ACM impacted soil would be placed in a containment cell onsite under the review of another auditor who scope was limited to asbestos. We reviewed the containment cell design with respect to any potential impact on the retention of PFAS impacted soil at the site.
Task 11: Site inspections and verification	A final inspection of the Site was undertaken by the Auditor on 24 June 2019 to verify the construction of the detention basin
Task 12: Review of the Completion Report	The Auditor reviewed the completion report to verify the detention basin was constructed in accordance with the approved design.
Task 13: Prepare and issue final audit report	This Audit report was prepared after completion of the required tasks using the methodology detailed herein. It includes an Executive Summary component that summarises the main findings of the report. Outcomes from the review are reported in accordance with the NT EPA requirements. Prior to issue of this report, draft audit recommendations and outcomes were discussed with the NT EPA and the Client.

2.7 Previous Environmental Assessments and Audits

To the Auditor's knowledge, the current audit is the first that has been commenced for this site.

An audit is currently underway for construction of an asbestos containment cell on the same site, but has not been completed to date.

2.8 Documents Reviewed

The list of documents reviewed as part of the current Audit is summarised below, and provided in Appendix B. Documents reviewed as part of the audit included:

- EcOz Environmental Consultants (8 May 2017) *Rapid Creek Flood Mitigation at Section 4294, Sampling and Analysis Quality Plan Perfluoroalkyl and polyfluoroalkyl substances (PFAS)*;
- EcOz Environmental Consultants (17 January 2018) *Marrara Detention Basin Flood Mitigation at Section 4294, Detailed Site Investigation Perfluoroalkyl and polyfluoroalkyl substances (PFAS)*;
- EcOz Environmental Consultants (16 February 2018) *Environmental Management Plan, Soil Management Framework - Marrara Detention Basin*;
- EcOz Environmental Consultants (21 August 2019) *Marrara Detention Basin Completion Report; and*
- *EnRisks, Review of Risk Issues for PFAS Re-Use of Soil from the Marrara Flood Detection Basin, 28 June 2018.*

The following documents were prepared as part of the contractor management plans and therefore were only reviewed in relation to PFAS soil handling:

- Sitzler (19 June 2018) Earthworks Management Plan, Rapid Creek Flood Mitigation
- Sitzler (8 June 2018) Project Environmental Management Plan, Rapid Creek Flood Mitigation Project

2.9 Correspondence with Client and their Consultants

The Auditor sent a copy of the proposed audit scope to the Client, who agreed the scope should be undertaken to meet NT EPA requirements.

During the course of the Audit, the Auditor issued a series of formal review letters to the Client and their Consultant. These letters typically document the outcome of the Auditor's review of work plans and draft reports. A copy of these letters is provided as Appendix C.

In addition, the Auditor also provided numerous e-mails to the Client and Consultant. Copies of these documents are held with AEA.

2.10 Correspondence with NT EPA

The Auditor submitted a Notification of Request to Conduct an Environmental Audit of an Activity to the NT EPA on 17 May 2017 along with the proposed draft audit scope. A copy of this document is provided in Appendix D. NT EPA provided verbal feedback on the adequacy of the proposed audit scope.

In accordance with the PFAS NEMP, the Auditor provided his opinion on the level of protection to be applied at Rapid Creek and Shoal Bay and sought NT EPA's opinion. NT EPA responded on 20 February 2018 that:

- '*As Rapid Creek is a highly disturbed ecosystem situated within a commercial/residential area, the NT EPA agrees with the adoption of 90% protection level for freshwater.*
- *In accordance with Conditions 61 and 62 of the Environmental Protection Licence EPL 188 – City of Darwin The Shoal Bay Waste Management Facility, leachate monitoring has a protection level of 90% of marine ecosystems.*
- *The PFOS leaching into the receiving environment, Rapid Creek and the associated flood mitigation works should be assessed against the 95% protection level of fresh/marine ecosystems.*'

The Auditor provided his opinion to the client on 2 March 2018 (EA0514-C3) that he considered that the '*material to be disturbed as part of the Marrara Detention Basin project does not present an unacceptable risk to human health or the environment for the reuse onsite and at the landfill*' as if relates to PFAS contamination. NT EPA provided a letter to the client on 12 March 2018 that after reviewing the Auditor's endorsement, spoil from the site is suitable for reuse within the embankment walls of the Marrara Detention Basin and as daily cover within the lined landfill cell at the Shoal Bay Waste Management Facility, subject to implementation of a comprehensive Construction Environmental Management Plan with tracking of soil movements. The NT EPA letter is provided in Appendix D

The Auditor provided a copy of the draft EAR to NT EPA for comment on 15 October 2019 with comments received on 7 November 2019 and incorporated into the final EAR.

2.11 Audit Team and Expert Support

The auditor utilised an external specialist audit support team comprising of:

- Dr. Ismail Gulec of EP Risk Management (technical expert risk assessment) – assisting with the review of the risk assessment

The Auditor utilised an internal specialist audit support team, comprising of:

- Shandel Coleman (internal Auditor's Assistant and project manager) – assisting with reviewing of assessment reports, environmental management plans, close out report and drafting of this report;
- Alyson Macdonald (internal Auditor's Assistant) – assisting with site inspection; and
- Lyn Howard (internal editor) – editorial review of EAR.

2.12 Auditor's Verification of Site Condition

The Auditor has undertaken work to verify that the environmental activities and quality of the Site is as reported by the various reports reviewed.

Four site inspections were performed by the Auditor and/or the Auditor's Assistant. An initial inspection was undertaken by the Auditor on 12 February 2018. This Site visit included observation of the overall site layout and condition. A second site inspection was undertaken by the auditor on 31 July 2018 to observe the construction of the detention basin. Ms. MacDonald undertook a further site inspection on 27 September 2018 to observe the detention basin construction, specifically at the completion of the zone 1 and zone 2 excavation and while readying drains and culverts for the wet season. The auditor completed a final inspection on 24 June 2019, observing the final loads being removed from site to be transported to Shoal Bay.

The Auditor considered that verification sampling was not necessary to complete the 53V audit. This determination was made based upon:

- The lack of unexpected or unexplained pollution;
- The competency of the Consultant who conducted the sampling and the laboratories which conducted the analysis;
- The quality of the documentation provided by the Consultant and laboratories; and
- The verification between Consultant's documentation and site observations and the audit team.

2.13 Uncertainties of the Audit Process

This Audit Report has been prepared for DIPL for the purposes described in the Audit Report. This document may not be suitable for other purposes.

The Auditor has prepared this document in good faith but is unable to provide certification outside of areas over which he had some control or is reasonably able to check.

It is not possible in an Environmental Audit Report to present all data, which could be of interest to all readers of this report. Readers are referred to the referenced Investigation Reports for further data. Users of this document should satisfy themselves concerning its application to, and where necessary, seek expert advice with respect to their situation.

The Auditor notes that any comments and conclusions provided in this document regarding the suitability of the Site for the proposed land use are implicitly limited to consideration of contamination related issues as

defined under the *Victorian EP Act* and the audit scope. The Auditor has prepared this Audit Report on the legislation, regulations and guidelines specified in Section 2.2.

3 Site History and Characterisation

3.1 Site History Summary

Site history information was provided from the EcOz DSI. An aerial photograph from 1969 and 1972 shows the site was undeveloped. A large portion in the north eastern area of the Site had been cleared in the 1974 aerial, though the use is unknown, EcOz speculated about it possibly being a sporting field or associated with the construction of McMillans road to the north. The 1975 aerial shows that several drains have been cut through the Site and these were still present at the start of the Audit.

Other than the cleared area in the north east of the Site, no other evidence of point sources of contamination or significant contaminating activities were identified at the audit site, such as underground fuel storage tanks or industrial activities.

The Site is part of the Marrara Detention Basin project and is undergoing redevelopment to create a detention basin to capture water during large rainfall events. Culverts and drains under Henry Wigley Drive will divert flow into the basin, while culverts along the western boundary will discharge flows towards Rapid Creek.

3.2 Surrounding Land Uses

The surrounding land uses are as follows:

- North: McMillans Road then residential;
- East: Henry Wrigley Drive then sporting grounds and Marrara Fire Station;
- South: Rapid Creek, Charles Eaton Drive then Darwin International Airport; and
- West: Rapid Creek, Charles Eaton Drive then childcare centre.

3.3 Potential Contaminants of Concern

The site history did not identify any historical use of the site by a potentially contaminating activity. However, there are ubiquitous potentially contaminating activities such as application of herbicides, importation of contaminated fill (such as construction and demolition waste with asbestos containing material). The site is located adjacent to Rapid creek and is downgradient of the Darwin International Airport, both of which are known for PFAS contamination. Marrara fire station is also a potential PFAS source, though is not considered likely to impact the site due to the distance.

Due to proximity to creek, identification of PFAS in site soils and as requested by EPA, the key contaminant of concern for this audit is PFAS.

3.4 Council Planning Scheme

The Site is located within a public open space zone under the Northern Territory Planning Scheme.

3.5 Topography and Surface Waters

The Site itself is relatively flat. No on-site surface water bodies are present.

The nearest surface water body is Rapid Creek, located immediately south of the Site and Beagle Gulf/Timor Sea located 4 km to the north-west. Rapid Creek is inferred to be ultimate environmental receptor of any contaminated water from the site.

The detention basin, once constructed, will discharge directly into Rapid Creek.

3.6 Regional Geology and Hydrogeology

The Spatial Territory Resource Information Kit for Exploration (STRIKE-NT Gov 2018) indicates that natural soils at the Site are likely to comprise sand, silty clay; sediments deposited by unconcentrated surface runoff; and colluvium. Regional geology in the vicinity of the Site is part of the Money Shoal Basin, where lithology includes sandstone, coal, shale, claystone and marls overlain by Cainozoic carbonates. The site geology indicates that natural soils are likely to comprise sand, clayey sand with limonite gravels or variably cemented and mottled laterite.

Surface water is expected to discharge into Rapid Creek, located approximately immediately south of the site, which flows into the Beagle Gulf/Timor Sea, approximately 4 km north-west. Groundwater is present in the local fractured and weathered rock aquifer (shale, greywacke, sandstone). In the absence of a site-specific groundwater investigation, groundwater is conservatively to flow towards and discharge to the nearest surface water receptor, that being Rapid Creek towards the south-west.

Ten registered groundwater bores are present within a 500 m radius of the site. The Site is located immediately adjacent to Rapid Creek, with two production bores near McMillans Road, between the site and Rapid Creek, constructed in 1980 and installed to depths of 13m and 56 m. The groundwater level in both bores located immediately adjacent to Rapid Creek at the time of installation was 1.5 mbgl, but is anticipated to be a perched system given the proximity to the creek.

The geotechnical investigation extended to 4 mbgl and encountered groundwater in one location (TP124) next to Rapid Creek, which is anticipated to be perched as a result of the creek. Groundwater was not encountered onsite in the other sampling locations or subsequently site development works. The consultant reported that the regional aquifer would be more than 30 mbgl. However, the auditor notes that there is expected to be large seasonal groundwater fluctuation with rainfall in the wet season. In the absence of an a seasonal onsite groundwater investigation but lack of encountered groundwater during site development, the depth to groundwater (when assessing the risk to groundwater) is conservatively assumed to be several metres below the depth of the detention basin excavation rather than the consultants 30m seperation.

3.7 Conceptual Site Model

A conceptual site model (CSM) was prepared by EcOz (2017). The Auditor considers the CSM prepared by EcOz to be representative of the site conditions.

The extent of contamination, identified by this assessment to pose a potential risk, is PFAS from the material in the embankment walls of the detention basin. No volatile contamination was identified in any of the sampled materials.

The following potential receptors have been identified:

- Aquatic ecosystems of Rapid Creek;
- Workers during construction works;
- Residents within reach of windblown dust; and
- Future site users and workers.

Pathways for contamination to reach these receptors are discussed below.

The main contaminant pathway during excavation and construction of the basin was identified as vertical migration through the soil and into groundwater, with groundwater eventually discharging into Rapid Creek and then into Darwin Harbour. Surface runoff (including sediments) was also identified as another key pathway, particularly during the wet season and when water carts are required during construction to suppress dust.

Since all dry weight results and leachable concentrations of PFAS were below assessment criteria, potential for migration of contaminants to underlying groundwater and for contaminants to migrate off site via groundwater, are low. This potential risk is further mitigated by the reduced water infiltration due to the design and construction of the detention basin to be water retaining.

A copy of the EcOz CSM is included as Figure 3.

The Auditor's assessment of risk to human health and the environment is further defined in Section 6.

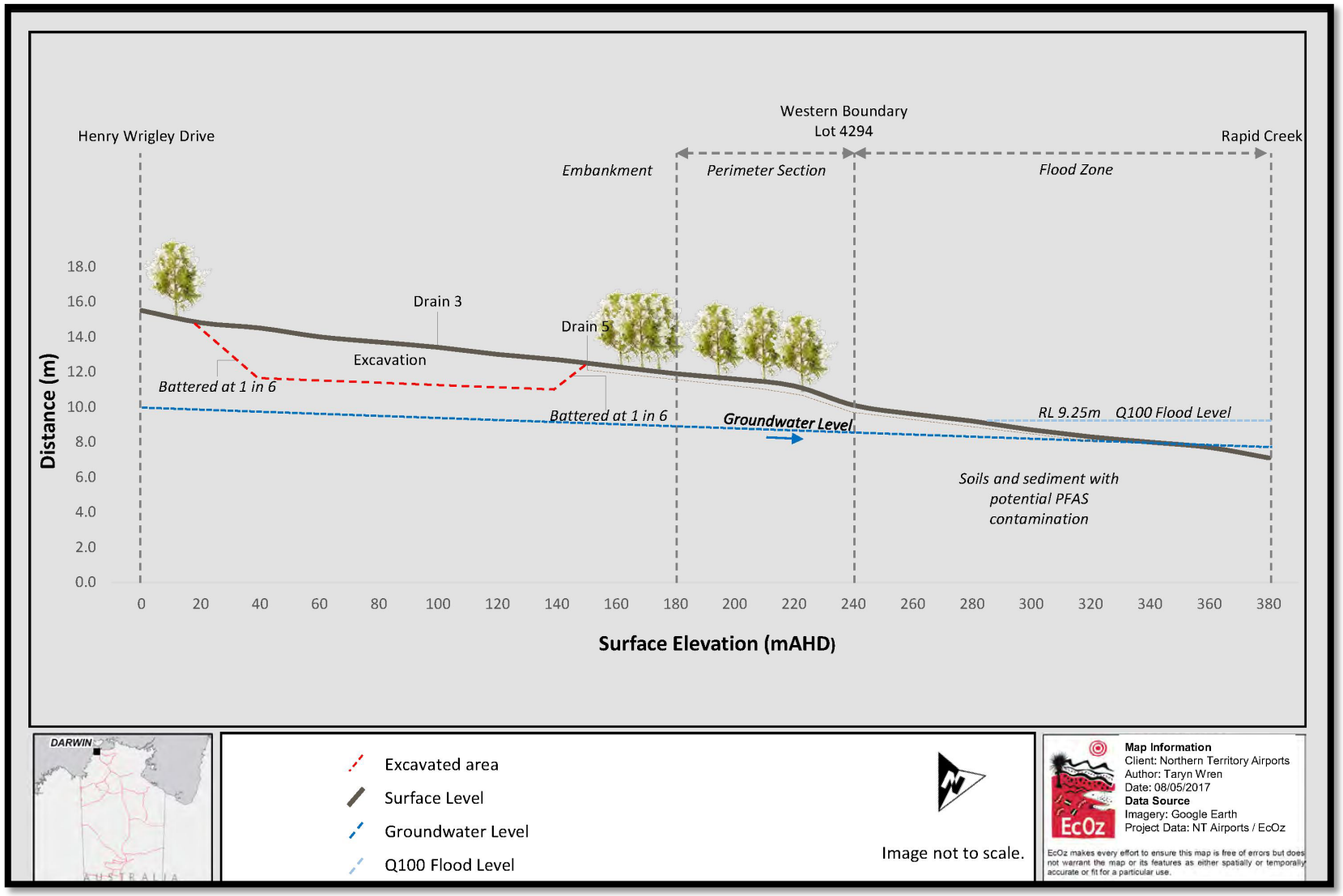

Figure 3: Conceptual Site Model
(Source: EcOz)

4 Summary of Investigation Process and Findings

4.1 Intrusive Investigation

The following investigations were undertaken at the Site during the Auditor's engagement:

- EcOz completed an investigation of the surface soils across the site to assess the concentrations of PFAS throughout the soil profile where the material will be disturbed to create the detention basin.

A summary of the soil investigation and soil sampling undertaken at the Site is provided below. The sampling zones, sample locations and leachate results are shown in Figure 4 to 8.

Detailed assessment to determine which PFAS is present at the site was undertaken using Total Oxidisable Precursor Analysis (TOPA), which identified PFOS, PFHxS and PFOA to be a minimum of 76% and possibly up to 100% of the PFAS constituents. Further EcOz concluded that PFOS is the primary PFAS chemical of concern and that PFOA was encountered in a few isolated samples, though 6:2 and 8:2 FTS were not detected.

EcOz undertook a PFAS assessment of soils within Section 4294 and 4295. The 19.9 hectare area was split into five zones (Zone 1 to Zone 5) with surface samples collected from 151 locations. The assessment undertaken in each zone is described below:

- Zone 1 is Rapid Creek and Zone 2 is the Rapid Creek flood plain.
    - 73 samples were collected from 25 locations at the surface and up to 1.5 mbgl across Zone 1 and Zone 2, with 36 samples submitted for ASLP analysis.
- Zone 3 is the drains where floodwater will enter the detention basin. Additionally, outside the Site area an area noted as the Southern Drain was also sampled as it is an extension of the drainage system.
    - 15 samples were collected from 10 locations at the surface and up to 3.9 mbgl across Zone 3, with 5 samples submitted for ASLP analysis.
    - 26 samples were collected from 6 locations at the surface and up to 1.5 mbgl in the Southern Drain area, with all samples submitted for ASLP analysis.
- Zone 4 is the area adjacent to the detention basin that is to be disturbed to create the embankments
    - Surface samples were collected from 53 locations across Zone 4, with 22 submitted for ASLP analysis.
    - Surface samples were collected from 9 locations along the Western Perimeter between Zone 4 and Zone 5, with all samples submitted for ASLP analysis.
    - Surface samples were collected from 6 locations along the northern perimeter of Zone 4 and Zone 5, with 2 samples submitted for ASLP analysis.
- Zone 5 is the detention basin which is to be excavated to a depth of 4 m.
    - 140 samples were collected from 40 locations across Zone 5 at the surface and up to a depth of 2.5 m from a majority of the 40 locations, with 69 samples submitted for ASLP analysis
- Background samples were collected from 30 locations, including several adjacent to the Marrara Fire Station.

Of the 326 samples collected from the site (not including the Southern Drain) 145 were submitted for ASLP analysis.

Zones 4 and 5 were considered the most important as the proposed development of the detention basin will require considerable excavation within this area. Zone 4 will be excavated down to rock, in the location of the embankment structures only, where the rock will be removed and the soil will be used in creating the

detention basin embankments. Zone 5 is the detention basin site which will be excavated to a depth of 4 m. Some of this material will need to be removed from site as it is excess to the needs of the project. Zone 1, 2 and 3 were assessed but were less important because Zone 1 and 2 are not going to be disturbed. Zone 3 will only be disturbed in order to create drains to enable floodwater to enter the detention basin.

BACKGROUND RESULTS

The background soil results are:

Statistical Parameter	Soil (µg/kg)			ASLP (µg/L)			
	PFHxS	PFOS	PFOA	PFHxS	PFOS	PFHxS+PFOS	PFOA
# of Samples above LOR	1	26	1	1	1	1	1
Minimum	<0.1	<0.1	<0.1	<0.001	<0.001	<0.001	<0.001
Maximum	0.3	51	0.1	0.0130	0.580	0.593	<0.001
Average	-	2.7*	-	-	-	-	-

*EcOz noted that these results are slightly skewed due to one sample (S22 – adjacent to the offsite fire station) being significantly higher than all other background samples. If S22 is removed then the average concentration is 0.7 µg/kg

ZONE 1 & ZONE 2 RESULTS

The Zone 1 and Zone 2 soil results are:

Statistical Parameter	Soil (µg/kg)			ASLP (µg/L)			
	PFHxS	PFOS	PFOA	PFHxS	PFOS	PFHxS+PFOS	PFOA
# of Samples above LOR	22	51	7	5	9	9	5
Minimum	<0.1	<0.1	<0.1	<0.001	<0.001	<0.001	<0.001
Maximum	2.2	59	1.2	0.008	0.028	0.036	0.002
Average	0.6	2.5	0.4	0.005	0.010	0.012	0.001

PFOS was detected in soil in every location across Zone1 and Zone 2, though in only half of the ASLP leachate.

ZONE 3 AND SOUTHERN DRAIN RESULTS

The Zone 3and Southern Drain soil results are:

Statistical Parameter	Soil (µg/kg)			ASLP (µg/L)			
	PFHxS	PFOS	PFOA	PFHxS	PFOS	PFHxS+PFOS	PFOA
# of Samples above LOR	3	27	0	11	20	20	0
Minimum	<0.1	<0.1	<0.1	<0.001	<0.001	<0.001	<0.001
Maximum	0.1	1.3	-	0.013	0.031	0.044	-
Average	0.1	0.4	-	0.003	0.006	0.008	-

PFOS was detected in almost all soil locations and ASLP leachate in Zone 3 and the Southern Drain. Although the soil concentrations were generally low (range 0.2-1.2 µg/kg in Southern Drain), the Southern Drain recorded the highest ASLP leachate.

ZONE 4 RESULTS

The Zone 4 soil results are:

Statistical Parameter	Soil (µg/kg)			ASLP (µg/L)			
	PFHxS	PFOS	PFOA	PFHxS	PFOS	PFHxS+PFOS	PFOA
# of Samples above LOR	6	52	0	5	18	18	1
Minimum	<0.1	<0.1	<0.1	<0.001	<0.001	<0.001	<0.001
Maximum	0.5	3.9	-	0.003	0.017	0.019	-
Average	0.2	0.5	-	0.002	0.006	0.007	-

Laterally, the PFOS, PFHxS and PFOA were identified in low concentrations in a majority of locations across the site. A majority of samples locations reported PFOS soil as 1µg/kg or less. All samples collected in Zone 4 were surface samples. There was generally a positive correlation with increasing soil concentration and ASLP leachate, thought occurrences of higher ASLP leachate did occur with low soil concentrations.

ZONE 5 RESULTS

The Zone 5 soil results are:

Statistical Parameter	Soil (µg/kg)			ASLP (µg/L)			
	PFHxS	PFOS	PFOA	PFHxS	PFOS	PFHxS+PFOS	PFOA
# of Samples above LOR	0		0	0	16	16	0
Minimum	<0.1	<0.1	<0.1	<0.001	<0.001	<0.001	<0.001
Maximum	0.1	7.1	-	-	0.016	0.016	-
Average	-	0.5	-	-	0.003	0.003	-

Laterally, the PFOS, PFHxS and PFOA was identified in low concentrations in a majority of locations across the site and although it was more likely to be found in higher concentrations at the surface, there were limited locations where higher concentrations were identified in underlying samples. Though this was in isolated locations and the soil concentrations did not differ greatly. The majority of samples locations reported PFOS soil as 1µg/kg or less. There was generally a positive correlation with increasing soil concentration and ASLP leachate, though occurrences of higher ASLP leachate did occur with low soil concentrations.

A detailed risk assessment was completed by Environmental Risk Sciences Pty Ltd (EnRiskS). The risk assessment reported that:

- Concentrations of metals and PFAS in soils from Zone 4 (embankments) and Zone 5 (basin and embankments) are below the health and ecological guidelines for reuse in a low density residential setting (Residential A, ASC NEPM).
- Concentrations of metals and PFAS in soils from Marrara Zone 4 and 5 comply with NSW EPA waste classification guidelines for general solid waste.
- Concentrations of PFAS in leachates at Shoal Bay are higher than those detected in leachates from soil in Zones 4 and 5.

Any soil that is reused must also meet the Leachate Risk Based Criteria (RBC) alongside the relevant soil data. The Environmental 1 RBC applies to the reuse of soil in and around Darwin, and the reuse of soil as capping material at Shoal Bay. EnRiskS concluded that:

Reuse/Disposal Option	Comments
Reuse in and around Darwin	Further soil sampling is required for the following area prior to reuse: • Zone 4: downstream of Zone 5 Detention Basin: metals including chromium VI and ASLP PFSO+PFHxS • Zone 4 Existing Drain 3: metals including chromium VI • Zone 5 Southern Drain: ASLP PFOS+PFHxS Soil cannot be reused within a surface water body or in areas of high ecological sensitivity, such as in national Parks and Reserves
Reuse at Shoal Bay Landfill as capping	None
Disposal at Shoal Bay Landfill as waste	None

EcOz reported that no soils, other than rock, from Zone 4 and/or the Southern Drain would be removed offsite. There is sufficient capacity of excess material within Zone 5 for the reuse as daily cover within the lined cell at Shoal Bay with no further management requirements.

The Auditors independent expert, Dr Ismail Gulec of EP Risk Pty Ltd reviewed the risk assessment and agreed with the findings of the risk assessment.

4.2 Auditor's Opinion on Investigations

When preparing this section of the EAR, the Auditor has given particular attention to Section 14 of EPA Victorian Publication 952 which states that:

> *'If using secondary sources of information, the environmental auditor should consider the reliability and veracity of that information in light of personal observations and evaluation of data collected on-site. In evaluating environmental monitoring data the environmental auditor must be satisfied that the data are representative of the emissions or discharges from the activity.'*

The Auditor considers that as a whole, the data collected is within acceptable error margins as determined through the Auditor's Data Quality Objectives (DQO), provided in Appendix E. As such the Auditor considers that the data collected are sufficient to adequately assess risk of harm for the audit purposes, given:

- The site history investigation was limited but considered sufficient for the audit objectives, given limited historical land use on the site, and the concern being PFAS entering the site from offsite sources;
- The soil assessment was limited to PFAS as per the audit scope, and in-situ characterisation was conducted prior to disturbance and zones created to determine what was suitable for placement into the embankment of the Detention Basin and what was acceptable for reuse to Shoal Bay (for daily cover use);
- The material destination (placed in the embankment of the detention basin or reused as daily cover within the lined cell at Shoal Bay) was pre-approved by NT EPA based on the Auditor's endorsement;
- The lack of significant systematic errors with the data collection process;
- The laboratory analysis was undertaken by NATA accredited laboratories;
- The site-specific geology and hydrogeology is consistent with anticipated regional conditions;
- The results are consistent with expectations based on the site history and field observations;

- Auditor inspection of the movement of material for placement into the embankment of the detention basin; and
- The detention basin was designed for the specific site conditions and material placed as per the approved design.

The Auditor considers that the quantity and quality of the site investigations undertaken to be adequate to evaluate the risk of harm due to the on-site retention of PFAS impacted soil on the Site. The Auditor considers the data collected are sufficient for the purposes of this environmental audit.

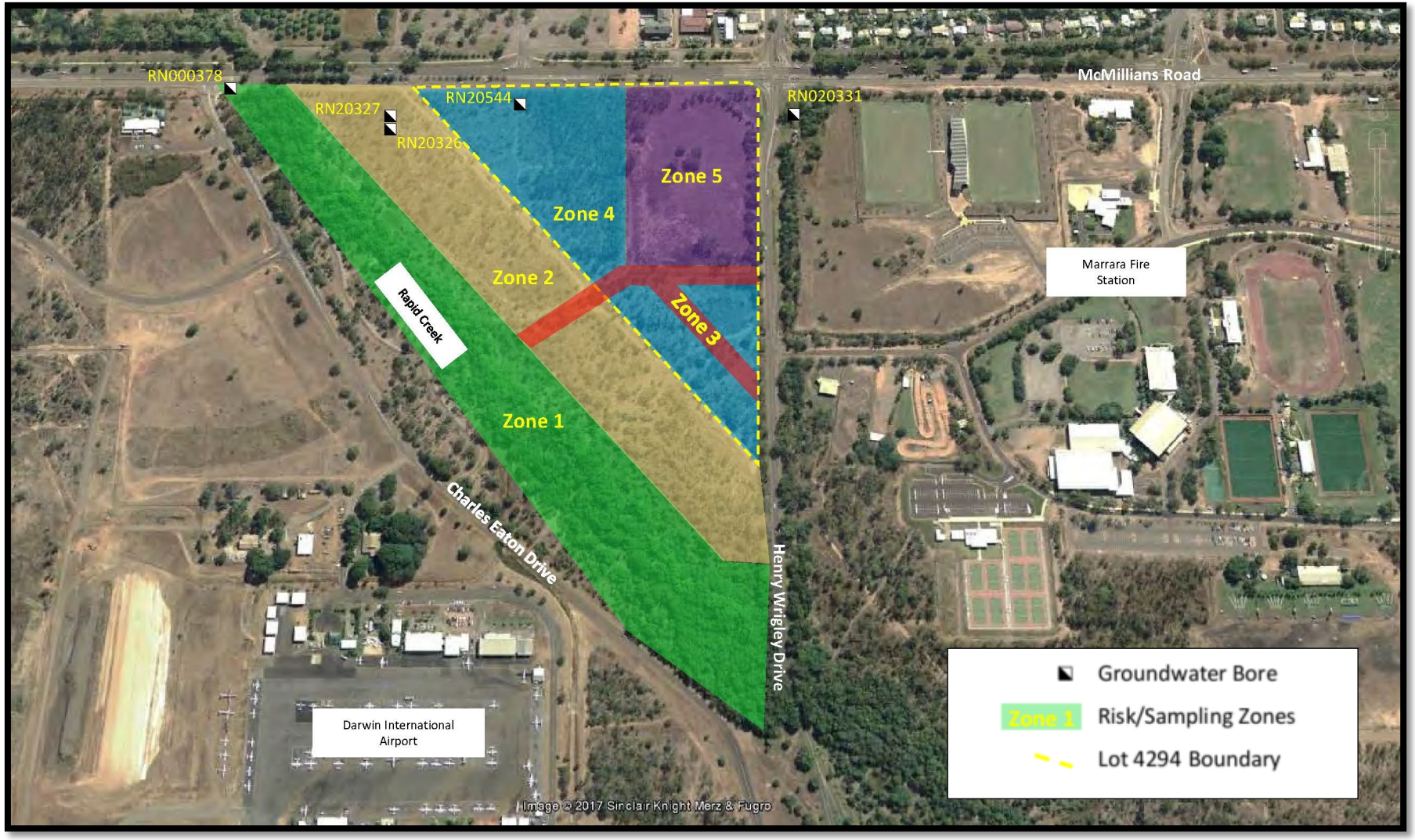

Figure 4: DSI Zones for sampling
(Source: EcOz DSI)

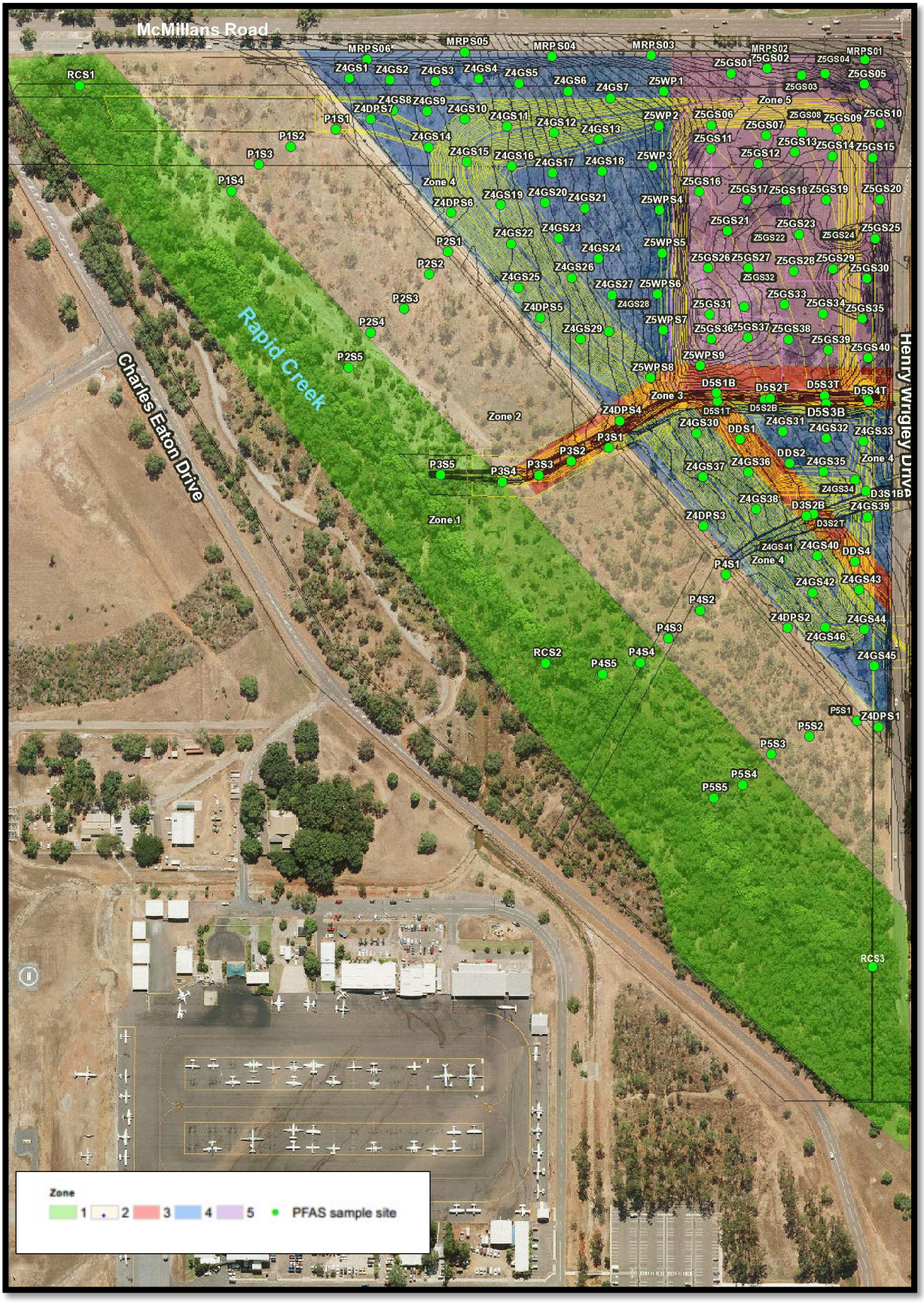

Figure 5: DSI Sample Locations (Main Detention Basin)
(Source: EcOz DSI)

Figure 6: DSI Sample Locations (Southern Drain and Surrounding Area)
(Source: EcOz DSI)

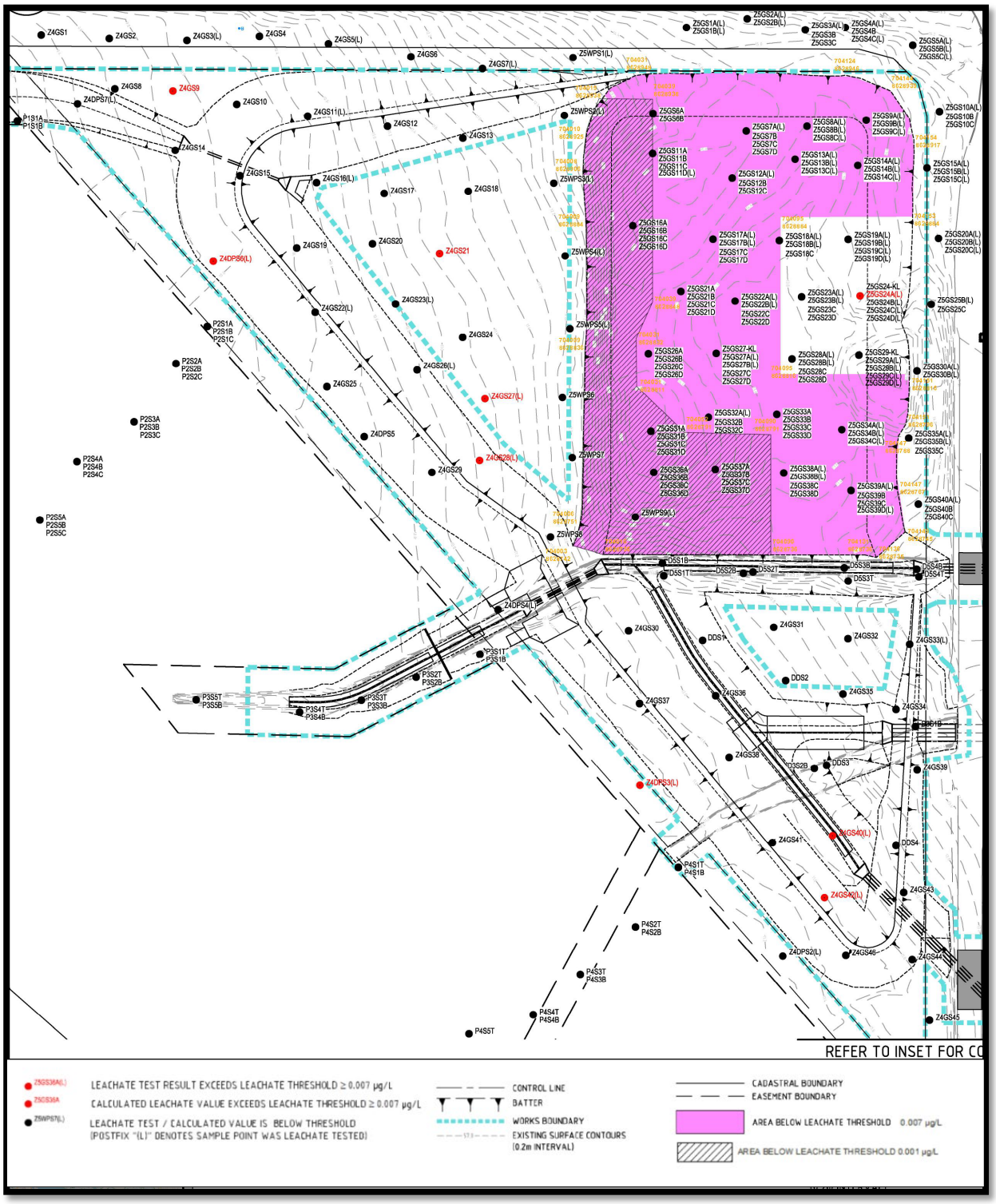

Figure 7: Leachate Results (Main Detention Basin)
(Source: EcOz DSI)

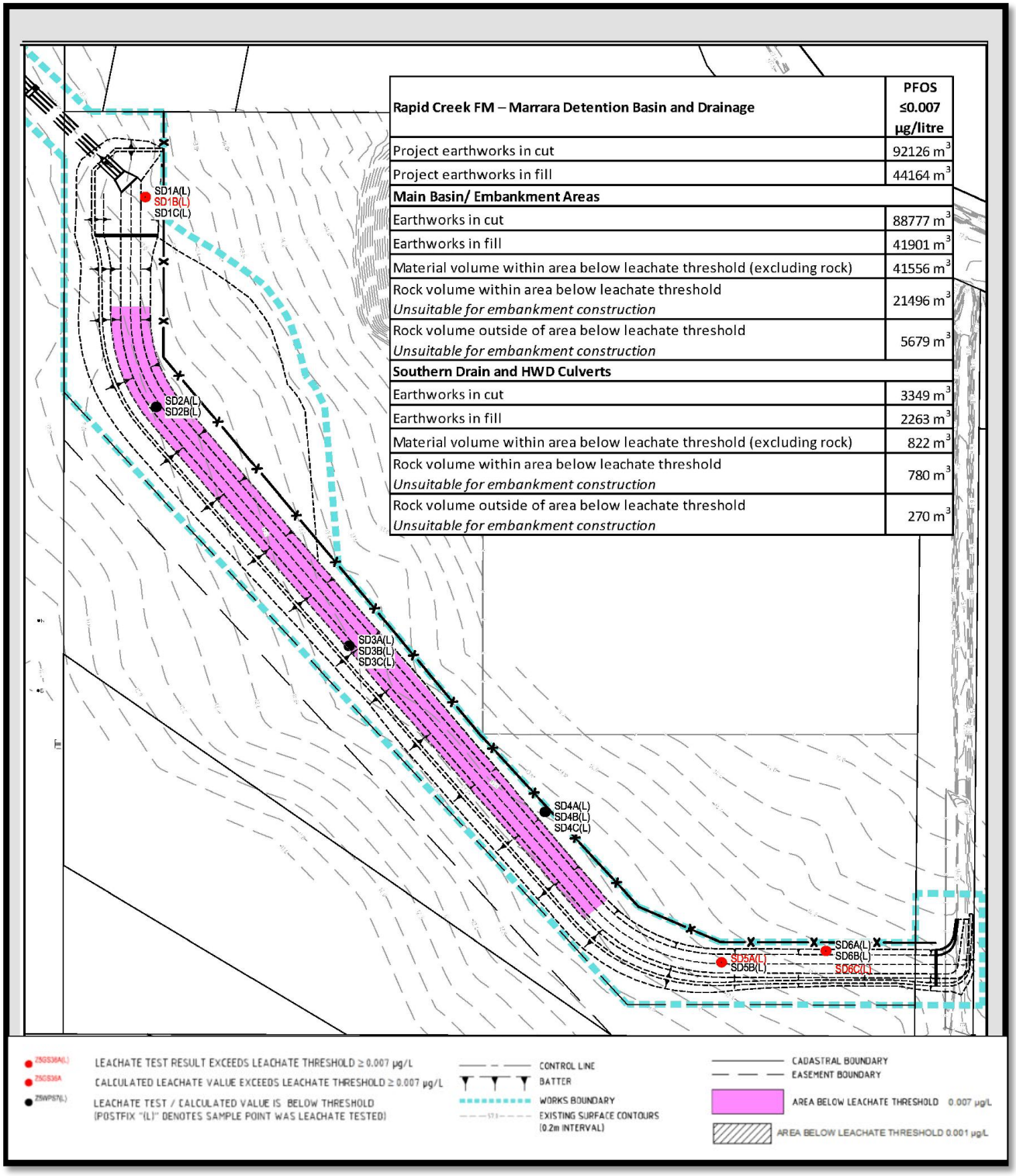

Figure 8: Leachate Results (Southern Drain)
(Source: EcOz DSI)

5 Summary of Management

PFAS impacted soils were identified in defined zones onsite and the reuse onsite or as daily cover within the lined cell at Shoal Bay was required to be managed to ensure soil was appropriately reused.

The project identified that there would be excess spoil. The intention was to reuse this material onsite and offsite in a safe manner. A risk assessment undertaken by EnRisks (2018) identified that offsite reuse on recommercial/industrial sites, including roads, would be acceptable. However, no suitable projects were available at the time. The risk assessment also identified that the material would be suitable for residential, however this was not supported by the auditor and was unlikely to be supported by the NT EPA. The alternative management option available to the client was sending the material to landfill. To avoid filling up void space, it was agreed by NT EPA and the landfill that the material would be suitable for reuse as daily cover within the lined cells, subject to implementation of a construction environmental management plan

The leachate results from Zone 5, as shown in pink in Figure 7 were identified to be the ones that were suitable for reuse at Shoal Bay. It is noted that the zone numbering in the management plans does not align with the zone numbering used during the DSI sampling. The zone numbering used during management is shown in Figure 8.

5.1 Detention Basin Design

The works comprised the construction of a detention basin with embankments and associated drainage infrastructure, including open drains and culverts, in order reduce the impact of flood waters on the Rapid Creek floodplain. The material re-used for the embankment walls was designed to avoid erosion and leaching impact to Rapid Creek, with batters constructed to a 1 in 6 gradient, compacted to 98% maximum dry density (MDD), capped with 100 mm of topsoil, and grassed.

A review of available information indicated the following activities:

- Clearing, grubbing and topsoil stripping
- Bulk earthworks, including cut and fill, importing and placing granular filter material, and transport of excess excavated material to Shoal Bay for reuse as daily cover within lined cell
- Blending and working selected excavated earth material at controlled moisture contents to produce fill for a water retaining embankment
- Landscaping, including revegetation with grasses, trees and shrubs, and provision of temporary irrigation to enable establishment.
- Drainage structures, including open drains, box culverts, headwalls and protection works using various concrete, rock, rock filled mattress and geotextile treatments.
- Other miscellaneous construction including concrete works, road pavements, fencing and signage.

During the site works a considerable volume of ACM impacted soil was identified along the northern boundary of the site. It was decided that the material would be retained into a containment cell onsite. The assessment and audit of the asbestos containment cell design did not form part of this audit and therefore the only role of the auditor was to provide advice regarding the suitability and any impact of this proposed plan with regard to PFAS. The containment cell was placed in the north western portion of the site, north of the detention basin northern embankment (Figure 10).

The Auditor considers that the detention basin design is adequate to minimise the risk of harm due to the on-site retention of soil on the Site. The Auditor's opinion is based on:

- The PFAS impacted soil did not exceed the soil or leachate assessment criteria;

- The detention basin was designed to retain approximately 95,000 m^3 of water and therefore by design would inhibit erosion and leaching of PFAS into underlying groundwater and Rapid Creek;
- Permeability of the natural soils is considered to be semi-pervious (average 2.1 x 10^{-5} m/sec) based on the result of site-specific permeability testing; and
- By placing and compacting materials with PFHxS and PFOS ASLP Leachability ≥0.007 µg/L in the embankments essentially contain these contaminants and prevents leaching into the downstream environment.

5.2 Offsite Transport and Reuse

The material selected for transport to and reuse at Shoal Bay was that with the lowest leachate concentration. The first priority was material with <0.001 µg/L, followed by material with <0.007 µg/L. Table 9 shows that material transported to Shoal Bay for reuse as daily cover within the lined cell.

- First priority for transport to Shoal Bay was removal of soils from Zone 1 with results <0.001 µg/L.
- Second priority for transport to Shoal Bay was removal of soils from Zone 2 and 4 with results <0.007 µg/L.
- All material in Zone 3, 5 and-6 were to be reused onsite.

Table 8: Material Disposed to Shoal Bay Waste Management Facility

Zone	Estimated Volume available for transport to Shoal Bay (m^3)	Actual Volume trasnported (m^3)
Zone 1: <0.001 µg/L.	25,270	24,300
Zone 2: <0.007 µg/L.	16,280	12,957
Zone 3, 5 and 6: >0.007 µg/L.	All remained onsite	
Total	**41,556**	**37,257 (45,435 with bulking)**

Noting that some of the Zone 2 and all of Zone 4 material was reused onsite.

5.3 Construction Environmental Management Plan

The Construction Environmental Management Plan (CEMP) was documented across two contractor documents. The Project Environmental Management Plan (PEMP) and the Earthworks Management Plan (EMP). The PEMP addresses typical environmental risks and controls associated with an earthworks project, with the EMP specifically covering PFAS contamination issues. The auditors review therefore focused on the EMP consistent with the approved scope of the audit.

The EMP detailed the earthworks tracking, including identification of PFAS zones, along with the management and traceability of material from each zone, stockpiling of material and offsite transport to Shoal Bay. The EMP also detailed the information to be provided to site personnel and general health and safety requirements.

EcOz assessed the contractors compliance with the EMP. EcOz reported that the site construction was managed in accordance with the site EMP, including daily toolbox meetings, daily inspection records, incident reporting, auditing and inspections. The Auditor's site inspections and review of EcOz and contractor documentation did not identify any material deviations from the EMP.

5.4 Auditor Endorsement of Soil Reuse

5.4.1 SUITABILITY FOR SOIL REUSE WITHIN DETENTION BASIN

The soil reuse within the detention basin will effectively result in the soil being reused immediately upgradient to the creek environment. It is therefore considered appropriate to apply the ecosystem protection criteria for Rapid Creek to this site. NT EPA confirmed that a 90% protection level for freshwater ecosystems applies to Rapid Creek. In accordance with the HEPA NEMP 2018 and ANZECC 2000, the next level of protection is to be applied for PFAS due to the bioaccumulative nature of this contaminant, therefore a 95% species protection level is applied (PFOS+PFHxS - 0.13 µg/L).

As noted above, no ASLP leachate sample from site exceeded the 95% species protection criterion, the maximum PFOS+PFHxSASLP across the site was 0.044 µg/L.

No soil concentration exceeded the assessment (screening) criteria in any sample analysed from site. The human health screening value in a public open space setting is 1000 µg/kg and the interim soil criteria for ecological direct exposure in a public open space is 1000 µg/kg. The maximum onsite soil concentration was 59 µg/kg.

On the above basis alone, the reuse of soil within the embankment walls onsite is considered suitable.

The material is proposed to be reused in embankment walls which will need to be constructed in a manner that avoids their erosion (i.e. embankments will be constructed with moderate batters, generally 1 on 6 slopes, capped with 100mm of topsoil and grassed) and leaching (100mm topsoil capping layer and embankments compacted to 98% MMDD), which will reduce the rate of leachate and therefore discharge rate into Rapid Creek.

Further, the effects of dilution of the leachate concentrations by the water flow as discussed in the EnRiskS 2018 report (20 times Dilution Attenuation Factor whereby leachate criteria increases to 2.6µg/L) provides an additional factor of safety to the onsite reuse.

A Construction Environment Management Plan (CEMP) was required to document the process to be undertaken during earthworks to ensure the soil movement is adequately tracked. Management measures should be documented to ensure that there is no risk to human health or the environment during the construction of the detention basin.

5.4.2 SUITABILITY FOR SOIL REUSE AT SHOAL BAY LANDFILL

In determining the appropriate criteria to apply to the receiving environment, NT EPA confirmed that a 90% protection level for marine ecosystems applies to the Shoal Bay Landfill. In accordance with the HEPA NEMP, the next level of protection is to be applied for PFAS, therefore a 95% interim marine species protection level is applied (PFOS+PFHxS - 0.13 µg/L).

As noted above, no ASLP leachate sample exceeded the 95% species protection criterion, the maximum PFOS+PFHxS ASLP across the site was 0.044 µg/L.

No soil concentration exceeded the assessment (screening) criteria in any sample analysed. The human health screening value in a commercial/industrial setting is 20,000 µg/kg and the maximum soil concentration was 59 µg/kg.

On the above basis alone, the temporary storage and reuse of spoil within the landfill operational area is considered suitable. The proposal to use the spoil for daily cover within the operation lined landfill cells is also considered suitable and provides an additional level of safety due to leachate collection system intercepting any leachate from the waste cell (inclusive of the daily cover).

It is noted that background concentrations of PFOS in landfill leachate are at least two orders of magnitude higher than the highest concentration detected at the Marrara site. Further, the effects of dilution of the

leachate concentrations by the water flow as discussed in the EnRiskS 2018 report provides an additional factor of safety to the reuse at the landfill.

5.5 Detention Basin Construction and Verification

Site earthworks occurred from July 2018 until June 2019. In total, approximately 80,950 m^3 of soil was excavated with 43,693 m^3 reused onsite and 37,257 m^3 transported to Shoal Bay.

A lot plan was implemented to ensure that movement of PFAS material was tracked and could be traced at the completion of the construction (Figure 9). The location of the material is shown in Table 10 below.

Table 9: Material Reused Onsite

Zone	Volume Reused (m^3)						
	Lot 1	Lot 2	Lot 3	Lot 4	Lot 1 East	Lot 2 East	Total
1							**0**
2	11,000	13,000	6,000	1,443			**31,443**
3	4,400	4,500					**8,900**
4			320		1,150	200	**1,670**
5			370		300		**670**
6			300	100	50	560	**1,010**
Total	**15,400**	**17,500**	**6,990**	**1,543**	**1,500**	**760**	**43,693**

The detention basin was built as per design with verification by EcOz through the process and by the Audit team. The Auditor's Assistant attended the Site on 27 September 2018 and the auditor visited the site on 24 June 2019, the final day of soil transport to Shoal Bay. The as constructed detention basin is shown in Figure 10.

5.6 Asbestos Containment Cell

During the site works approximately 6,500-8,000 m^3 of asbestos impacted soil was identified along the northern boundary of the site. It was decided that the material would be retained within an onsite containment cell in accordance with the remediation and waste management hierarchy. The assessment and audit of the asbestos containment cell design did not form part of this audit and therefore the only role of the auditor was to provide advice regarding any impact of this proposed plan with regard to PFAS. The containment cell was placed in the north western portion of the site, north of the detention basin northern embankment (Figure 10).

With regard to PFAS, the auditor was advised that the asbestos is from an area where the leachability of PFAS was <0.007 µg/L. This material was considered suitable for reuse onsite with consideration for avoiding erosion and leaching, and this will apply to the final placement of the asbestos impacted material. The base of the containment cell is reportedly approximately 1 metre above the water table; however, the Auditor notes that the water table fluctuates markedly throughout the year. The placement of this material within or near the groundwater may increase the amount of PFAS leachate generated from the spoil; however, this won't be sufficient to change the risk profile given the low concentrations of PFAS present in the material, the temporary nature of wetting and dilutional effects.

The onsite containment of slightly PFAS impacted material (i.e. <0.007 µg/L) was not considered to pose an unacceptable risk to human health or the environment provided the containment cell is appropriately designed, constructed and managed.

In accordance with my approved audit scope, I have not considered the management of risks from contaminants beyond PFAS nor any approvals for the onsite construction of a containment cell, as this is being audited separately by another auditor.

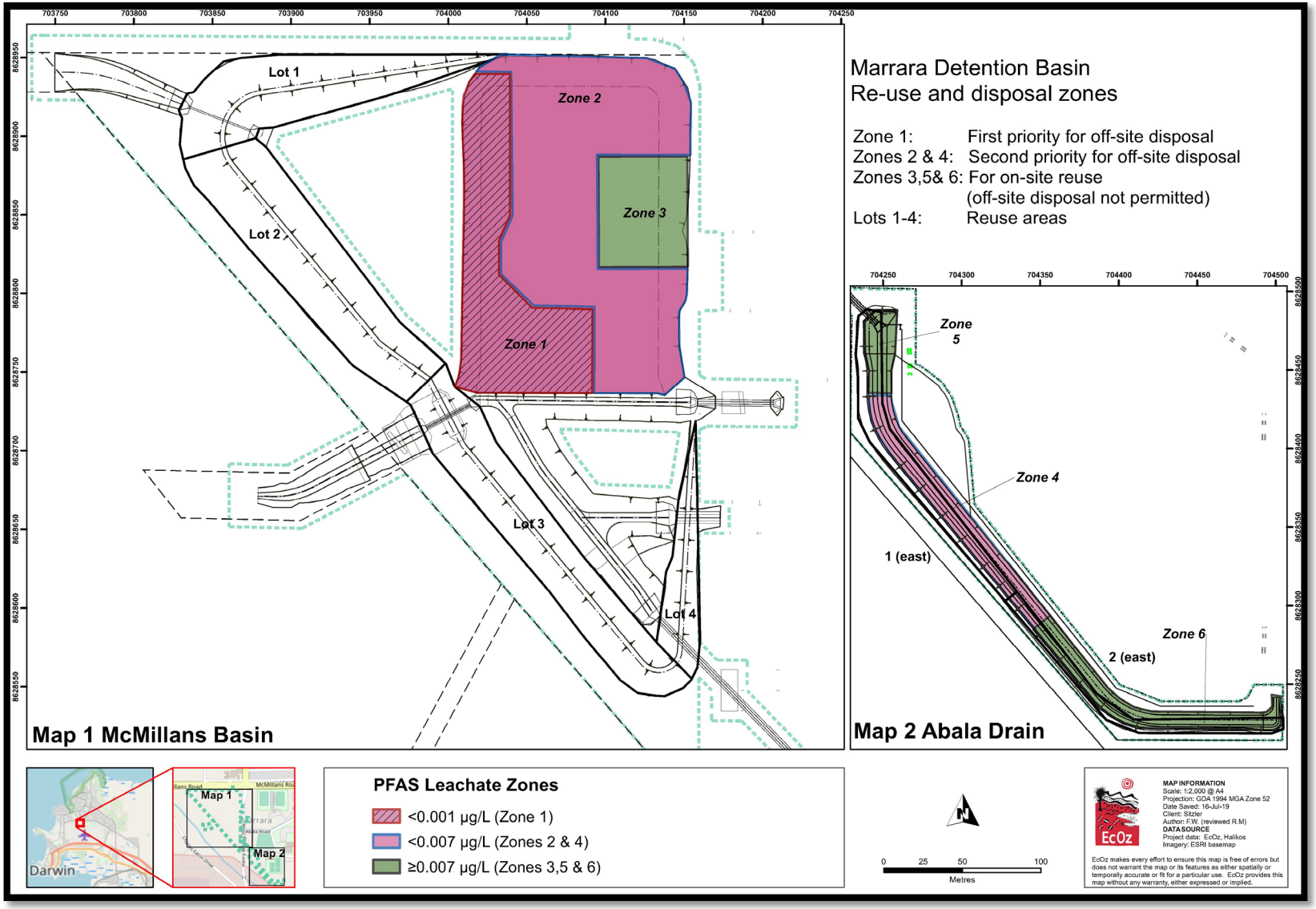

Figure 9: PFAS Zones and Lots for Reuse
(Source: EcOz Completion Report)

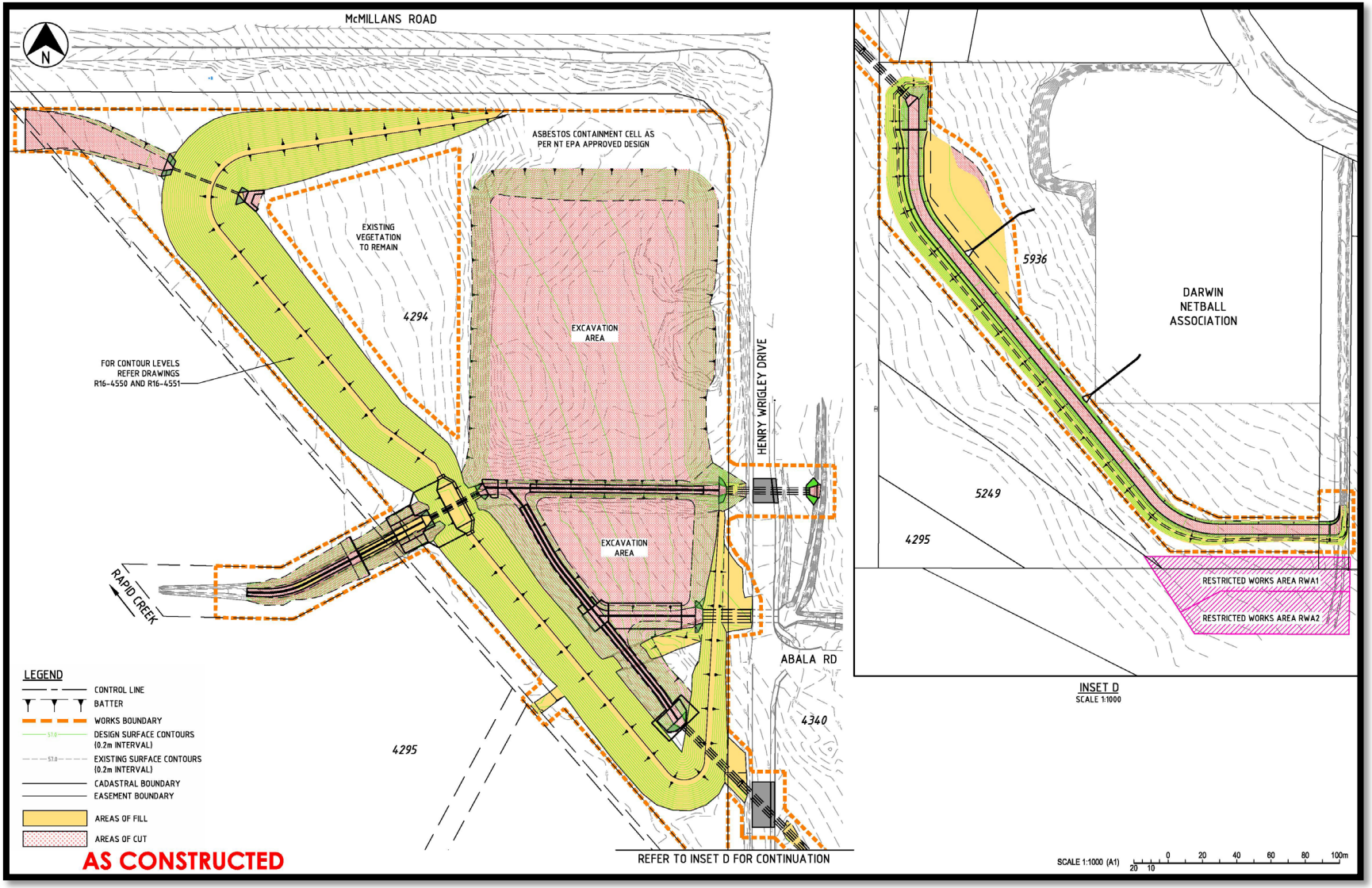

Figure 10: Detention Basin - As Constructed
(Source: EcOz Completion Report)

6 Assessment of Risk of Harm or Detriment to the Environment

6.1 Final Site Condition

At the completion of the audit, the detention basin had been constructed in accordance the approved design plans and CEMP.

The less contaminated spoil was disposed of offsite at the Shoal Bay Landfill with the more impacted spoil reused within the embankment cover compaction to 98% maximum dry density (MDD) as detailed in Section 5. The Site, including the embankment was capped with 100 mm of topsoil- and grassed, with the exception of the gravel drains and concrete spillway. A portion of remnant vegetation is located within the basin and remains undisturbed.

6.2 Assessment of Risks

The following sections summarise the risk to land and water from PFAS contamination.

The overall risk profile and recommendations for any works to be undertaken to mitigate this risk are further discussed in Section 7 of this report.

6.2.1 Summary of Risks to Beneficial Uses of Land

PFAS impacted spoil that was excavated has been deposited into the embankment walls of the detention basin or transported to Shoal Bay for reuse as daily cover.

Based on the results of the sampling undertaken by EcOz, the risk assessment completed by EnRiskS and reviewed and accepted by the auditors expert, and the latest version of the HEPA NEMP, the auditor considers that the material disturbed as part of the Marrara Detention Basin project does not present an unacceptable risk to human health or the environmental for the reuse onsite and at Shoal Bay as daily cover

Therefore, the risk to site workers and users (i.e. visitors, etc) is within acceptable levels without additional controls as the impacted soils were more than an order of magnitude below the PFAS NEMP human health screening level for public open space.

The risk to the environment is within acceptable levels as the soil was more than an order of magnitude below the PFAS NEMP interim soil ecological direct exposure criteria and the soil is contained with the embankment walls and is covered with a layer of topsoil and grassed.

There may be additional risks associated with the asbestos containment cell which have not been considered in this audit.

6.2.2 Summary of Risks to Beneficial Uses of Waters

The risk to groundwater from PFAS impacted soil at the Site is within acceptable levels for the following reasons:

- The material contained in the detention basin is low level PFAS (max detection of PFOS 0.059 mg/kg; max leaching concentration PFOS+PFHxS - 0.044 µg/L);
- The impacted soil is above the groundwater table and underlain by natural soils with low to medium permeability;

- Should a perched groundwater system occur during the wet season such that groundwater interacts with the impacted material, this is unlikely to present an unacceptable offsite risk due to the temporary nature of the wetting and dilutional effects from the water; and
- The detention basin was designed and constructed to temporarily retain water and minimise erosion, with spill ways and flow outlets as opposed to a infiltration style system.

The risk to surface water bodies from PFAS impacted soil at the Site is within acceptable levels for the following reasons:

- The detention system is designed to minimise water flow through the soils;
- Soil leachate concentrations were lower than the 95% protection level for aquatic ecosystem should water flow through the soil and into the creek;
- Erosion of impacted soils and transport into the creek is minimised by the 100 mm of clean top soil, grassed covering and general maintenance of the detention basins; and
- Should leaching or erosion occur, there would be significant dilution occurring from the water transporting to the contamination into the receiving surface water body.

The impacted soils are therefore not considered a risk to waters, subject to maintaining the integrity of the detention basin. The detention basin will require regular ongoing maintenance into the future to ensure that grass cover is adequate and erosion is not causing soils to wash away.

6.2.3 Summary of Risks to Beneficial Uses of Ambient and Indoor Air

PFAS is not considered a volatile contamination and risk to ambient and indoor air therefore relate to the inhalation of PFAS contaminated dust.

The concentrations of PFAS in soil are not considered sufficient to present a human health inhalation risk from PFAS contaminated dust. Further, the PFAS impacted soils are covered with 100mm of clean top soil and grassed which will reduce the potential for generation of PFAS contaminated dust from the Site.

The risk to ambient and indoor air from site derived PFAS contaminated soils is therefore within acceptable levels.

6.2.4 Summary of Risks from Offsite Transport and Reuse to Shoal Bay Landfill

Approximately 24,300 m3 of spoil with leachate concentrations of <0.001 µg/L and a further 12,957 m3 of <0.007 µg/L were transported to Shoal Bay landfill for reuse as daily covering material within the lined cell.

In determining the appropriate criteria to apply to the receiving environment, NT EPA confirmed that a 90% protection level for marine ecosystems applies to the Shoal Bay Landfill. In accordance with the HEPA NEMP, the next level of protection is to be applied for PFAS, therefore a 95% interim marine species protection level is applied (PFOS+PFHxS - 0.13 µg/L). Leachate concentration from the material sent to the landfill was several orders of magnitude below this adopted protection level.

No soil concentration exceeded the assessment (screening) criteria in any sample analysed. The human health screening value in a commercial/industrial setting is 20,000 µg/kg and the maximum soil concentration was 59 µg/kg.

On the above basis alone, the temporary storage and reuse of spoil within the landfill operational area is considered suitable. The proposal to use the spoil for daily cover within the operation lined landfill cells is

also considered suitable and provides an additional level of safety due to leachate collection system intercepting any leachate from the waste cell (inclusive of the daily cover).

It is noted that background concentrations of PFOS in landfill leachate are at least two orders of magnitude higher than the highest concentration detected at the Marrara site. Further, the effects of dilution of the leachate concentrations by the water flow as discussed in the EnRiskS 2018 report provides an additional factor of safety to the reuse at the landfill.

EcOz assessed the contractors compliance with the EMP. EcOz reported that the site construction was managed in accordance with the site EMP, including daily toolbox meetings, daily inspection records, incident reporting and material tracking. The Auditor's site inspections and review of EcOz and contractor documentation did not identify any material deviations from the EMP. This includes evidence that the spoil generated from the site was sent to the landfill.

The risks from offsite transport and reuse as daily cover at a lined cell at Shoal Bay Landfill is within acceptable levels.

7 Conclusions and Audit Findings

The Auditor was engaged on 10 May 2017 by DIPL to carry out an audit under section 53V of *the Act* of the vacant land comprising the property at 226 McMillans Road, Marrara, in response to a request from the NT EPA regarding the reuse of PFAS impacted soil within the embankment walls of a detention basin.

The Site is part of the Marrara Detention Basin project and has undergone redevelopment to create a detention basin to capture water during large rainfall events, to mitigate and reduce the impact of flooding from Rapid Creek on private residential properties in the suburb of Milner. Culverts and drains under Henry Wigley Drive will divert flow into the basin, while culverts along the western boundary will discharge flows towards Rapid Creek.

The soil assessment to support this audit was limited to PFAS as per the audit scope, and in-situ characterisation was conducted prior to disturbance and zones created to determine what was suitable for placement into the embankment of the Detention Basin and what was acceptable for reuse as daily cover within the lined cell at Shoal Bay. All dry weight results were more than an order of magnitude below the PFAS NEMP human health screening values for public open space and interim soil ecological direct exposure values and leachable concentrations of PFAS were below the 95% species protection assessment criteria for freshwater aquatic ecosystems.

A risk assessment indicated that the material was suitable for reuse onsite and the excess would be suitable for reuse at Shoal Bay as daily cover within the lined cells. This approach was endorsed by the auditor and accepted by NT EPA subject to the implementation of a suitable Environmental Management Plan. The auditor approved the EMP and conducted site inspections during the construction works to verify the approved management measures were being implemented appropriately. In total 80,950 m^3 of material was excavated, with 43,693 m^3 reused onsite and 37,257 m^3 sent to Shoal Bay for use as daily cover in the lined cell.

The detention basin was designed and constructed to hold 95,000 m^3 of flood water. The material re-used for the embankment walls was designed to avoid erosion and leaching impact to Rapid Creek, with batters constructed to a 1 in 6 gradient, compacted to 98% maximum dry density (MDD), capped with 100 mm of topsoil, and grassed. The detention basin embankment walls are covered with a topsoil layer and therefore water flowing through the soils is likely to be minimal and the impacted soil is above the groundwater table and underlain by natural soils with low to medium permeability. Should a perched groundwater system occur during the wet season such that groundwater interacts with the impacted material, this is unlikely to present an unacceptable offsite risk due to the temporary nature of the wetting, dilutional effects from the water and low concentrations in soils. The detention basin was designed and constructed to temporarily retain water and minimise erosion, with spill ways and flow outlets. The risk to human health and the environment from offsite migration of contamination via leaching of contamination from soil or via erosion is within acceptable levels.

The Auditor concludes there is no unacceptable risk to human health (i.e. future site users) or the environment (i.e. onsite and within Rapid Creek) from site derived PFAS contamination provided the integrity of the detention basin is maintained.

8 References

Legislation and Regulations

Environment Protection Act, 1970 (Act No.8056/1970), Victoria.

Government of Victoria (2002). State Environmental Protection Policy (Prevention and Management of Contamination of Land). Victorian Government Gazette, S95, 4 June 2002.

Government of Victoria (1999). State Environment Protection Policy. Ambient Air Quality. Victorian Government Gazette, S19, 9 February 1999 as varied by the Victoria Government Gazette S240 on 21 December 2001

Government of Victoria (2001). State Environment Protection Policy. Air Quality Management. Victorian Government Gazette S240, 21 December 2001

Guidelines

EPA (2013) *Environmental Auditor Guidelines for the Preparation of Environmental Audit Reports on Risk to the Environment*, Publication 952.4, April 2013.

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

HEPA (2018) PFAS National Environmental Management Plan (NEMP), Heads of EPAs Australia and New Zealand

Site-Specific Reports

EcOz Environmental Consultants (8 May 2017) *Rapid Creek Flood Mitigation at Section 4294, Sampling and Analysis Quality Plan Perfluoroalkyl and polyfluoroalkyl substances (PFAS)*;

EcOz Environmental Consultants (17 January 2018) *Marrara Detention Basin Flood Mitigation at Section 4294, Detailed Site Investigation Perfluoroalkyl and polyfluoroalkyl substances (PFAS)*;

EcOz Environmental Consultants (16 February 2018) *Environmental Management Plan, Soil Management Framework - Marrara Detention Basin*;

EcOz Environmental Consultants (21 August 2019) *Marrara Detention Basin Completion Report*;

Environmental Risk Sciences (EnRisks) (28 June 2018) *Review of Risk Issues for PFAS Re-Use of Soil from the Marrara Flood Detection Basin.*

Sitzler (19 June 2018) Earthworks Management Plan, Rapid Creek Flood Mitigation

Sitzler (8 June 2018) Project Environmental Management Plan, Rapid Creek Flood Mitigation Project

APPENDICES

Appendix A
Detention Basin (as constructed) and Title Certificate

Appendix B
Consultant's Reports

Appendix C
Client and Consultant Correspondence

Appendix D
NT EPA Correspondence

Appendix E
Auditor Data Quality Objectives and QA/QC Review

Data Quality Evaluation

General

In accordance with the audit guidelines, this section provides an evaluation of the data quality objective (DQO) process and summary of data quality indicators used by the Auditor. This evaluation has been undertaken in consideration of the following:

- NEPC, National Environment Protection (Assessment of Site Contamination) Measure, 1999 (as amended 2013);
- AS 4482.1, Guide to the Sampling and Investigation of Potentially Contaminated Soils, Part 1: Non-volatile and semi-volatile compounds, 2005;
- US EPA, Data Quality Objectives Process for Hazardous Waste Site Investigations (QA/G-4HW), January 2000; and
- HEPA (2018) PFAS National Environmental Management Plan (NEMP), Heads of EPAs Australia and New Zealand

Data Quality Objectives

The DQOs are a seven stepped process to assist with developing a sampling and analysis plan to ensure sufficient, reliable data is obtained in an efficient and defensible manner.

A summary of the DQOs established for the project by the Auditor is provided below:

- Step 1, State the problem. Surrounding land uses may have resulted in contamination of soils and groundwater, rendering the Site unsuitable for the proposed use or presenting an unacceptable risk to the environment;
- Step 2, Identify the decisions. To assess the potential risks posed by potential site contamination and obtain sufficient data to indicate whether the Site is likely to be suitable for the proposed use, or to allow the development of strategies to remediate and/or manage any identified contamination;
- Step 3, Identify inputs to decisions. Historical information, site inspections, grid and targeted soil sampling across the Site, laboratory analysis of samples for contaminants of concern, determination of background conditions and assessment of results against relevant assessment criteria;
- Step 4, Define the study boundaries. The lateral extent of the Site and the top of the regional aquifer, extending off-site for any site derived groundwater contamination;
- Step 5, Develop a decision rule. Site observations and analytical results assessed against the audit criteria and taking into consideration constitution and distribution heterogeneity. If the audit criteria is exceeded, then a site-specific assessment of risk may be undertaken. If unacceptable risks are identified, then remediation and/or management measures may be undertaken. Analytical data will be accepted if laboratories are accredited by NATA for the analysis undertaken, relative percentage difference in duplicate samples are within acceptable limits and laboratory quality assurance/quality control (QA/QC) protocols and results comply with the requirements specified in the above guidelines;
- Step 6, Specify limits of decision errors. Analyte selection based on identified contaminants of concern and site observations and measurements, risk based probabilities incorporated in the audit criteria and acceptance limits for analytical data in accordance with the requirements specified in the above guidelines; and
- Step 7, Optimize the design for obtaining data. Sampling program designed to satisfy the above DQOs in the most resource-effective manner. This includes a combined grid-based and targeted sampling of site soils.

Data Quality Indicators

The Auditor has assessed the adequacy of the sampling and analytical data as part of the audit, including verification and validation of the data. The Auditor has made this assessment with respect to the relevant requirements detailed in the above guidelines. This assessment of the adequacy of the sampling and analytical data is undertaken through the assessment of the data quality indicators which comprise:

- Completeness, which is a measure of the amount of useable data (expressed as a %) from a data collection activity. Field considerations include, all critical locations sampled, all samples collected (from grid and at depth), all appropriate media assessed, appropriate sampling techniques, experienced sampling, and documented correctly. Laboratory considerations include, all critical samples analysed for the contaminants of concern, appropriate analytical methods meeting holding times, and required detection limits;
- Comparability, which is the confidence that the data may be considered to be equivalent for each sampling and analytical event and is expressed qualitatively. Field considerations include: consistent sampling techniques, field personnel, climatic conditions and sample type (i.e. filtered). Laboratory considerations include, consistent sample preparation, analytical techniques and laboratories;
- Representativeness, which is the confidence (expressed qualitatively) that data is representative of each medium present on the site. Field considerations are undertaken on a micro scale (i.e. sampling unit tested by the laboratory is representative of soil in the jar which is in turn representative of the borehole – also known as constitution heterogeneity) and macro scale (i.e. borehole is representative of the site – also known as distribution heterogeneity). Laboratory considerations include ensuring all samples are analysed according to the sampling analysis and quality plan (SAQP);
- Precision, which is a quantitative measure of the variability (or reproducibility) of date. Field considerations include appropriate sampling technique including duplicate sampling and field equipment rinsates. Laboratory considerations include intra and inter laboratory duplicate, equipment rinsates, trip and field blanks and trip spikes; and
- Accuracy (or bias), which is a quantitative measure of the closeness of reported data to the true value. This includes appropriate sampling techniques (i.e. loss of volatiles or cross-contamination) and laboratory analysis of blanks, spikes and control samples.

The assessment of the data quality indicators of the sampling and analytical data comprised (but not limited to) the assessment of the following.

<u>Field Quality Assurance</u>:

- Site inspections by the Auditor (and/or their representative) to observe critical stages of the assessment and/or remediation undertaken by the Consultant along with Auditor verification sampling if necessary;
- Soil sampling methodology appropriate with respect to chain of custody (COC);
- Soil samples screened for contamination using visual/olfactory observations and/or field instruments (i.e. PID for volatiles);
- Soil sampling logs provided indicating subsurface conditions, sample collection depth and evidence of contamination (at a minimum);
- Cross contamination avoided through use of disposable gloves during soil sampling;
- Groundwater monitoring well construction appropriate (i.e. backfill, seal above screen etc.);
- Groundwater sampling records provided;
- Leak testing on soil vapour bores;

- Calibration certificates provided for field instruments used;
- Cross contamination avoided through appropriate decontamination of reused sampling equipment;
- Samples collected into laboratory supplied and appropriately preserved sampling containers;
- Samples placed in a chilled insulated container (ideally <4°C) during sample handling and transport to laboratory;
- Samples transported to laboratory under COC conditions (signed by representative of Consultant); and
- Ensure comparability through experienced sampler as well as consistent sampler, sampling methods and climatic conditions during project.

Field Quality Control:

- Split duplicates collected/analysed at a rate of ≥5%;
- Blind duplicates collected/analysed at a rate of ≥5%;
- Rinsate blanks collected/analysed at a rate of 1 per reused piece of sampling equipment per batch;
- Trip blanks collected/analysed at a rate of 1 per batch (important where COC includes volatiles);
- Trip spikes (important where COC includes volatiles and holding time exceedances are anticipated);
- Field blanks collected/analysed at a rate of 1 per batch (important where COC includes volatiles);
- Split duplicate RPD% ≤50%;
- Blind duplicate RPD% ≤50%;
- COC <PQLs in rinsate blank;
- COC < PQLs in trip blank;
- Trip spike recoveries 70% to 130%; and
- COC <PQLs in field blank.

Field Quality Assurance:

- Samples received by laboratory under COC conditions (signed by representative of Laboratory);
- Laboratories NATA accredited and utilised NATA endorsed analytical methods;
- Comparability of data through consistency in laboratories/analytical methods throughout project;
- Samples extracted and analysed within recommended holding times; and
- Practical quantitation limits (PQL) for COC below respective Environmental Quality Criteria.

Field Quality Control:

- Preparation and analysis of laboratory QC samples at rates in general accordance with NEPM (1999), including surrogate spikes, matrix spikes, matrix spike duplicates, laboratory duplicates, method blanks (as applicable);
- Laboratory surrogate spike recoveries 70% to 130% (exceptions for some contaminants);
- Laboratory matrix spike recoveries 70% to 130% (exceptions for some contaminants);
- Contaminants <PQLs in laboratory method blanks;
- Laboratory matrix duplicate/laboratory duplicate RPD% ≤50%; and

- 95% of laboratory QA results within data quality indicators (DQI).

Data Quality Evaluation

The Auditor has undertaken an evaluation of the data quality using the above data quality indicators against the Auditor's data quality objectives. This evaluation has been undertaken initially on a stage by stage basis and then assessed using all available data (all reports, Auditor inspections, verification sampling if required, etc.) to determine if the data, in its totality, is sufficiently reliable and complete to allow the Auditor to meet the objectives of the audit. The key factors considered in this evaluation are provided in the following table.

Data Evaluation	Auditor Comments
Documentation Completeness	The Auditor is satisfied that the relevant reports are complete.
Data Completeness	The Auditor is satisfied that each identified source of contamination has been assessed for all of the identified contaminants of concern. All potentially contaminated mediums have been adequately assessed. Grid based sampling has been undertaken to address extent of contamination.
Data Comparability	The Auditor is satisfied that the sampling events are comparable being undertaken by the same Consultants using consistent field techniques and field teams.
Data Representativeness	The Auditor is satisfied that the data is representative of the site conditions at the time of sampling.
Precision and Accuracy of Sampling and Analysis	Whilst there are some relative percentage difference (RPD) exceedances for the Site, the Auditor is satisfied that the primary cause for elevated RPD is natural sample/medium heterogeneity and not an indication of inappropriate sampling. Furthermore, there are sufficient samples without elevated RPDs to indicate the majority of the data set meets this requirement. The Auditor is satisfied with the accuracy of the sampling and analysis.

A review of the critical reports undertaken by the Auditor is provided in the follow table.

Report Reference: EcOz (2018) DSI, Marrara Detention Basin Flood Mitigation at Section 4294		
Data Quality Indicator (DQI)		**Comment**
Field QA Program	Appropriate sampling strategy used and representative samples collected.	Soil sampling strategy met AS4482.1-2005.
	Soil sampling methodology appropriate with respect to COC.	DQI requirement met.
	Relevant environmental media sampled (i.e. soil, groundwater, surface water, vapour, dust, sediments).	Soil sampled.
	Appropriate locations sampled at critical depths.	DQI requirement met.
	Appropriate background locations sampled.	Background soil samples collected.
	Standard operating procedures appropriate and complied with.	DQI requirement met.
	Soil samples screened for contamination using visual/olfactory observations and/or field instruments (i.e. PID for volatiles).	DQI requirement generally met. Visual/olfactory observations
	Soil sampling logs provided indicating subsurface conditions, sample collection depth and evidence of contamination (at a minimum).	DQI requirement met (Unified Soil Classification System).
	Cross contamination avoided through use of disposable gloves during soil sampling.	DQI requirement met.
	Samples collected into laboratory supplied and appropriately preserved sampling containers.	DQI requirement met.
	Samples placed in a chilled insulated container (ideally <4^{0}C) during sample handling and transport to laboratory.	DQI requirement generally met. The laboratory reported that an attempt to chill was evident, with the exception of workorder 168789.
	Samples transported to laboratory under Chain of Custody conditions (signed by representative of Consultant). Any alterations to original COC documented and provided in report.	DQI requirement met. COC sheets list sample numbers, date of collection and analysis required and were appropriately signed.
Field QA Program	Ensure comparability through experienced sampler as well as consistent sampler, sampling methods and climatic conditions during project.	DQI requirement met. Sampler generally appears consistent, climatic conditions stated on field sheets.
	Soil/groundwater/vapour sampling methods appropriate / any limitations	Soil sampling methods were appropriate.
Field QC Program	Split duplicates collected/analysed at a rate of ≥5%.	DQI requirement met. The number of soil samples collected for QC purposes included primary samples (n=326), and inter laboratory duplicate samples (n=0) which is a rate of 0%.

Report Reference: EcOz (2018) DSI, Marrara Detention Basin Flood Mitigation at Section 4294		
Data Quality Indicator (DQI)		**Comment**
		This is not considered significant as the intra duplicate results are sufficient.
	Blind duplicates collected/analysed at a rate of ≥5%.	DQI requirement not quite met. The number of soil samples collected for QC purposes included primary samples (n=326), and intra laboratory duplicate samples (n=13) which is a rate of 4%
	Rinsate blanks collected/analysed at a rate of 1 per reused piece of sampling equipment per batch.	DQI requirement generally met. Two rinsate blanks collected for one day of soil sampling.
	Trip Blanks collected/analysed at a rate of 1 per batch (important where COC includes volatiles).	Not applicable
	Trip Spikes (important where COC includes volatiles).	Not applicable
	Field Blanks collected/analysed at a rate of 1 per batch (important where COC includes volatiles).	Not applicable
Field QC Results	Acceptable soil QC sample RPD results (RPD% ≤50%).	DQI requirement generally met. Only one sample had a RPD >50 %. Max was 67 %. Likely due to sample heterogeneity, highest results were used for comparison with criteria and therefore no impact to outcomes of report.
	COC <PQL's in Rinsate Blank.	DQI requirement met.
	COC < PQL's in Trip Blank.	Not applicable.
	Trip Spike recoveries 70% to 130%.	Not applicable.
	COC <PQL's in Field Blank.	Not applicable.
Laboratory QA	Samples received by laboratory under Chain of Custody conditions (signed by representative of Laboratory).	DQI requirement met.
	Correct samples and compounds analysed by laboratory as requested in COC.	DQI requirement met.
	Laboratories NATA accredited and utilised NATA endorsed analytical methods (list laboratories used).	DQI requirement met.
	Comparability of data through consistency in laboratories/analytical methods throughout project.	DQI requirement met.
	Samples extracted and analysed within recommended holding times.	DQI requirement generally met. Total organic carbon and cation exchange capacity were outside holding time. This is not considered significant.

Report Reference: EcOz (2018) DSI, Marrara Detention Basin Flood Mitigation at Section 4294		
Data Quality Indicator (DQI)		**Comment**
	PQLs for COC below respective Environmental Quality Criteria.	DQI requirement met.
Laboratory QC Program	Preparation and analysis of laboratory QC samples at rates in general accordance with NEPM (2013), including surrogate spikes, matrix spikes, matrix spike duplicates, laboratory duplicates, method blanks (as applicable).	DQI requirement met.
Laboratory QC Results	Surrogate spike recoveries 70% to 130% (exceptions for some contaminants).	DQI requirements generally met.
	Control samples analysed	
	Matrix spike recoveries 70% to 130% (exceptions for some contaminants).	
	Contaminants <PQL's in Method Blanks.	
	Matrix Duplicate / Laboratory Duplicate RPD% ≤50%.	
	95% of laboratory QA results within DQI's.	DQI requirement met.

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