



SITA Australia
Lucas Heights Resource Recovery Park Project
Environmental Impact Statement
VOLUME 6 – APPENDICES

October 2015

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SITA Australia Pty Ltd
Lucas Heights Resource Recovery Park Project
Biodiversity Assessment Report

September 2015

Executive summary

SITA Australia (SITA) is proposing a number of activities at the Lucas Heights Resource Recovery Park (LHRRP) in Lucas Heights. This report has been prepared by GHD Pty Ltd to identify the potential impacts of the proposal on biodiversity values using the Framework for Biodiversity Assessment (FBA) (OEH 2014) as an input to the environmental impact statement. This included:

- Desktop assessment to describe the existing environment and landscape features of the study area and to identify the suite of threatened biota potentially affected by the proposal.
- Field survey to describe the biodiversity values of the proposal footprint and surrounding study area and determine the likelihood of threatened biota and their habitats occurring in the proposal footprint or being affected by the proposal.
- FBA calculations using the credit calculator v.4 to quantify the biodiversity impacts of the proposal and to determine the biodiversity credits that would be required to offset these impacts.

The majority of the proposal footprint is located within the existing landfill, which has been cleared and substantially modified. The proposed ARRT and GO facility have been positioned within vegetated land of which much had been previously cleared but is now regenerating. The proposal's impacts are therefore substantially less than would be associated with an undisturbed 'green field' site. The proposal has been purposefully designed to avoid or further reduce impacts on biodiversity values as far as is practicable.

No threatened ecological communities would be directly impacted. The proposal may have a minor indirect impact on a nearby Coastal Upland Swamp, however this is unlikely to change the species composition of the community or reduce its extent. The stand of Shale Sandstone Transition Forest located to the north of the existing landfill is unlikely to be impacted by the proposal given its distance from the proposal footprint and lack of any clearing in this area.

One individual of the endangered plant *Acacia bynoeana* (listed as an endangered species under the *Threatened Species Conservation Act 1995* (TSC Act) and the *Environment Protection and Biodiversity Conservation Act 1999*) would be removed as a result of the proposal. 82 ramets of the *Allocasuarina diminuta* subsp. *mimica* (listed as an endangered population under the TSC Act) that form part of the endangered population in the proposal footprint would be removed.

The proposal would remove a very small proportion of available habitat resources for local populations of native fauna. Impacts would include the removal of:

- 13.03 ha of potential foraging habitat for mobile threatened fauna species, including the Grey-headed Flying-fox, birds and microbats
- 13.03 ha of potential foraging, shelter and nest or den sites for the Eastern Pygmy-possum and the Spotted-tailed Quoll
- 13.03 ha of potential shelter, foraging and low quality potential breeding habitat for the Giant Burrowing Frog.
- The loss of five hollow-bearing trees and two rock outcrops
- The removal of one artificial dam and a section of Mill Creek. Mill Creek would be realigned to allow continued flow.

The proposal would not impact any threatened biota listed under the *Fisheries Management Act 1994*.

A FBA assessment and credit calculations have been performed in accordance with the methodology (OEH 2014a) and using credit calculator Version 4.0. The FBA includes thresholds for assessing and offsetting impacts of development (see table 4 of OEH, 2014a). With reference to these thresholds the proposal:

- Would remove 82 ramets of the endangered population of *Allocasuarina diminuta* subsp. *mimica*. Note that this species has not yet been added to the credit calculator and thus no credits can be calculated for it.
- Includes a total of 13.03 hectares of impacts for which the assessor is required to determine an offset, comprising:
 - 459 ecosystem credits for impacts on Red Bloodwood - Scribbly Gum heathy woodland on sandstone plateaux (ME014).
 - 77 species credits for *Acacia bynoeana*
 - 169 species credits for the Giant Burrowing Frog
 - 430 species credits for Rosenberg's Goanna
 - 261 species credits for the Eastern Pygmy-possum.
- Includes a total of 98.45 hectares of impacts for which the assessor is not required to determine an offset, comprising the removal of exotic grassland and cleared land.

The Biodiversity Offset Strategy for the proposal would include the purchase and retirement of biodiversity credits as calculated in accordance with the FBA, and would include an onsite offset to ensure credits are within the Sutherland Shire. The offset strategy would require approval from the Sutherland Shire Council.

To address potential impacts of the proposal on biodiversity, a series of mitigation and management measures have been identified, which would be implemented as part of the construction environmental management plan for the site. These include measures relating to:

- General – including inductions and dust suppression measures
- Flora species – including collection of seeds / propagules / ramets and the translocation of plants
- Vegetation clearing – including limiting disturbance of vegetation, vehicle washing, fencing, appropriate stockpiling during construction and sediment fences
- Weeds – including weed management actions/planning, weed propagule spread control measures and sediment control
- Fauna habitat – including hygiene protocol implementation, presence of an ecologist during clearing, staged vegetation clearing, removal of hollow-bearing trees and other habitat features, inspections and so forth
- Water quality and aquatic habitats – including erosion and sediment control measures, plans and surface stabilisation, dust control, spill kits and protocols, removal of large woody debris from the realigned creek and construction of new section of Mill Creek.

During operation there would be minimal increase in existing impacts on native biodiversity values. Therefore few additional mitigation measures are proposed, but these include:

- Ongoing management of noxious weeds according to legislative requirements.
- Ongoing suppression of dust within the landfill and ARRT and GO facilities.

- Ongoing water quality management.

This report addresses the Secretary's Environmental Assessment Requirements and concludes that the proposal would meet the following objectives:

- No significant impacts on the natural environment and threatened biota
- Avoid or further reduce impacts on biodiversity values as far as is practicable
- Minimise the occurrence of pests, vermin and noxious weeds

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Appendix B Desktop assessment of threatened biota
Appendix C Framework for Biodiversity Assessment Data
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Glossary

Term	Definition
ANSTO	Australian Nuclear Science and Technology Organisation.
BioBanking Assessment Methodology (BBAM)	The rules of BioBanking established under the TSC Act that determine credits created, credits required and the circumstances that improve or maintain biodiversity values.
BioBanking	The biodiversity banking and offsets scheme established under Part 7A of the TSC Act.
Biodiversity credit report	Specifies the number and type of biodiversity credits: required to offset the impacts of a development to obtain a Biobanking statement; or required to offset the impacts of a Major Project in accordance with the FBA; or that would be generated through conservation and management of a biobank site under a BioBanking agreement.
Biodiversity credit	A unit of biodiversity value to measure specific development impacts or conservation gains in accordance with the FBA or the BBAM. Includes ecosystem credits or species credits.
Biodiversity offsets	Specific measures that are put in place to compensate for impacts on biodiversity values.
Biodiversity values	The composition, structure and function of ecosystems including threatened species, populations and ecological communities, and their habitats.
Local Government Area	A spatial unit representing the geographic area that is under the responsibility of an incorporated Local Government Council
Ecosystem credit	A credit that relates to a vegetation type and the threatened species that are reliably predicted by that vegetation type (as a habitat surrogate).
DotE	Department of the Environment (previously Department of Sustainability, Environment, Water, Population and Communities - DEWHA)
DPI	Department of Primary Industries
EPBC Act	EPBC Act Environment Protection and Biodiversity Conservation Act 1999
EP&A Act	NSW <i>Environmental Planning and Assessment Act 1979</i> . The Act pertains to the core legislation relating to planning and development activities in NSW
FBA	The Framework for Biodiversity Assessment. The methodology to assess impacts on biodiversity that must be used by a proponent to assess all biodiversity values on the development site for a Major Project in accordance with The NSW Biodiversity Offsets Policy for Major Projects.
FM Act	<i>Fisheries Management Act 1994</i> . This Act provides the framework for the protection of fishery resources within NSW.
LHRRP	Lucas Heights Resource Recovery Park. Includes land owned by SITA and land owned by ANSTO.
Locality	The area within a 10 km radius of the proposal site.
Major project	Major projects include State Significant Development (SSD) and State Significant Infrastructure (SSI)
NW Act	The <i>Noxious Weeds Act 1993</i> . This Act provides for the declaration of noxious weeds by the Minister for Primary Industries.
OEH	Office of Environment and Heritage (previously Department of Environment and Climate Change – DECC).
PCT	Plant Community Type. A classification of vegetation types which is designed to be the NSW standard for community-level vegetation

Term	Definition
	mapping.
SEARs	Secretary's Environmental Assessment Requirements. These requirements set out the matters to be addressed in the EIS. This may include biodiversity impacts not considered by the FBA.
SICTA	Sydney International Clay Target Association. Located within the LHRRP.
SITA	SembSITA Australia Pty Ltd (SembSITA) is the holding company for the SITA Australia (SITA) group of companies in Australia. SembSITA is the parent company of both SITA and WSN Environmental Solutions Pty Ltd (WSN). WSN owns part of the land on which the LHRRP is situated, and leases the remainder from ANSTO. SITA holds the environmental protection licence (EPL), and so is the operator of the facilities at LHRRP. For simplicity, the term 'SITA' is used to refer to all of these organisations in this report.
Species credit	A credit that relates to an individual threatened species that cannot be reliably predicted based on habitat surrogates. Threatened species that require species credits are identified in the Threatened Species Profile Database.
SSC	Sutherland Shire Council.
SSD	State Significant Development
SSI	State Significant Infrastructure
Study area	The area that was subject to a site survey and assessed for indirect impacts arising from construction and operation of the proposal.
TSC Act	Threatened Species Conservation Act 1995. This Act provides the statutory framework for biota of conservation significance in NSW.

1. Introduction

1.1 Purpose of this report

SITA Australia (SITA)¹ is proposing a number of activities at the Lucas Heights Resource Recovery Park (LHRRP) in Lucas Heights (referred to in this report as 'the proposal'). This report has been prepared by GHD Pty Ltd on behalf of SITA to provide an assessment of biodiversity associated with the proposal as an input to the environmental impact statement. Due to the existing operational arrangements at LHRRP, Sutherland Shire Council (SSC) is a joint applicant for the proposal. The environmental impact statement is being prepared by GHD in accordance with the requirements of Part 4 of the NSW *Environmental Planning and Assessment Act 1979* (the EP&A Act).

The report addresses the requirements of the Secretary of the NSW Department of Planning and Environment (the Secretary's Environmental Assessment Requirements (SEARs No SSD-6835) dated 3 February 2015).

In addition to addressing the SEARs requirements, this report provides an assessment of how well the proposal meets SITA's objectives of having no significant impacts on the community or environment. Environmental management and mitigation measures related to biodiversity are proposed (where necessary) to mitigate potential impacts and ensure that they are managed in accordance with statutory requirements, regulations and community expectations.

1.2 Objectives

The following objectives have been identified:

- No significant impacts on the natural environment and threatened biota
- Avoid or further reduce impacts on biodiversity values as far as is practicable
- Minimise the occurrence of pests, vermin and noxious weeds

1.3 Proposal overview

The LHRRP consists of approximately 205 hectares (ha) in two ownerships. 89 ha is owned by SITA and 116 ha owned by Australian Nuclear Science and Technology Organisation (ANSTO) and leased to SITA for waste management or other agreed purposes. The following activities are proposed at the LHRRP and are collectively referred to as 'the proposal'. The proposal would not have a significant impact on the community. In addition to the proposal detailed below, SITA is committed to better environmental outcomes by the application of best practice prevention, mitigation and rectification measures:

- **Reprofiling of existing landfill areas to provide up to 8.3 million cubic metres of additional landfill airspace capacity.** This is equivalent to approximately 8.3 million tonnes of waste, assuming 1 tonne of waste utilises 1 cubic metre of waste disposal airspace. As the process of reprofiling would include removal and replacement of capping material over previously landfilled waste and augmentation of gas and leachate collection systems, the environmental performance of the site would be ultimately improved by

¹ SembSITA Australia Pty Ltd (SembSITA) is the holding company for the SITA Australia (SITA) group of companies in Australia. SembSITA is the parent company of both SITA and WSN Environmental Solutions Pty Ltd (WSN). WSN owns part of the land on which the LHRRP is situated, and leases the remainder from ANSTO. SITA holds the environmental protection licence (EPL), and so is the operator of the facilities at LHRRP. For simplicity, the term 'SITA' is used to refer to all of these organisations in this report.

reducing the infiltration of stormwater into the landfill (resulting in reduced landfill leachate in the longer term) and increase the overall amount of landfill gas recovered from the site.

As part of the proposal, SITA is seeking permission to increase the approved quantity of waste landfilled at the site from 575,000 to 850,000 tonnes per year. This would enable the reprofiling of the site to be completed in 2037.

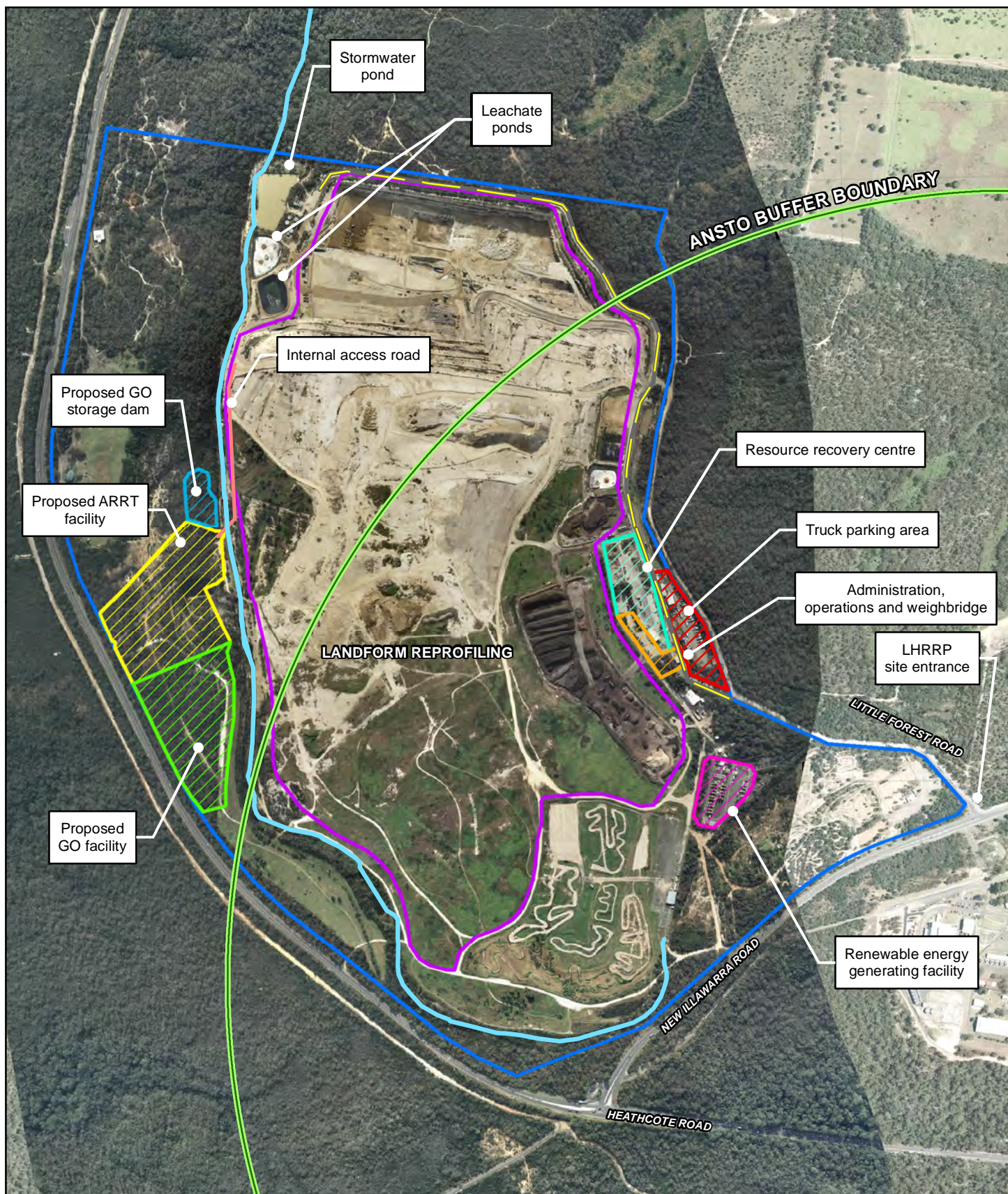
- **Relocation and expansion of the existing garden organics (GO) facility.** The existing garden organics facility would be relocated to the western side of the site adjacent to Heathcote Road. Approval is being sought to increase the approved capacity from 55,000 to 80,000 tonnes of green waste and garden waste received per year at the facility. The new facility would include the partial enclosure, active aeration and covering of the first four weeks of the active composting process, which coincides with the period of highest potential for odour generation, to enable more effective control of odour. Relocation of the facility would result in increased separation distances from the current nearest occupied land at ANSTO, existing residential areas and the proposed new residential area at West Menai.
- **Construction and operation of a fully enclosed advanced resource recovery technology (ARRT) facility.** The ARRT would be located on the western side of the site adjacent to the GO facility and would process and recover valuable resources from up to 200,000 tonnes of general solid waste per year, reducing the amount of waste disposed to landfill to approximately 60,000 tonnes per year. This would divert up to 140,000 tonnes of waste per year from landfill. SSC and other councils would have the opportunity to have their municipal waste processed by the ARRT facility.
- **Community parkland.** The landfill reprofiling would increase the area available for future passive recreation following site closure from 124 ha (existing approved parkland) to a total of 149 ha, an increase of approximately 25 ha. Landfilling would cease in 2037 after which time the site would be rehabilitated and converted to a community parkland, with capping and landscaping to be completed and the site made available for community use in 2039.

As part of the proposal SITA has committed to entering into an agreement with SCC in the form of a Voluntary Planning Agreement which includes 'environmental undertakings'. In addition operational environmental management plans have been prepared for the landfill, GO facility, ARRT facility and post closure measures to manage potential environmental impacts, reflect regulatory requirements and provide guidance for site operators to undertake activities in an environmentally sound manner.

A Planning Proposal is being submitted in parallel with this State Significant Development Application. The Planning Proposal seeks to include new local provisions on the LHRRP site within the Sutherland Local Environmental Plan 2015 (SLEP), which would allow the proposal (a waste or resource management facility) to be undertaken on the proposal site.

The expansion of the LHRRP which is outlined in this EIS would permit the proposed future use of the land for recreational purposes, which is currently approved and would occur when the existing facility ceases operation in 2025. The proposal would however extend the timeframe for which the land would be unavailable for recreational purposes until 2037, due to the extension of operations at the proposed LHRRP.

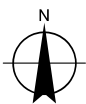
These key components of the proposal are shown on Figure 1.1. The proposed final landform and preliminary masterplan for the parkland is shown in Figure 1.2.



LEGEND

ANSTO buffer boundary	Proposed GO facility	Renewable energy generating facility
Mill Creek	Proposed ARRT facility	Lucas Heights Resource Recovery Park boundary
Internal access road	Resource Recovery Centre	Landform reprofiling boundary
Existing access road	Administration, operations and weighbridge	Truck parking area

Paper Size A4
0 100 200 400
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



SITA Australia
Lucas Heights Resource Recovery Park

Job Number 21-23482
Revision A
Date 28 May 2015

Key existing infrastructure and proposed facility layout

Figure 1.1

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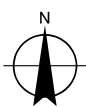
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Aerial Imagery: ESRI, 2014. Works: GHD/SITA, 2014. Roads: NSW LPMA, 2012. Created by: richardson



Paper Size A4

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SITA Australia
Lucas Heights Resource Recovery Park

Job Number	21-23482
Revision	A
Date	24 June 2015

Proposed parkland master plan **Figure 1.2**

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

N:\AU\Sydney\Projects\21\23482\GIS\Maps\MXD\21-23482-2058_Parkland_Master.mxd

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Data source: Taylor Brammer Landscape Architects Pty Ltd. Created by:jrichardson

1.4 Definitions

The following terms are used within this report when referring to the proposal site and surrounding areas:

- The 'LHRRP' refers to the entire Lucas Heights Resource Recovery Park. The boundary of the LHRRP is shown as the blue line on Figure 1.3
- The 'proposal site' refers to the areas where the activities described in Section 1.2 would be located. The boundary of the proposal site is shown as the red line on Figure 1.3

1.5 Location of the proposal

1.5.1 Existing

The proposal would be located within the boundary of the existing LHRRP. The LHRRP is located within the Sutherland local government area, approximately 30 kilometres (km) south west of the Sydney city centre. The site is bound to the west by Heathcote Road and New Illawarra Road to the south.

Specifically, the proposal would be located on:

- Lot 101 DP 1009354
- Lot 3 DP 1032102
- Lot 2 DP 605077

It is noted that the proposal directly affects only a portion of each of these lots. There is minimal encroachment into the SICTA leased land (part of Lot 3 DP 1032102).

The proposal site, within the boundary of the LHRRP, is shown on Figure 1.3.

The site is currently accessed from Little Forest Road, off New Illawarra Road.

Current facilities at the LHRRP include:

- Landfill
- Resource recovery centre and waste collection point
- GO facility for processing garden organics
- Renewable energy production (operated by Energy Developments Ltd)
- Truck parking area
- Community use areas (mini bike area at the southern extent of the site run by the Sutherland Police Citizens Youth Club and the Sydney International Clay Target Association (SICTA) leased land on the north western side of the site)

There are also several ancillary buildings and structures (e.g. weighbridge, machinery workshop, administration offices, stormwater and leachate dams).

The following land uses are located in the immediate vicinity of the LHRRP:

- Bushland areas that form part of ANSTO's exclusion zone (to the east and south)
- ANSTO's facilities (to the east on the opposite side of New Illawarra Road)

Land uses in the surrounding area include:

- Holsworthy Military Reserve (to the west, northwest and southwest)

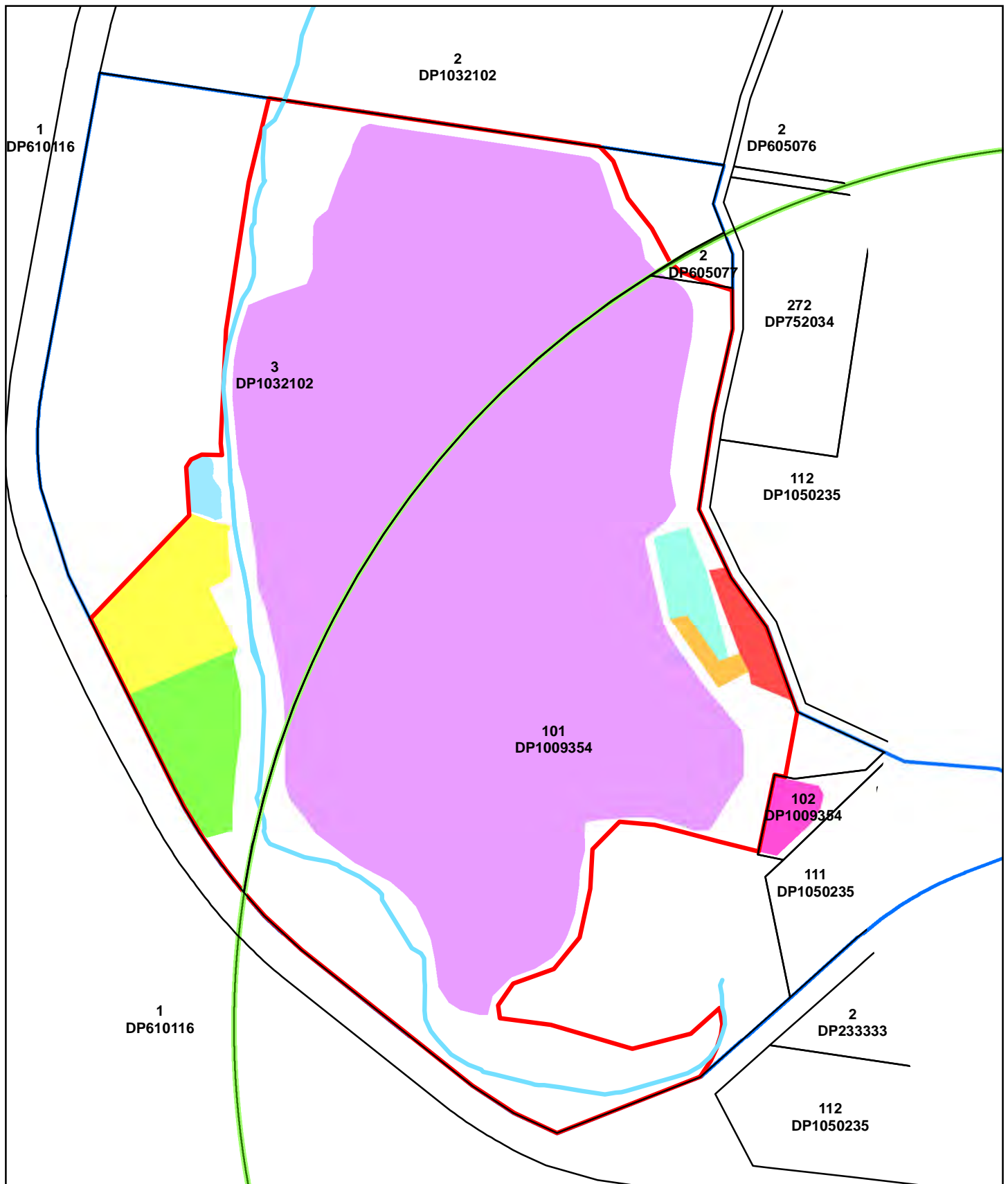
- The Ridge Sports Complex, a major regional sporting facility being developed on the site of the former Lucas Heights Waste and Recycling Centre (approximately 2.5 km to the north east)
- Lucas Heights Conservation Area (immediately to the north of the LHRRP)
- The suburbs of North Engadine (approximately 2 km to the east) and Barden Ridge (approximately 3 km to the north east)

Figure 1.4 shows these key areas.

1.5.2 Potential future surrounding land uses

The Gandangara Local Aboriginal Land Council (GALC) is proposing a development in the West Menai area. The West Menai State Significant Site contains 849 ha of mostly undeveloped land, covering parts of Menai, Barden Ridge and Lucas Heights.

The western boundary of the proposed development is Heathcote Road and the site extends east across Mill Creek to the edge of the existing Menai residential area close to New Illawarra Road. The location of the proposed West Menai State Significant Site is shown on Figure 1.4.



LEGEND

ANSTO buffer boundary

Mill Creek

Cadastre

Proposal site boundary

Lucas Heights Resource Recovery Park boundary

Truck parking area

Proposed GO facility

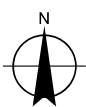
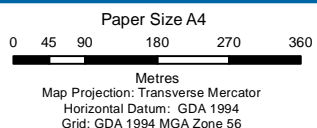
Proposed ARRT facility

Resource Recovery Centre

Administration, operations and weighbridge

Renewable energy generating facility

Landform reprofiling boundary

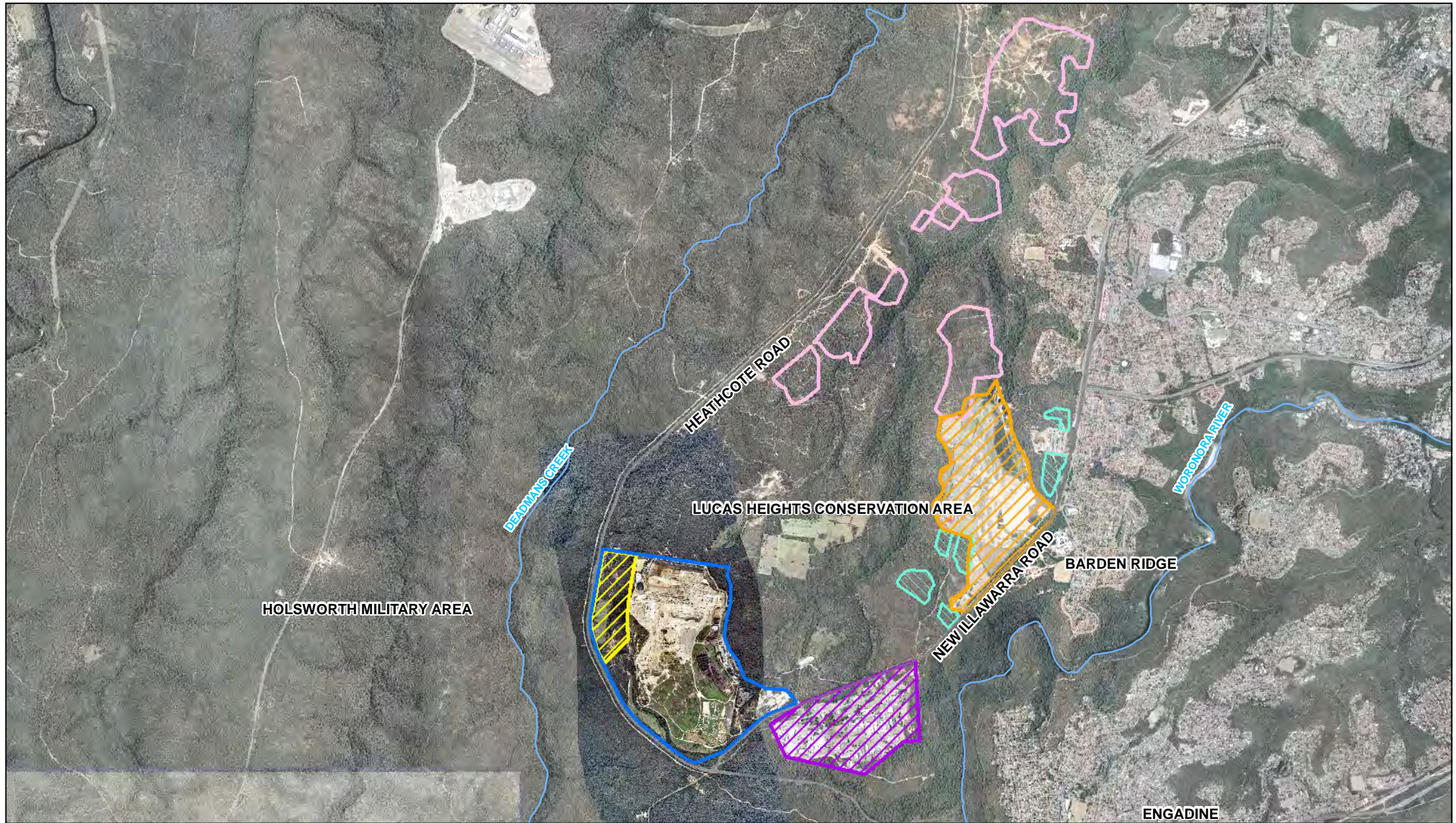


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Lucas Heights Resource Recovery Park

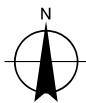
Job Number 21-23482
Revision A
Date 25 Jun 2015

The proposal site

Figure 1.3



Paper Size A4
0 250 500 1,000 1,500
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56



Legend

- LHRRP boundary
- SICTA boundary
- ANSTO
- Barden Ridge Sports Complex

- Potential future receptors
- Future receptors – Residential



SITA Australia
Lucas Heights Resource Recovery Park

Job Number	21-23482
Revision	B
Date	14 Aug 2015

Surrounding landuses

Figure 1.4

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1.6 Secretary's Environmental Assessment Requirements and agency requirements

The specific SEARs and agency requirements addressed in this report are summarised in Table 1.1.

Table 1.1 Secretary's Environmental Assessment Requirements and agency requirements

Assessment requirements	Where addressed in report
Accurate estimates of any vegetation clearing associated with the project;	The methodology for identifying and mapping native vegetation is provided in section 3.3. Vegetation clearing calculations are provided in section 5.1.1.
A detailed assessment of the potential impacts of the project on any threatened species, populations, endangered ecological communities, groundwater dependent ecosystems or their habitats; and	Assessment of impacts on biodiversity values are provided in sections 5 and 7.
Where impacts cannot be avoided, detailed description of the measures that would be implemented to maintain or improve biodiversity values of the surrounding region in the medium to long term, including proposed biodiversity offset measures and details of the provision and protection of land for conservation purposes.	Mitigation measures are provided in section 6.3. Offset requirements have been calculated according to the Framework for Biodiversity Assessment (FBA) in section 7. A draft biodiversity offset strategy is provided in section 8.
Accurate estimates of any vegetation clearing associated with the project;	The methodology for identifying and mapping native vegetation is provided in section 3.3. Vegetation clearing calculations are provided in section 5.1.1.
Agency requirements	
Biodiversity impacts related to the proposed project are to be assessed and documented in accordance with the Framework for Biodiversity Assessment by a person accredited in accordance with s142B(1)(c) of the Threatened Species Conservation Act 1995.	This Biodiversity Assessment Report has been prepared in accordance with the Framework for Biodiversity Assessment (FBA). FBA calculations are detailed in section 7. Accreditation details of relevant staff are provided in Table 3.4.
Impacts on the following species, populations and ecological communities will require further consideration and provision of the information specified in s9.2 of the Framework for Biodiversity Assessment: Threatened ecological communities: Shale Sandstone Transition Forest Endangered Populations: <i>Allocasuarina diminuta</i> subsp. <i>mimica</i> L.A.S.Johnson population in the Sutherland and Liverpool local government areas. <i>Prostanthera saxicola</i> population in Sutherland and Liverpool local government areas.	Further consideration of these threatened biota is provided with respect to the requirements of s9.2 of the FBA in section 7.4.3.
Biodiversity impacts related to the proposed project are to be assessed and documented in accordance with the Framework for Biodiversity Assessment by a person accredited in accordance with s142B(1)(c) of the Threatened Species Conservation Act 1995.	This Biodiversity Assessment Report has been prepared in accordance with the Framework for Biodiversity Assessment (FBA). FBA calculations are detailed in section 7. Accreditation details of relevant staff are provided in Table 3.4.

1.7 Scope and structure of the report

1.7.1 Scope of report

This Biodiversity Assessment Report has been prepared to describe the impacts of the proposal on biodiversity values using the FBA (OEH, 2014a).

The main components of the methodology for the biodiversity assessment were:

- Desktop assessment to describe the existing environment and landscape features of the study area and to identify the suite of threatened biota potentially affected by the proposal.
- Field survey to describe the biodiversity values of the proposal footprint and surrounding study area and determine the likelihood of threatened biota and their habitats occurring in the proposal footprint or being affected by the proposal.
- FBA calculations using the credit calculator v.2.1 to quantify the biodiversity impacts of the proposal and to determine the biodiversity credits that would be required to offset these impacts.

The biodiversity assessment and biodiversity credit calculations were performed by Kirsten Crosby in accordance with the FBA (Accredited Assessor number 160) and reviewed by Ben Harrington (Accredited Assessor number 0073).

Definitions

For the purposes of this assessment, the following definitions are employed:

Proposal footprint – this is the area to be directly affected by the proposed works as described above. In this case it encompasses the area proposed for the ARRT and GO facilities, the access road, realignment of Mill Creek and the reprofiling of the landfill.

Study area – the proposal footprint and adjacent areas that may be indirectly impacted by the proposal. This includes vegetation within 100 metres of the proposal boundary.

Locality – 10 kilometre radius of the proposal footprint.

IBRA subregion – the proposal is located within the Sydney Cataract subregion of the Sydney Basin bioregion, according to the Interim Biogeographical Regionalisation for Australia (IBRA) version 7 (Thackway and Cresswell 1995; DotE 2015).

1.7.2 Structure of report

This report includes:

- Legislative context (Chapter 2)
- Description of the method of assessment, site survey, FBA calculations, staff qualifications and assumptions and exclusions (Chapter 3)
- A review of the existing environment including site survey results and conservation significance (Chapter 4)
- Assessment of biodiversity impacts (Chapter 5)
- Proposed mitigation and management measures (Chapter 6)
- FBA calculations (Chapter 7)
- Draft biodiversity offset strategy (Chapter 8)
- Conclusions (Chapter 9)

- References (Chapter 10).

2. Legislative context

2.1 State legislation

2.1.1 Environmental Planning and Assessment Act 1979

The NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) is the core legislation relating to planning and development activities in NSW. It is the principal law overseeing the assessment and determination of development proposals. All development in NSW is assessed in accordance with the provisions of the EP&A Act.

Part 4 of the EP&A Act

Part 4 of the EP&A Act provides for the control of development that requires development consent from a consent authority. Depending on the circumstances of the proposal, the consent authority may be the local Council or the Minister.

Part 4, Division 4.1 of the EP&A Act establishes an approval regime for development that is declared to be State significant development by either a State Environmental Planning Policy (SEPP) or Ministerial Order. In accordance with Section 89E of the EP&A Act, the Minister is the consent authority for State significant development (SSD). Pursuant to sub-section 78A(8A) of the EP&A Act, an environmental impact statement (EIS) is required to support a development application for SSD.

The NSW biodiversity offsets policy for major projects (the policy) applies to state significant development and state significant infrastructure. The policy is underpinned by the Framework for Biodiversity Assessment (FBA) which commenced in October 2014. It provides the methodology for assessing impacts and determining biodiversity offsets for major projects. The FBA is a modified form of the BioBanking methodology and includes increased flexibility in delivery of biodiversity offsets for Major Projects.

Under the policy, the SEARs for the proposal require SITA to apply the FBA to assess impacts on biodiversity values. The FBA has also been applied to the proposal to identify reasonable measures and strategies that can be taken to avoid and minimise impacts on biodiversity. This Biodiversity Assessment Report describes the biodiversity values present on the development site (the proposal footprint) and the impact of the proposal on these values. A draft Biodiversity Offset Strategy has also been prepared to outline how SITA proposes to offset the impacts of the proposal.

Approval process

SSD to which Division 4.1 of the EP&A Act applies is identified in the *State Environmental Planning Policy (State and Regional Development) 2011* (State and Regional Development SEPP) and in declarations made by the Minister. The proposal is considered to be SSD as it is of a type listed in Schedule 1 of the State and Regional Development SEPP.

The Minister is therefore the consent authority for the proposal and a development application is required to be lodged with the NSW Department of Planning and Environment, accompanied by an EIS. The EIS would be placed on public exhibition for a period of at least 30 days to allow public and agency submissions to be lodged, after which the proponent may be requested to respond to issues raised in the submissions.

2.1.2 Threatened Species Conservation Act 1995

The TSC Act provides the statutory framework for biota of conservation significance in NSW. The TSC Act aims to, inter alia, 'conserve biological diversity and promote ecologically sustainable project'. It provides for:

- The listing of threatened species, populations and ecological communities, with endangered species, populations and communities listed under Schedule 1, critically endangered species and communities listed under Schedule 1A, vulnerable species and communities listed under Schedule 2.
- The listing of Key Threatening Processes (under Schedule 3 of the TSC Act.)
- The preparation and implementation of Recovery Plans and Threat Abatement Plans.

The TSC Act has been addressed in the current assessment through:

- Desktop review to determine the threatened species, populations or ecological communities (threatened biota) listed under the TSC Act that have been previously recorded within the locality of the site and consequently could occur subject to the habitats present.
- Targeted field surveys for threatened biota.
- Identification of suitable impact mitigation and environmental management measures for threatened biota, where required.
- Assessment of potential impacts on threatened biota.
- Identification of offset requirements.

2.1.3 Fisheries Management Act 1994

The objects of the *Fisheries Management Act 1994* (FM Act) are to conserve, develop and share the fishery resources of the State for the benefit of present and future generations. It provides for:

- The listing of threatened species, populations and ecological communities, with endangered species, populations and communities listed under Schedule 4, critically endangered species and communities listed under Schedule 4A, vulnerable species and communities listed under Schedule 5.
- The listing of Key Threatening Processes (under Schedule 6).
- Diseases affecting fish and marine vegetation (under Schedule 6B).
- Noxious fish and noxious marine vegetation (under Schedule 6C).
- The preparation and implementation of Recovery Plans and Threat Abatement Plans.

The FM Act has been addressed in the current assessment through undertaking:

- A desktop review to determine the threatened species, populations or ecological communities that have been previously recorded within the locality of the site and consequently could occur subject to the habitats present.
- Assessment of aquatic habitats during terrestrial field surveys.
- Assessment of impacts on aquatic habitats and threatened aquatic biota.

2.1.4 Noxious Weeds Act 1993

The *Noxious Weeds Act 1993* (NW Act), provides for the declaration of noxious weeds by the Minister for Primary Industries. Noxious weeds may be considered noxious on a National, State,

Regional or Local scale. All private landowners, occupiers, public authorities and Councils are required to control noxious weeds on their land under Part 3 Division 1 of the NW Act. Noxious weeds have been identified in the study area (see Section 4.2.2). SITA currently manages weeds as per the controls in their existing Environmental Management Plan (EMP). If required, the EMP would be updated to include the control of any new noxious weeds identified during field surveys.

2.2 Commonwealth legislation

The purpose of the Commonwealth EPBC Act is to ensure that actions likely to cause a significant impact on matters of national environmental significance undergo an assessment and approval process. Under the EPBC Act, an action includes a project, undertaking, project or activity. An action that 'has, will have or is likely to have a significant impact on a matter of national environmental significance' is deemed to be a 'controlled action' and may not be undertaken without prior approval from the Commonwealth Minister for the Environment (the Minister).

The EPBC Act identifies matters of national environmental significance (MNES) as:

- World heritage properties.
- National heritage places.
- Wetlands of international importance (Ramsar wetlands).
- Threatened species and ecological communities.
- Migratory species.
- Commonwealth marine areas.
- Nuclear actions (including uranium mining).
- A water resource, in relation to coal seam gas development and large coal mining development.

A referral for the proposal has been submitted to the Department of Environment (DotE).

3. Methodology

3.1 Approach

This Biodiversity Assessment Report has been prepared to describe the impacts of the proposal on biodiversity values using the FBA (OEH, 2014a).

The main components of the methodology for the biodiversity assessment were:

- Desktop assessment to describe the existing environment and landscape features of the study area and to identify the suite of threatened biota potentially affected by the proposal.
- Field survey to describe the biodiversity values of the proposal footprint and surrounding study area and determine the likelihood of threatened biota and their habitats occurring in the proposal footprint or being affected by the proposal.
- FBA calculations using the credit calculator v.2.1 to quantify the biodiversity impacts of the proposal and to determine the biodiversity credits that would be required to offset these impacts.

The biodiversity assessment and biodiversity credit calculations were performed by Kirsten Crosby in accordance with the FBA (Accredited Assessor number 160) and reviewed by Ben Harrington (Accredited Assessor number 0073).

3.2 Desktop assessment

3.2.1 Literature and database review

A desktop database review was undertaken to identify threatened flora and fauna species, populations and ecological communities (biota) listed under the TSC Act and FM Act, and MNES listed under the EPBC Act, that could be expected to occur in the locality, based on previous records, known distribution ranges, and habitats present. Biodiversity resources pertaining to the proposal footprint and locality (i.e. within a 10 km radius of the site) that were reviewed prior to conducting field investigations included:

- The Commonwealth Department of the Environment (DotE) Protected Matters Search Tool (PMST), for MNES (threatened and migratory biota) known or predicted to occur in the locality (DotE, 2014a).
- DotE online species profiles and threats database (DotE, 2014b).
- OEH Wildlife Atlas database (licensed) for records of threatened species, populations and endangered ecological communities listed under the TSC Act that have been recorded within the locality of the proposal (OEH, 2014a).
- OEH threatened biota profiles for descriptions of the distribution and habitat requirements of threatened biota (OEH, 2014b). This resource was used to identify the suite of threatened ecological communities (TECs) that could potentially be affected by the proposal and to inform habitat assessments.
- The NSW vegetation types database (OEH, 2014c) to identify plant community types (PCTs) known or likely to occur in the study area as required by the FBA.
- Regional-scale vegetation mapping of the study area (Tozer *et al.*, 2010).
- Mapping and descriptions of the NSW Mitchell landscapes (DECC 2008a, 2008b).

- DPI online protected species viewer for records of threatened aquatic species in the locality (DPI, 2014a).
- The NSW Department of Primary Industries (DPI) 'Threatened Fish and Marine Vegetation – Find a Species by Geographic Region' online search tool for Hawkesbury/Nepean (CMA) (DPI, 2014b).
- The list of species credit-type species identified by the FBA Credit Calculator based on the initial credit calculations.
- Aerial photographs and satellite imagery of the study area.

The threatened and migratory species identified in the desktop assessment are presented in Appendix B. Following collation of database records and threatened species and community profiles, a 'likelihood of occurrence' assessment was prepared for threatened and migratory species and ecological communities with reference to the broad vegetation types and habitats contained within the study area. This was further refined following field surveys and verification of vegetation types and identification and assessment of habitat present within the study area, or the species was found to occur in the proposal footprint. A likelihood of occurrence ranking was attributed to these biota based on this information (see Appendix B).

3.3 Site survey

3.3.1 Survey effort

A number of surveys have been conducted by GHD within the study area over recent years. These have included detailed surveys on land to the east of the landfill (GHD 2011), an ecological constraints assessment of the proposal footprint in November 2012, and detailed surveys for this proposal in December 2014 and January and March 2015.

Staged surveys of the development site were conducted with reference to the FBA and appropriate targeted survey guidelines were carried out in December 2014 and January and March 2015. Site surveys included:

- BioBanking plot/transect surveys.
- Vegetation mapping.
- Identification of flora species.
- Identification of potential habitat for threatened flora species.
- Fauna habitat assessment.
- Targeted frog surveys.
- Spotlighting, call playback and anabat surveys.
- Remote camera surveys.
- Opportunistic fauna surveys.
- Identification of potential habitat for threatened fauna species.

Survey effort that has directly contributed to this biodiversity assessment is summarised in Table 3.1 and is described below.

Table 3.1 Survey effort

Stage	Date	Survey Techniques
Previous surveys to the east of the landfill (eastern side of the study area) (GHD 2011)	June and November 2010	Vegetation mapping, quadrat surveys, targeted threatened flora searches, Koala spot assessments, diurnal bird surveys, mammal trapping (Elliot, cage and harp traps), spotlighting, call playback, anabat.
Constraints assessment within the area proposed for the ARRT and GO facilities (GHD 2012)	November 2012	Vegetation mapping, targeted threatened flora searches
Targeted threatened fauna surveys, opportunistic fauna surveys within the proposal footprint.	8, 9, 11, 15 December 2014	Three nights of Anabat recording; four nights of spotlighting and call playback; opportunistic fauna observations; fauna habitat assessment.
BioBanking plot/transect surveys, vegetation mapping, identification of flora species, fauna habitat assessment, opportunistic fauna surveys, aquatic habitat assessment within the proposal footprint.	22 January 2015	Vegetation survey and seven plot/transects. General fauna habitat assessment, diurnal bird surveys, Koala spot assessments, hollow-bearing tree searches. Aquatic habitat assessment and water quality.
Targeted flora searches, opportunistic fauna surveys within the proposal footprint, SICTA land and along Heathcote Road.	2 March 2015	One day targeted flora searches, opportunistic fauna surveys.

3.3.2 Previous surveys

Surveys to the east of the landfill

Detailed surveys were conducted to the east of the landfill to determine suitability for the ARRT facility. Surveys included a preliminary three day survey in June 2010 followed by a detailed five day survey in November 2010. Flora surveys included vegetation mapping, 20x20m quadrats, and targeted threatened flora searches. Fauna surveys included diurnal bird surveys, mammal trapping, including harp nets, Elliot traps targeting Eastern Pygmy-possums (*Cercartetus nanus*) and cage traps targeting Rosenberg's Goanna (*Varanus rosenbergi*), anabats, spotlighting, and call playback (GHD 2011). Development at this location was determined to be highly constrained due to the presence of two threatened ecological communities (Shale-Sandstone Transition Forest and Coastal Upland Swamp), and a large stand of *Eucalyptus camfieldii* a threatened species listed under the TSC Act.

Constraints assessment for the current proposal

A constraints assessment was conducted by one ecologist for one day in the proposal footprint in November 2012. The focus of this survey was to identify vegetation types and determine if any threatened ecological communities were present in the area identified for the ARRT and GO facilities (current proposed location near Heathcote Road). Surveys for threatened flora species

and potential habitat for threatened flora species were carried out. This survey focussed in particular on searches for *Acacia bynoeana*, *Eucalyptus camfieldii* and *Melaleuca deanei*, which are known to occur within or in close proximity to the proposal footprint. Searches for other threatened flora species that could potentially occur were also conducted.

3.3.3 Current surveys

Site stratification

Pre-existing vegetation mapping (eg Tozer 2010, NPWS 2002) and vegetation mapping from the constraints assessment (GHD 2012) were ground-truthed in the field via systematic walked transects across the entire proposal footprint and by walking the boundary of vegetation units. Necessary adjustments were made by hand on aerial photographs of the study area. The site was divided into relatively homogenous or discrete zones for assessment based on observed vegetation structure, species composition, soil type, landscape position and condition. Plot/transect and quadrat data was compared with Tozer (2010) diagnostic plant species lists to help confirm the presence of native vegetation and the identity of PCTs (OEH, 2014c). Native vegetation was divided into vegetation zones which represented a distinct PCT and broad condition state. Two native PCTs and two vegetation zones were identified in the proposal footprint as shown on Figure 4.1.

The remainder of the proposal footprint contains non-native vegetation that was divided into separate units based on observed structure and species composition.

Coastal Upland Swamp vegetation to the north of the proposed ARRT facility was also sampled as this vegetation type may be subject to indirect impacts.

Plot/transect surveys

Plot and transect surveys were conducted on site in accordance with the FBA to confirm vegetation types, assess site condition and where required to calculate biodiversity credits. The site value was determined by assessing ten site condition attributes against benchmark values. Benchmarks are quantitative measures of the range of variability in condition in vegetation with relatively little evidence of alteration, disturbance or modification by humans since European settlement. Cover abundance data was also collected for each species within the 20 metre x 20 metre portion of each plot/transect.

Plots were used to sample potential vegetation zones (i.e. PCTs and broad condition classes) based on the initial site stratification. Six plots were sampled within the proposal footprint and one outside the proposal footprint as shown on Figure 3.1. Plot/transects are shown on Figure 3.1 and summarised in Table 4.3.

Additional vegetation surveys

Additional vegetation survey effort was used to supplement the plot/transect surveys and help describe the vegetation of the study area. Area searches within both native vegetation and exotic grassland were conducted in the proposal footprint to compile a more exhaustive species list for proposal footprint.

Targeted threatened flora surveys

Threatened plant surveys were conducted throughout the proposal footprint during surveys in November 2012, January 2015 and March 2015. The suite of threatened plants potentially present was identified based on the desktop assessment results (see Appendix B) and the species credit-type species identified by preliminary FBA Credit Calculations (see Table 4.1). Habitat for these species was identified based on OEH threatened species profiles and the experience and judgement of GHD ecologists. The majority of the proposal footprint contains

highly modified landforms such as embankments or cuttings that are dominated by exotic or planted native species. These areas feature very little native plant cover, do not contain natural soil profiles or soil seed banks and could be readily discounted as containing any threatened plant species. Areas of potential threatened plant habitat (i.e. near-intact native vegetation and areas with natural topsoil) were systematically traversed on foot and inspected for threatened plants.

The March 2015 surveys specifically targeted the endangered population of *Allocasuarina diminuta* subsp. *mimica* which had been recorded during the earlier survey. Surveys were carried out via a random meander within areas of potential habitat, mainly disturbed edges and open heathy woodland. Surveys also included searches for *Genoplesium baueri* and other orchids that flower in early autumn. This targeted survey was conducted within woodland and heath located in the proposal footprint, the SICTA land to the north of the proposed ARRT facility, and woodland within the road reserve of Heathcote Road adjacent to the proposal footprint.

Identification of groundwater dependent ecosystems

The NSW Groundwater Dependent Ecosystem (GDE) Policy defines GDEs as ecosystems, which have their species composition, and their natural ecological processes determined by groundwater (DLWC 2002). The Policy defines groundwater as the water beneath the earth's surface that has filtered down to the zone where the earth or rocks are fully saturated (DLWC 2002). Ecosystems vary dramatically in the degree of dependency of groundwater, from having no apparent dependence through to being entirely dependent on it (DLWC 2002). With the exception of the Great Artesian Basin's mound springs, the level of scientific understanding of the role that groundwater plays in maintaining ecosystems in Australia is generally low (DLWC 2002). Currently the approach for assessment of terrestrial groundwater dependent ecosystems is not well documented or understood.

The Australian Government Atlas of Groundwater Dependent Ecosystems was used to identify any previously mapped GDEs that occur in or near the study area. This atlas identifies GDEs reliant on surface groundwater (rivers, springs and wetlands) and subsurface groundwater (vegetation). The Atlas was reviewed to ascertain whether any GDEs are likely to occur in the study area.

The *Risk Assessment Guidelines for Groundwater Dependent Ecosystems – The Conceptual Framework* (Serov et al., 2012) has recently been developed by the NSW Office of Water (NOW) and the OEH. This presents an approach to GDE identification, classification, ecological valuation, and ecological risk assessment for a given activity or potential impact on a groundwater source. This also details a series of steps to identify and infer the level of groundwater dependency and provides a summary of risk assessment guidelines for GDEs. This risk assessment has assigned probabilities of vegetation types in the Sydney Metro CMA being a GDE (Kuginis et al 2012).

Fauna habitat assessment

The site survey methodology included relatively limited targeted fauna survey techniques (e.g. no trapping) because of the limited extent and quality of fauna habitat in the study area and because the FBA assesses the majority of threatened fauna species that could occur based on habitat surrogates.

An assessment was made of the type and quality of habitats present in the study area for native fauna. Habitat quality was based on the level of breeding, nesting, feeding and roosting resources available. The study area was searched for habitat features of particular relevance to threatened species, such as hollow-bearing trees, specific feed trees, termite mounds (breeding

habitat for Rosenberg's Goanna), rock outcrops (potential den sites for the Spotted-tailed Quoll), and water bodies. Areas of planted trees that may provide habitat for fauna were inspected.

Habitat assessments included searches for and inspection of:

- rocks, logs, peeling bark and leaf litter for small reptiles
- winter-flowering eucalypts (important for the Swift Parrot (*Lathamus discolor*), and Grey-headed Flying-fox (*Pteropus poliocephalus*)) and feed trees of the Koala (*Phascolarctos cinereus*) and Glossy Black-cockatoo (*Calyptorhynchus lathami*)
- hollow-bearing trees and logs which provide refuge, nest and den sites for a range of threatened fauna species
- stags and other roost sites for raptors and owls
- termite mounds comprising potential habitat for Rosenberg's Goanna (*Varanus rosenbergi*)
- wetlands, moist grassland and other foraging habitat for waterbirds (including migratory birds) and frogs
- mammal scats at the base of trees or along tracks and runways
- tracks in soft substrate
- nest/den sites within logs, tree bases or tree trunks
- guano or moth remains at the base of hollow-bearing trees (diagnostic of the presence of tree-roosting bats)
- scratches on tree trunks (diagnostic of Koalas, gliders or goannas) and worn bark around tree hollows (diagnostic of active use of hollows)
- owl pellets, whitewash or animal remains beneath trees (diagnostic of owl or raptor roosts).

Searches for hollow-bearing trees were undertaken throughout the fauna habitat assessment and opportunistic fauna surveys. Positions of hollow-bearing trees were logged on a hand-held GPS, and details of tree species, height, diameter, and number, position and size of hollows recorded on a proforma.

Koala spot assessments

Koala spot assessments were carried out at four locations within the proposal footprint within patches of intact native vegetation. Spot assessments comprised searches for Koala scats at the base of up to 30 trees, centred on a secondary or supplementary feed tree identified within DECC (2008). In some areas, trees were very scattered or restricted in distribution, meaning that fewer than 30 trees were searched.

Targeted frog surveys

Giant Burrowing Frog surveys were completed following the Commonwealth Department of the Environment (DotE) survey guidelines for the species. These guidelines recommend targeted surveys for a minimum of four nights of survey within a week of >50mm of rain over seven days in warm weather (spring-autumn). Weather details for the survey period and the preceeding week is provided in Table 3.2.

Targeted surveys consisted of:

- nocturnal streamside searches along Mill Creek within the study area for signs and presence of this species

- nocturnal searches (walked and driven) along access tracks in the study area. No surveys were conducted along Heathcote Road or New Illawarra Road as these are very busy arterial roads
- call playback through a megaphone to illicit an audible response. A GPS was used to record the locations where call playback techniques were conducted
- visual searches for tadpoles.

Targeted Green and Golden Bell Frog and Red-crowned Toadlet surveys were conducted simultaneously with the nocturnal streamside searches and call playback surveys for the Giant Burrowing Frog described above.

Anabat surveys

Microbat ultrasonic echolocation call recordings (Anabat surveys) were undertaken at two locations in the study area on the nights of 8, 9 and 15 December 2014. Anabat detectors were placed in a flyway between native vegetation running parallel to Heathcote Road and also adjacent to the dam in the southern portion of the study area. The anabats were deployed about one hour before sunset and collected the following morning. Calls were identified using zero-crossing analysis and AnalookW software (version 3.8v, Chris Corben 2012). *The Bat calls of NSW: Region based guide to the echolocation calls of microchiropteran bats* (Pennay et al. 2004) was used to assist call analysis. Call identification was also assisted by consulting distribution information for possible species (Pennay et al 2011; Churchill 2008; van Dyck and Strahan 2008) and records from the Atlas of NSW Wildlife (OEH 2013a).

Spotlighting

Spotlighting for nocturnal fauna was also carried out on all four nights of frog surveys. Spotlighting was conducted within the riparian vegetation of the creekline, around dams and drainage lines, and along tracks and in disturbed areas of native vegetation. Some areas of vegetation were very dense and spotlighting was not possible in these areas.

Remote cameras

Two infrared cameras were placed in the study area for a period of one week between 8th and 15th December 2014. One infra red camera was placed in a flyway between native vegetation running parallel to Heathcote Road, the other camera was placed in a patch of open vegetation adjacent to the boundary fence separating the gun club from the SITA land. A second camera was then set from 15th December 2014 to 22 January 2015. Cameras were set to take three pictures over one minute when triggered by movement, with at least five minutes between each set of photographs. Cameras were baited with chicken wings, targeting Spotted-tailed Quolls (*Dasyurus maculatus*) and Rosenberg's Goanna.

Opportunistic fauna surveys

Opportunistic and incidental observations of fauna species were recorded at all times during field surveys. Casual fauna observations were made in suitable areas of habitat throughout the course of the survey and while incidentally traversing the development site. This included visual inspection of trees and woody debris, active searches for small fauna and opportunistic observation of scats, tracks, burrows or other traces. Skeletal remains of mammals were identified by their dental and cranial anatomy and with reference to Triggs (1996).

Aquatic habitat assessment

Habitat descriptions were documented with reference to the NSW Australian River Assessment System (AUSRIVAS) Sampling and Processing Manual (Turak *et al*, 2004), and included assessment of different instream habitat types, and the structure and condition of riparian

vegetation. The information recorded was used to describe the nature of aquatic habitats present within the study area, and identify any areas of potential habitat for threatened aquatic fauna species.

Descriptions of aquatic habitat were based on visual estimates of characteristics such as streambed composition (percentage of total composition for each substrate category), aquatic and riparian vegetation cover, amount of in stream organic material, and area of aquatic habitat and canopy cover. Estimates of channel morphology characteristics were made including width (wetted width in metres), bank full width (mean width between top of banks), and estimated depth. Photographs of each site were taken as a further record of physical conditions observed at the time of assessment.

Given the lack of natural waterways within the study area, no fish trapping or electrofishing surveys were carried out. The condition of the waterway and potential habitat suitability for threatened fish were assessed during field surveys.

Macroinvertebrate sampling and identification

An aquatic ecology assessment was prepared to assess the current state of Mill Creek within and downstream of the LHRRP (GHD 2015d). A copy of the report prepared as part of this assessment is contained in Appendix E. The principal aims of this survey were to assess the condition of aquatic and riparian habitat and the aquatic macroinvertebrate community within Mill Creek. Field sampling of macroinvertebrates was undertaken at five monitoring locations (Figure 3.1) using Rapid Bioassessment (RBA) protocols in accordance with the NSW AUSRIVAS Sampling and Processing Manual (Turak et al., 2004). One monitoring location was located within the study area for this project and four sites were located downstream of the study area, in order to assess the potential impacts the existing LHRRP may be having on Mill Creek (GHD 2015d).

RBA sampling methods are described in detail in GHD (2015d). In summary, these involved sampling about 10 metres of the stream edge at each site using a sweep net. Macroinvertebrates collected were sorted in the field into taxonomic groups and preserved in 70% ethanol before being transported to the laboratory. Macroinvertebrates contained within the samples were examined in the laboratory using a microscope and identified using published taxonomic keys, unpublished working keys and an extensive specimen reference collection maintained by GHD following protocols identified in Hawking (2000).

Following identification of macroinvertebrates, a variety of data analyses were carried out. These are described in detail in GHD (2015d). These analyses provide indices allowing for a broad assessment of the condition or “health” of sites and allows a comparison between sites based upon community structure and defined habitat characteristics. Analyses conducted included:

- Taxa Richness Index – generally higher richness scores indicate better ecological health.
- EPT Taxa Index – the EPT taxa index refers to the proportional representation of key macroinvertebrate taxa belonging to the Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) groups. These groups are generally recognised to be among the more pollution-sensitive macroinvertebrate taxa.
- SIGNAL 2 Taxa Richness Index – this is a biotic index based on pollution sensitivity values
- SIGNAL 2 Biotic Index (Chessman, 2003) - SIGNAL2 scores can be mapped on a biplot against taxa richness. High values of both SIGNAL2 scores and number of families indicates good habitat and chemically dilute water, low SIGNAL2 scores with high family diversity can indicate high salinity or nutrient levels, high SIGNAL2 and low diversity

indicate toxic pollution or harsh physical conditions, and low SIGNAL2 scores and low taxa richness usually indicate urban, industrial or agricultural pollution.

- SIGNAL-SF (Sydney Families) – this is similar to that described above, but has been designed specifically for the Sydney region.
- NSW AUSRIVAS – Autumn Edge Model – this generates site-specific predictions of the macroinvertebrate fauna expected to be present in the absence of environmental stress. Sites are classified into bands depending on the ratio of expected to observed taxa.

In situ water quality

In situ physical and chemical parameters were measured at four locations along Mill Creek and within two dams located in the study area (see Figure 3.1). In addition, *in situ* physical and chemical parameters were measured at the five macroinvertebrate monitoring sites described in GHD (2015d). Parameters were measured using a Hydrolab MS5 water quality meter with the standard sensor suite. This meter was calibrated in accordance with GHD's Quality Assurance requirements and the manufacturer's specifications prior to its use in the field.

Water quality measurements were taken just below the water surface adjacent to the bank and included Temperature (°C), Conductivity (µS/cm), Dissolved Oxygen (mg/L and % saturation) and pH.

3.3.4 Survey conditions

Weather during the December nocturnal surveys was moderately warm with intermittent rain only occurring on the third night of surveys. Thunderstorm activity was present on the first night of nocturnal surveys. The nearby Holsworthy aerodrome weather station (~5 km from the study area) had received up to 46.4 mm of rain in the week before surveys commenced (BOM 2014), while Bankstown Airport (~14 km from the study area) had received 110.6 mm. Standing water was present within track ruts and low-lying depressions during the initial surveys. Weather conditions during the nocturnal surveys were appropriate for the detection of frogs, including for the detection of the threatened Giant Burrowing Frog. Rain may have hampered detection of birds, mammals and reptiles during these nocturnal surveys.

Table 3.2 Daily weather observations prior to and during the targeted frog surveys (December 2014)

Date	Holsworthy			Bankstown		
	Minimum temp (° C)	Maximum temp (° C)	Rainfall (mm)	Minimum temp (° C)	Maximum temp (° C)	Rainfall (mm)
01/12/2014	17.7	31.7	3.0	18.1	31.5	3.8
02/12/2014	18.1	33.8	3.4	18.7	34.4	6.6
03/12/2014	19.6	34.3	2.4	20.8	34.9	0.6
04/12/2014	19.6	31.5	5.2	20.0	31.4	30.0
05/12/2014	18.7	29.6	10.6	18.5	30.2	28
06/12/2014	18.8	28.5	0.0	19.4	29.2	1.8
07/12/2014	17.7	29.1	21.8	17.6	29.5	39.8
08/12/2014	17.3	29.5	2.2	18.3	30.5	3.8
09/12/2014	20.0	24.9	0.8	20.1	25.0	0.8
11/12/2014	19.7	21.6	4.4	20.3	21.8	13.0
15/12/2014	14.7	28.1	0.0	14.8	27.9	0.0

Dates in bold are survey dates.

Weather during the vegetation surveys and fauna habitat assessment conducted in January was hot and humid, with temperatures reaching up to 29.8°C and 30.1°C in nearby Holsworthy and Bankstown aerodromes respectively. Conditions were appropriate for reptile searches and opportunistic fauna observation.

Weather was warm and humid during the March survey. The warm and stormy summer preceeding the survey would have provided good growing conditions for autumn-flowering orchids, including potentially the threatened *Genoplesium baueri*.

Table 3.3 Daily weather observations prior to and during the January and March 2015 survey

Date	Holsworthy			Bankstown		
	Minimum temp (° C)	Maximum temp (° C)	Rainfall (mm)	Minimum temp (° C)	Maximum temp (° C)	Rainfall (mm)
19/01/2015	19.0	20.6	0.0	19.9	22.2	0.0
20/01/2015	17.0	25.8	2.2	18.2	26.5	0.6
21/01/2015	18.6	28.8	2.4	19.1	29.8	2.8
22/01/2015	20.0	29.8	0	19.9	30.1	0
27/02/2015	16.7	27.1	0.2	18.1	28.3	0
28/02/2015	17.4	28.8	0	17.7	29.4	0
01/03/2015	17.6	35.5	0	17.8	36.9	0
02/13/2015	15.0	23.5	8	16.6	24.0	2.4

Dates in bold are survey dates.

3.4 FBA calculations

The proposal was assessed according to the methodology presented in the FBA (OEH, 2014a), the Department of Environment and Climate Change (DECC, 2009) *BioBanking Assessment Methodology and Credit Calculator Operational Manual* and the *Draft Operational Manual for using the BioBanking Credit Calculator v2.0* (OEH, 2011). The credit calculator is a software application that is used to apply the FBA as well as BioBanking assessments. Data is entered into the credit calculator based on information collected in the desktop assessment, site surveys and from using GIS mapping software.

The FBA credit calculations were performed by Kirsten Crosby (assessor accreditation number 160) and reviewed by Ben Harrington (assessor accreditation number 0073) using credit calculator Version 4.0. The credit calculations will be submitted to OEH. The biodiversity credit report is included Appendix A.

The data and assumptions used to perform the FBA credit calculations are summarised in Chapter 7.

3.5 Staff qualifications

Field surveys were conducted by Kirsten Crosby, Gary Leonard, Mal Weerakoon, Adrian Dickson and Ben Harrington of GHD Pty Ltd. Credit calculations were prepared by Kirsten Crosby and checked by Ben Harrington. The Biodiversity Assessment Report was prepared by Kirsten Crosby and peer reviewed by Jayne Tipping. Staff qualifications are presented in Table 3.4.

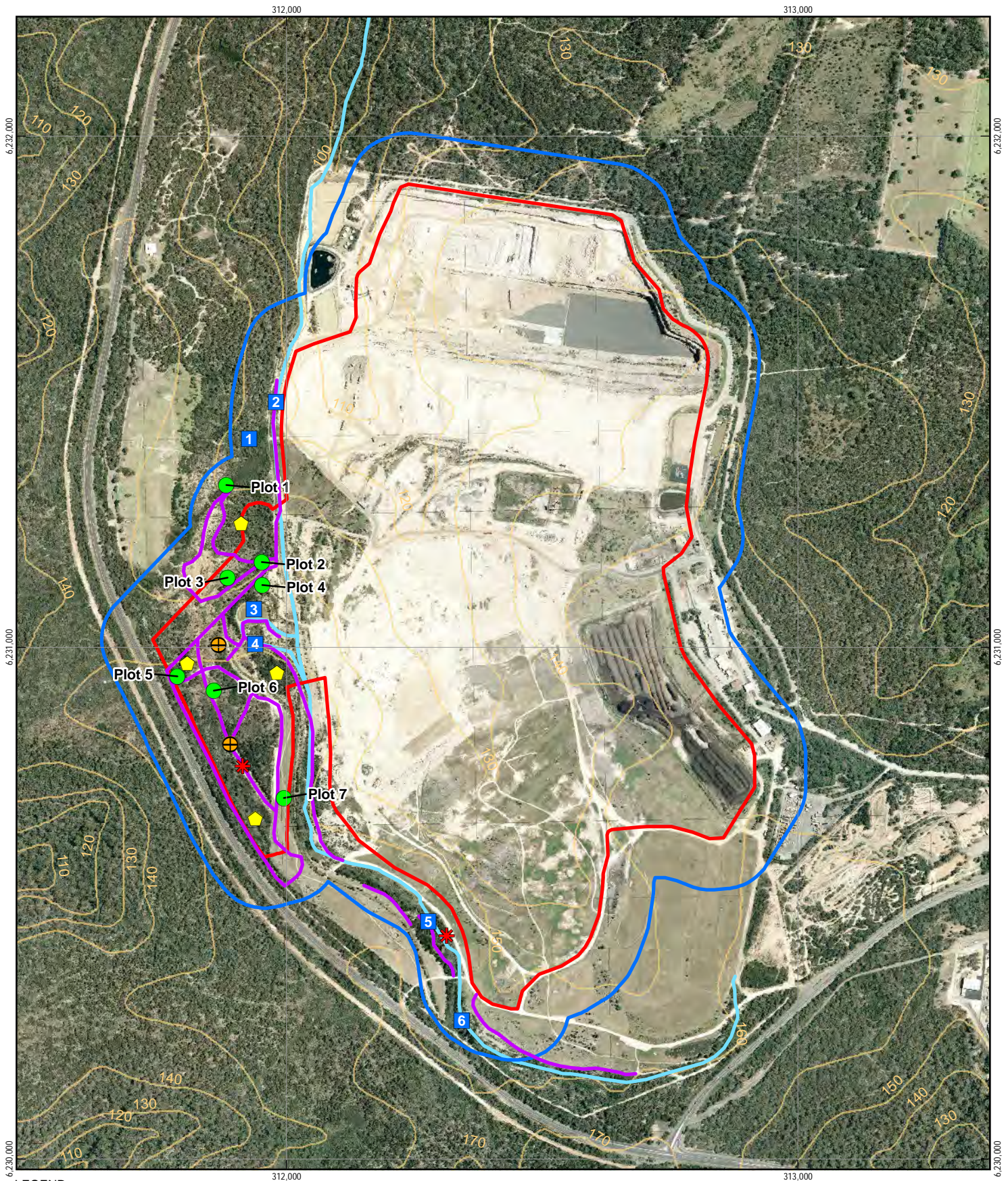
Table 3.4 Staff qualifications

Name	Position / Proposal Role	Qualifications	Relevant Experience
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Kirsten Crosby	Senior Ecologist / desktop assessment, site surveys, targeted frog surveys, reporting	BSc, PhD (Zoology) BioBanking Assessor Accreditation	10+ years
Gary Leonard	Senior Ecologist / vegetation mapping, plot/transects, targeted threatened flora searches	DipHort HortCert DipEd	40+ years
Adrian Dickson	Environmental Scientist / aquatic habitat assessment	BSc (Freshwater Ecology) RBA and AUSRIVAS Certificate of Competency (Level 2), Environment Protection Authority, Victoria	10+ years
Malith Weerakoon	Graduate Ecologist / desktop assessment, targeted frog surveys, data processing.	BSc, MPhil. (Zoology)	2+ years
Ben Harrington	Senior Ecologist / targeted frog surveys, review of credit calculations	BSc, MSc (Physical Geography) BioBanking Assessor Accreditation	10+ years
Jayne Tipping	Principal Ecologist/Technical Review	BSc (Ecology), MEnvLaw	20+ years

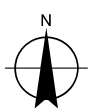
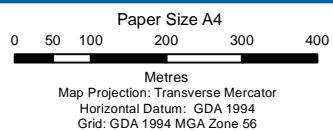
3.6 Assumptions and exclusions

This Biodiversity Assessment Report has been prepared based on the proposal description and engineering drawings provided by the proponent. A 'proposal footprint' polygon (i.e. disturbance footprint) was prepared for the biodiversity assessment based on these inputs and confirmed in consultation with the proponent. It is assumed that the description and spatial data accurately represent the extent of direct impacts arising from the proposal and so these data have been used to calculate the extent of removal of vegetation and habitat arising from the proposal using GIS. These calculations have in turn been relied upon in the FBA calculations and the determination of key thresholds such as whether the proposal would have a direct impact on a threatened species, whether biodiversity offsets are required for a particular impact and whether a particular impact is likely to be significant. The assessment conclusions may change as a result of the provision of an updated proposal design and/or spatial data.



LEGEND

- | | | |
|---|---|--|
| Study area | Survey effort | ✱ Anabat |
| Project footprint | ▮ Koala spot assessment | ▮ Water quality |
| — Mill Creek | ⊕ Camera | ● Plot/transect |
| — 10m Contour | — Spotlighting, call playback | |



SITA Australia
Lucas Heights Resource Recovery Park

Job Number	21-23482
Revision	A
Date	09 Apr 2015

Survey effort

Figure 3.1

N:\AU\Sydney\Projects\21\23482\GIS\Maps\MXD\21-23482-Z052_SurveyEffort_ECOLOGY_A4.mxd

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

© 2015. Whilst every care has been taken to prepare this map, GHD (and Google Earth, NSW Department of Lands) make no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.

Data source: Google Earth: Imagery- May 2014, NSW Department of Lands: contours - Jan 2012. Created by: MWeerakoon

4. Existing environment

4.1 Site context

4.1.1 Surface water features

Most of the site lies within the Mill Creek catchment. Mill Creek originates from LHRRP and flows north along the western boundary towards Georges River. The gradients of the LHRRP are typical of a dissected plateau, with the slopes becoming steeper close to Mill Creek. Mill Creek itself has a slope of 2% as it travels through the site. Baseflow for the perennial rivers and streams are generally sourced from seeps and springs derived from groundwater.

The majority of the site, the landfilled portion, constitutes runoff to Mill Creek. An area around the administration facilities is a tributary to Bardens Creek.

There are a number of surface water management features currently in place at the site. Surface water diversion drainage is constructed around the rim of each active waste disposal cell to control surface water runoff flowing into or from the cells. The drainage typically comprises open channel drains on the outer edge of earthen bunds. Surface water is collected in drains, swales and ponds and diverted to sediment dams. The dams are designed to allow for settlement of suspended solids before discharging offsite following large rainfall events when stormwater has reached capacity.

Most of the LHRRP lies within the catchment area of Mill Creek, with the exception of the area bounded by New Illawarra Road and Little Forest Road in the south-east, which drains to Bardens Creek. Mill Creek originates from within the site and flows in a northerly direction through approximately the centre of the site, covering most of the length of the site. Towards the origin of the creek, the channel is not always clearly visible. Apart from small overflows, flooding is not expected to occur over the site because the gradients of the site allow good drainage.

4.1.2 Geology, soils and geomorphology

The geology of the area is known as the Woronora Plateau and Hawkesbury Sandstone, approximately 200 m thick, dominates the surface.

The LHRRP is located on the dissected Hawkesbury sandstone of the Woronora Plateau, which was uplifted during the Triassic Period such that it now dips downwards in a northerly direction and forms part of the Sydney Basin.

The dominant surface geology is made up of Hawkesbury Sandstone, which is approximately 200 m thick in the Lucas Heights region. It is a medium to coarse grained sandstone and consists of a series of lenticular (and therefore laterally discontinuous) beds of quartz sandstones. Although the dominant lithology is Hawkesbury Sandstone, the formation also includes significant minor components of Wianamatta Shale and siltstone. The shales and siltstones generally occur in relatively thin units frequently interbedded with sandstones.

The LHRRP is part of the Gynea Soil Landscape, with soils up to 150 cm deep. They are formed from sandstone and shale parent material, and consist of a surface layer of sand and subsurface layers of sandy clay and clay. The soils are highly permeable, with very low general fertility. Outcrops of Hawkesbury sandstone are found within the region. A small amount of sandstone bedrock is exposed within the site as a result of soil erosion.

4.1.3 Climate

Review of data from Bureau of Meteorology (BOM, 2014) and data from Queensland Government Department of Science, Information Technology, Innovation and the Arts (DSITIA, 2014) suggests that a warm temperate climate with strong maritime influence is experienced in the Lucas Heights area. Mean daily temperatures range from 26.0 0C to 17.0 0C in February and from 15.8 0C to 6.6 0C in July. Frost is not experienced in this area.

Seasonal variations occur in rainfall with a greater proportion being received during summer months. A generally even rainfall distribution is experienced over the region with a mean annual rainfall of 1015 millimetres (mm).

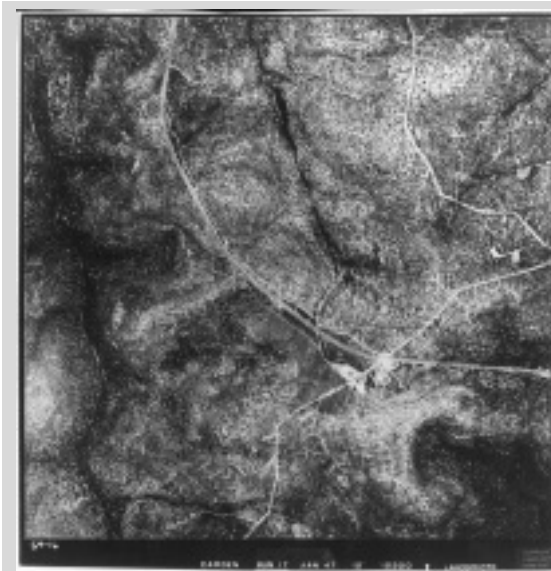
4.1.4 Disturbance

The LHRRP originally opened in 1987, based on a development consent received in 1985 permitting waste disposal operations. A development application was submitted and approved in 1999 which permitted the expansion of waste disposal operations and also the development of composting and other resource recovery operations at the site.

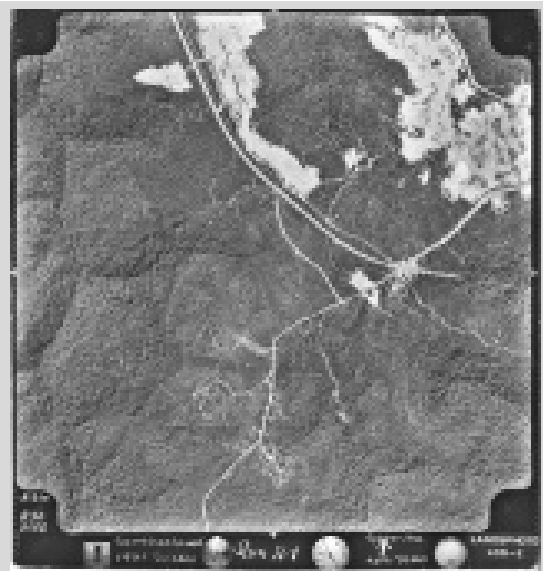
Historical aerial photographs show that the GO facility and ARRT facility area were vegetated in the earliest available photograph (1947) (Photograph 1) before being largely cleared of vegetation at some stage between 1947 and 1961 (Photograph 2). The GO facility and ARRT facility area remained predominantly cleared until the 1984 photograph where vegetation can be seen (Photograph 3, Photograph 4).

Mill Creek was previously located further to the east of the proposed GO facility and ARRT facility area, within the area currently occupied by the landfill. It was realigned to its present location in the late 1980s. Its original location shows up as a dark line running from south to north in the photographs.

Aerial photographs are provided below.



Photograph 1: 1947 aerial photo



Photograph 2: 1961 aerial photo



Photograph 3: 1970 aerial photo



Photograph 4: 1984 aerial photo

4.1.5 Vegetation mapping

Vegetation mapping of the region by NPWS (2002) maps much the native vegetation in the study area and surrounds as MU34 Sandstone Heath-Woodland. This is equivalent to Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux (ME014) in the NSW vegetation types database. A patch of *Eucalyptus squamosa* and *Eucalyptus paniculata* vegetation within the north-eastern portion of the study area is heritage listed under the Sutherland Local Environmental Plan 2006. This vegetation is commensurate with the Shale – Sandstone Transition Forest critically endangered ecological community (CEEC) listed under both the TSC Act and the EPBC Act. Previous vegetation surveys carried out to the east of the landfill identified an area of Coastal Upland Swamp (GHD 2011). Vegetation within the proposal footprint was ground-truthed during surveys (see section 4.2.2 for a description of vegetation types present).

4.1.6 Results of desktop review

The study area contains potential habitat for a number of threatened flora and fauna species. A search of the OEH Atlas of Wildlife database and DotE protected matters search indicated 34 threatened flora species or populations listed under the TSC Act and 27 threatened flora species listed under the EPBC Act that have been recorded or that are predicted to occur within 10 km of the study area. A total of 42 threatened fauna species listed under the TSC Act, one threatened fauna species listed under the FM Act and 20 threatened fauna species listed the EPBC Act have been recorded within 10 km of the study area or are predicted to occur. The likelihood of occurrence of these threatened biota are detailed in Appendix B.

In addition to the database review and the threatened biota likelihood of occurrence assessment for the study area, preliminary FBA credit calculations were performed to identify species credit-type species that may occur in the proposal footprint based on its geographic position and the PCTs and habitat resources present. Species-credit species that may occur in the proposal footprint based on the preliminary FBA credit calculations are listed in Table 4.1. A 'survey/time matrix' which shows the time of year that targeted surveys for each of these species can be conducted is included in Appendix C. The field surveys conducted by GHD match the required survey period for all species of relevance to the proposal (see Appendix B).

Table 4.1 Species-credit species that may occur in the proposal footprint

Scientific name	Common Name	TSC Act	EPBC Act
FLORA			
<i>Acacia baueri</i> subsp. <i>aspera</i>	-	V	
<i>Acacia bynoeana</i>	Bynoe's Wattle	E	V
<i>Acacia prominens</i> - endangered population	-	EP	
<i>Acacia pubescens</i>	Downy Wattle	V	V
<i>Astrotricha crassifolia</i>	Thick-leaf Star-hair	V	V
<i>Caesia parviflora</i> subsp. <i>minor</i>	Small Pale Grass-lily	E	
<i>Caladenia tessellata</i>	Thick Lip Spider Orchid	E	V
<i>Callistemon linearifolius</i>	Netted Bottle Brush	V	
<i>Epacris purpurascens</i> subsp. <i>purpurascens</i>	-	V	
<i>Eucalyptus camfieldii</i>	Camfield's Stringybark	V	V
<i>Genoplesium baueri</i>	Bauer's Midge Orchid	E	E
<i>Grevillea parviflora</i> subsp. <i>parviflora</i>	Small-flower Grevillea	V	V
<i>Hibbertia puberula</i>	-	E	
<i>Hibbertia stricta</i> subsp. <i>furcatula</i>	-	E	
<i>Leucopogon exolasius</i>	Woronora Beard-heath	V	V
<i>Melaleuca deanei</i>	Deane's Paperbark	V	V
<i>Persoonia bargoensis</i>	Bargo Geebung	E	V
<i>Persoonia hirsuta</i>	Hairy Geebung	E	E
<i>Prostanthera densa</i>	Villous Mint-bush	V	V
<i>Pterostylis</i> sp. <i>Botany Bay</i>	Botany Bay Bearded Orchid	E	E
<i>Pultenaea aristata</i>	Prickly Bush-pea	V	V
FAUNA			
<i>Cercartetus nanus</i>	Eastern Pygmy-possum	V	
<i>Heleioporus australiacus</i>	Giant Burrowing Frog	V	V
<i>Isodon obesulus</i> subsp. <i>obesulus</i>	Southern Brown Bandicoot	E	E

Scientific name	Common Name	TSC Act	EPBC Act
<i>Litoria aurea</i>	Green and Golden Bell Frog	E	V
<i>Phascolarctos cinereus</i>	Koala	V	V
<i>Pseudophryne australis</i>	Red-crowned Toadlet	V	
<i>Varanus rosenbergi</i>	Rosenberg's Goanna	V	

* Note: E= endangered, V=vulnerable, EP=endangered population.

4.2 Survey results

4.2.1 Flora species

A total of 236 flora species from 56 families were recorded within the study area, comprising 183 native and 53 exotic species. Poaceae (grasses, 31 species, 17 native), Myrtaceae (flowering shrubs and trees, 30 species, all native), Fabaceae (28 species, 24 native) and Proteaceae (shrubs or trees, 27 species, all native) were the most diverse families recorded. The full list of species recorded is presented in Appendix D. Species recorded are discussed below in relation to the vegetation communities occurring within the study area.

One threatened flora species and one endangered flora population were recorded in the proposal footprint:

- *Acacia bynoeana*, listed as an endangered species under the TSC and as a vulnerable species under the EPBC Act.
- *Allocasuarina diminuta* subsp. *mimica*, listed as an endangered population under the TSC Act.

These species are discussed in more detail in section 4.3.

4.2.2 Noxious and environmental weeds

A range of weed species occur within the proposal footprint. Weeds of National Significance (Thorp and Lynch 1999) include Bitou Bush (*Chrysanthemoides monilifera* subsp. *rotundata*), Lantana (*Lantana camara*), and Fire Weed (*Senecio madagascariensis*). Noxious species for the Sutherland Local Government Area that are present include Ludwigia (*Ludwigia peruviana*), Pampas Grass (*Cortaderia selloana*), Lantana (*Lantana camara*) and Fireweed (*Senecio madagascariensis*). Control requirements for noxious weeds are detailed in Table 4.2.

A range of environmental weeds are also present. It is noted that weed species are more common in the section of Mill Creek which flows along the western boundary of the ANSTO land, and evidence of weed management in the SITA land included harvested seed heads of *Juncus acutus* and poisoned clumps of African Lovegrass (*Eragrostis curvula*), Pampas Grass and Bitou Bush.

Table 4.2 Declared noxious weeds recorded in the study area

Scientific name	Common name	Control category	Legal requirements
<i>Cortaderia selloana</i>	Pampas Grass	3	The plant must be fully and continuously suppressed and destroyed and the plant must not be sold, propagated or knowingly distributed
<i>Ludwigia peruviana</i>	Ludwigia	3	The plant must be fully and continuously suppressed and destroyed

Scientific name	Common name	Control category	Legal requirements
<i>Lantana camara</i>	Lantana*	4	The growth of the plant must be managed in a manner that continuously inhibits the ability of the plant to spread
<i>Senecio madagascariensis</i>	Fireweed*	4	The plant must not be sold, propagated or knowingly distributed

* also a Weed of National Significance.

4.2.3 Vegetation

The majority of the vegetation in the proposal footprint and surrounding study area comprises cleared land or exotic grassland on highly modified landforms. Much of the area proposed to be developed as the ARRT facility and the GO facility has been previously disturbed and is currently vegetated with regrowth and, in several locations planted vegetation. Many tracks and trails pass through this area. Small patches of intact native vegetation are present in this area.

One native vegetation type is present in the proposal footprint: Red Bloodwood - Scribbly Gum heathy woodland on sandstone plateaux (ME 014). This vegetation type occurs as both moderate to good (medium) and moderate to good (poor) condition. This vegetation type also dominates the native vegetation in the study area. This vegetation type is not a threatened ecological community.

Three additional native vegetation types are present in the study area but not in the proposal footprint:

- Needlebush - Banksia wet heath on sandstone plateaux of the Sydney Basin (ME015)
- Hairpin Banksia - Slender Tea-tree heath on coastal sandstone plateaux (ME013)
- Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest (ME021).

All three vegetation types are commensurate with threatened ecological communities (see section 4.3.1).

Vegetation types present in the study area are detailed in Table 4.3 and described below.

Table 4.3 Vegetation in the study area

Vegetation Community	PCT / NSW Veg. Type ID (OEH, 2014d)	Condition	Location	Survey Effort	Conservation Significance
Red Bloodwood - Scribbly Gum heathy woodland on sandstone plateaux	ME014	Moderate to good (moderate)	Within proposal footprint	2 plot/transects	Native vegetation
Red Bloodwood - Scribbly Gum heathy woodland on sandstone plateaux (regenerating and planted)	ME014	Moderate to good (poor)	Within proposal footprint	3 plot/transects	Native vegetation
Needlebush - Banksia wet heath on sandstone plateaux of the Sydney Basin	ME015	Moderate to good (moderate)	Outside proposal footprint	1 plot/transect	Coastal Upland Swamps (endangered ecological community listed under both the TSC Act and the EPBC Act.
Hairpin Banksia - Slender Tea-tree heath on coastal sandstone plateaux	ME013	Moderate to good	Outside proposal footprint	Identified during quadrat surveys by GHD (2011).	Coastal Upland Swamps (endangered ecological community listed under the TSC Act and the EPBC Act.
Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest	ME021	Moderate to good	Outside proposal footprint	Identified by Sutherland Council. Part of the patch verified during quadrat surveys by GHD (2011).	Shale-Sandstone Transition Forest (critically endangered ecological community listed under the TSC Act and the EPBC Act.
Exotic grassland	N/A	Low	Within proposal footprint	1 plot/transect	Not native vegetation
Cleared land	N/A		Within proposal footprint		Not native vegetation

Red Bloodwood - Scribbly Gum heathy woodland

Red Bloodwood - Scribbly Gum heathy woodland occurs in small patches in the western portion of the proposal footprint. A linear patch is present as a narrow strip along the boundary with Heathcote Road, extending into the SICTA land to the north (Photograph 5). A second patch is present along the boundary fence between SITA and SICTA. A small patch of this vegetation type is also present south of the nearby dam (Photograph 6). This vegetation type is also the dominant vegetation type surrounding the proposal footprint.

Canopy species are low and broadly spreading, varying in height from 6m to 14m. Trees are well-spaced (>5m apart) and rarely occur in thickets. Common canopy species include Red Bloodwood (*Corymbia gummifera*), Scribbly Gum species *Eucalyptus racemosa* subsp. *racemosa* at the northern end of the ARRT facility area and, less commonly *Eucalyptus haemastoma* at the southern end of the GO facility. Other canopy species include Sydney Peppermint (*Eucalyptus piperita*), Narrow-leaved Stringybark (*Eucalyptus oblonga*) and Scaly Bark (*Eucalyptus squamosa*). Over-mature, hollow-bearing trees are not present, and it is likely that most of the canopy species are less than 40 years old. A number of small hollows (~5 cm diameter) were observed in Scribbly Gums.

The shrub layer is variable in height and density, possibly in response to previous disturbances and fire. Common shrub species include Dwarf Apple (*Angophora hispida*), Banksia species (*Banksia ericifolia*, *B. spinulosa*, *B. marginata* and *B. serrata*), She-Oak species (*Allocasuarina littoralis* and *A. distyla*), Wattle species (*Acacia longifolia* subsp. *longifolia*, *A. myrtifolia*, and *A. suaveolens*), Mountain Devil (*Lambertia formosa*), Geebungs (*Persoonia lanceolata* and *P. levis*) and Grevillea species (*Grevillea sphaelata*, *G. sericea* subsp. *sericea* and *G. phyllicoides*). Patches of the endangered population of *A. diminuta* subsp. *mimica* occur along the boundary fence adjacent to Heathcote Road (see Figure 4.1).

Groundcover is sparse, with only Lesser Flannel Flower (*Actinotus minor*) forming mats, while grasses, including *Anisopogon avenaceus*, *Entolasia stricta*, *Rytidosperma tenuous*, *Austrostipa pubescens*, *Poa sieberiana* and *Themeda australis*, generally occur as single clumps.



Photograph 5: Red Bloodwood - Scribbly Gum heathy woodland near the boundary fence alongside Heathcote Road



Photograph 6: Red Bloodwood - Scribbly Gum heathy woodland south of the dam

Red Bloodwood - Scribbly Gum heathy woodland (regenerating and planted)

Red Bloodwood - Scribbly Gum heathy woodland (regenerating and planted) occurs over much of the area proposed for the ARRT and GO facilities, as well as adjacent areas of the existing landfill, and along much of Mill Creek. This vegetation type varies from the self-recruiting sandstone heath-woodland described above in response to previous disturbance and supplementary planting (Photograph 7, Photograph 8). Planting was carried out historically around 15-20 years ago in the area near the dam by the Department of Lands. Provenience of these species is not known (L. Hedges, on-site nursery co-ordinator, pers. comm.). More recent planting has been carried out along the riparian corridor of Mill Creek, and has used specimens of local provenience (L. Hedges, on-site nursery co-ordinator, pers. comm.). The canopy is generally no more than 8 m in height and often less than 4 m. Trees may be spaced up to 10 m apart and the shrub layer is also sparse.

Species which are common in this vegetation include Dwarf Apple (*Angophora hispida*), Black She-Oak (*Allocasuarina littoralis*), Scrub She-oak (*Allocasuarina distyla*), *Allocasuarina diminuta* subsp. *diminuta*, Grey Gum (*Eucalyptus punctata*), Smooth-barked Apple (*Angophora costata*) and Bottlebrushes (*Callistemon citrinus* and *Callistemon linearis*). Within this vegetation type is one individual of an inter-generic hybrid *Corymbia gummifera* x *Angophora hispida*. Two individuals of the regionally rare Yellow-top Ash (*Eucalyptus luehmanniana*) occur in a patch of this community north-west of the dam, although it is likely that these specimens have been planted, along with several adjacent individuals of Grey Gum (*Eucalyptus punctata*). A small patch of the endangered population of *A. diminuta* subsp. *mimica* (listed under the TSC Act) occurs along a disturbed track margin in this community in the proposal footprint, as well as in a disturbed area in SICTA land to the north (see Figure 4.1).

Weed species occur in this vegetation type, particularly within constructed batters of Mill Creek. Noxious species include *Ludwigia peruviana*, Lantana (*Lantana camara*), Bitou bush (*Chrysanthemoides monilifera* subsp. *rotundata*), Crofton Weed (*Ageratina adenophora*), Moth Vine (*Araujia sericifera*), Pampas Grass (*Cortaderia selloana*), Vasey Grass (*Paspalum urvillei*) and *Cyperus eragrostis*.

The patch of this vegetation type in the SICTA land (the northern portion of the proposed ARRT facility) is regularly trittered or partially cleared during shot vacuuming operations. Trees are scarce and are mostly < 20 years old. Black Oak (*Allocasuarina littoralis*) occurs in dense thickets throughout this area. Ground cover is sparse to absent.



Photograph 7: Red Bloodwood - Scribbly Gum heathy woodland (regenerating), with dense stand of *Allocasuarina* in background



Photograph 8: Red Bloodwood - Scribbly Gum heathy woodland (regenerating) on SICTA land

Needlebush – *Banksia wet heath*

Needlebush – *Banksia wet heath* is located to the north of the proposed ARRT facility within SICTA land. The vegetation type occurs in a narrow band which follows a drainage line from the formed access track around the existing infill area to a dam in the SICTA land (refer to Figure 4). The vegetation includes components of sedgeland, restioid heath and cyperoid heath in the drainage line bed, to sparse fringing eucalypt woodland and mallee-heath on the sandstone slopes above the drainage line.

The floristics and structure of the vegetation comply with descriptions of Upland Swamp (see NSW NPWS 2004 and Tozer et al. 2010). It is commensurate with the endangered ecological community Coastal Upland Swamp listed under the EPBC Act and the TSC Act.

The most commonly occurring tree species is Narrow-leaved Stringybark (*Eucalyptus oblonga*). Several seedlings of Red Bloodwood (*Corymbia gummifera*) also occur. Shrub species include oak species (*Allocasuarina* spp.), tea trees (*Leptospermum* spp.), *Banksia* species, Crimson Bottlebrush (*Callistemon citrinus*) and Tickbush (*Kunzea ambigua*). Species within the drainage bed include Slender Twine-rush (*Leptocarpus tenax*), Wire Rush (*Empodisma minus*), *Eurychorda complanatus*, *Baumea teretifolia* and *Schoenus paludosus*. One fern species, Swamp Water Fern (*Blechnum indicum*), was an uncommon occurrence and mainly restricted to a pond adjacent to the dam.

Large quantities of lead shot are scattered throughout this vegetation type, with dense concentrations in depressions. These can be seen as grey deposits in Photograph 9. Lead shot was observed in the northern portion of the proposed AART facility, within the land currently leased by SICTA.



Photograph 9: Needlebush – *Banksia wet heath* showing lead shot



Photograph 10: Hairpin Banksia – Slender Tea-tree heath

Hairpin Banksia – Slender Tea-tree heath

Hairpin Banksia – Slender Tea-tree heath (Photograph 10) is located to the east of the existing landfill where it intergrades with the Red Bloodwood–Scribbly Gum heathy woodland. It occurs on shallow, damp Hawkesbury Sandstone derived soils, on a ridge top, with very slight cross-slopes and impeded drainage.

The floristics and structure of the vegetation comply with descriptions of Upland Swamp (see NSW NPWS 2004 and Tozer et al. 2010). It is commensurate with the endangered ecological community Coastal Upland Swamp listed under the EPBC Act and the TSC Act.

This community is a closed heath (Specht, 1970) of sclerophyllous shrubs to 2m tall with very occasional small trees, including Red Bloodwood (*Corymbia gummifera*), Dwarf Apple (*Angophora hispida*) and mallee-form Narrow-leaved Stringybark (*Eucalyptus oblonga*).

There is a very dense, near continuous cover of tall shrubs, including Slender Tea-tree (*Leptospermum trinervium*), Broad-leaf Drumsticks (*Isopogon anemonifolius*), Heath-leaved Banksia (*Banksia ericifolia*), Mountain Devil (*Lambertia formosa*), Lance Leaf Geebung (*Persoonia lanceolata*) and Needlebush (*Hakea sericea*). There is a very diverse assemblage of smaller shrubs, including Coast Coral Heath (*Epacris microphylla*), Pink Spider Flower (*Grevillea sericea*), Fern-leaved Banksia (*Banksia oblongifolia*), Heathy Mirbelia (*Mirbelia rubiifolia*) and Wreath Bush-pea (*Pultenaea tuberculata*).

The groundcover is dense, species rich and variable and includes: herbs such as Purple Fan-flower (*Scaevola ramosissima*), Lesser Flannel Flower (*Actinotus minor*), Germander Rاسpwort (*Gonocarpus teucroides*) and Silky Purple-Flag (*Patersonia sericea*); grasses, including *Entolasia stricta* and *Lomandra obliqua*; the fern *Lindsaea linearis*; and a diverse suite of sedges.

Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest

This community is located as a narrow strip to the northeast of the existing landfill, outside the proposal footprint (Photograph 11). A large patch extends out of the study area to the east (see Figure 4.1).

Ironbark – White Stringybark open forest is an open forest (Specht, 1970) with a grassy understorey and a canopy of Broad-leaved Ironbark (*Eucalyptus fibrosa*), White Stringybark (*Eucalyptus globoidea*), Thin-leaved Stringybark (*Eucalyptus eugenoides*), Turpentine (*Syncarpia glomulifera*) and occasional Grey Gum (*Eucalyptus punctata*). It occurs on deep, free draining clay loam soils on a dry ridge.

There is a sparse small tree layer of Black Oak (*Allocasuarina littoralis*), Forest Oak (*Allocasuarina torulosa*), *Persoonia linearis* and Cherry Ballart (*Exocarpos cupressiformis*). This community features occasional dense patches of the shrubs *Pultenaea villosa* and Blackthorn (*Bursaria spinosa* subsp. *spinosa*) though the shrub layer is generally open with occasional *Ozothamnus diosmifolius* and *Hibbertia aspera*.

There is a dense, grassy groundcover dominated by Kangaroo Grass (*Themeda australis*), Three-awn Speargrass (*Aristida vagans*) and Wallaby Grass (*Microlaena stipoides* var. *stipoides*). The understorey also features a diverse assemblage of forbs including Whiteroot (*Pratia purpurascens*), *Lomandra multiflora*, Solenogyne (*Solenogyne bellioides*), Kidney Weed (*Dichondra repens*), Small-leaf Glycine (*Glycine microphylla*) and Apple-dumplings (*Billardiera scandens*).

The mix of species in this community is indicative of transitional shale-sandstone soils around the edge of the Cumberland Plain at altitudes up to 350m (DECCW, 2010c). This vegetation type is commensurate with the critically endangered ecological community Shale-Sandstone Transition Forest listed under the TSC Act and the EPBC Act.



Photograph 11: Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest



Photograph 12: Exotic grassland

Exotic grassland

This vegetation type mainly consists of a dense groundcover of mostly exotic grasses and forbs (Photograph 12). Dominant species include Paspalum (*Paspalum dilatatum*), Kikuyu (*Pennisetum cladeustum*), Brome Grass (*Bromus* spp.), Whisky Grass (*Andropogon virginicus*), Fireweed (*Senecio madagascariensis*), Cotton weed (*Gomphocarpus fruticosus*) and Thistle (*Cirsium vulgare*). There are also occasional plantings of trees, including River Oak (*Casuarina cunninghamiana*) and Sydney Blue Gum (*Eucalyptus saligna*).

This vegetation does not constitute a native vegetation type.

Cleared land

Areas of cleared land, including the landfill, roads and buildings are also present. These include some areas of planted vegetation, particularly near the existing site buildings. These do not constitute a native vegetation type. Cleared land provides minimal habitat for native biota.

4.2.4 Groundwater dependent ecosystems

Seven broad GDEs have been identified in Australia, including three types of subsurface ecosystems and four types of above-ground ecosystems (Serov et al 2012). No subsurface GDEs are likely to be present in the study area. Two surface GDEs, groundwater dependent wetlands and groundwater dependent terrestrial ecosystems, may be present.

Groundwater dependent wetlands are defined as land permanently or temporarily under water or waterlogged with a known or likely component of groundwater discharge in their hydrologic cycle. Examples of groundwater dependant wetland ecosystems include upland swamps, paperbark swamp forests and woodlands (found on coastal dunes and coastal and river floodplains), swamp sclerophyll forests and woodlands (along riparian corridors of ephemeral or base flow dependent streams), swamp scrubs and heaths (coastal dunes and swampy areas) and swamp shrub lands, sedge lands (coastal, floodplain and valley floor environments) (Serov et al 2012).

Forests and woodlands can rely on groundwater for survival, particularly in areas of shallow groundwater. Groundwater dependency can range from total reliance to a proportional, opportunistic use of groundwater (Serov et al 2012).

Groundwater data for wells close to Mill Creek (i.e. MB116) suggest groundwater elevations may be very shallow in places and thus provide an environment for GDEs to exist (GHD 2015).

A literature review found conflicting information on the likelihood of GDEs being present in the study area. The Atlas of Groundwater Dependent Ecosystems maps vegetation in most of the study area as having no or low potential for groundwater interaction. Conversely, the vegetation types present are likely to be GDEs according to Kuginis et al (2012). According to that study, groundwater dependency can be inferred for many parts of the landscape as there is a strong association between floristic composition, topography and groundwater. Coastal Sandstone Ridgetop Woodland (with which Red Bloodwood - Scribbly Gum heathy woodland on sandstone plateaux is commensurate), Shale Sandstone Transition Forest and Coastal Upland Swamps are all identified as having a high probability of being a GDE (Kuginis et al 2012). These three vegetation types are present in the study area. As such, and as a precaution, it is assumed that all native vegetation types in the study area are groundwater dependent to some degree. Further downstream, outside the project footprint, vegetation in the Mill Creek gully is mapped in the Atlas of Groundwater Dependent Ecosystems as having been identified in a previous study as a GDE.

Mill Creek is not mapped by the Atlas of Groundwater Dependent Ecosystems as being groundwater dependent. The only waterway in the vicinity of the proposal with potential dependence on groundwater is the Woronora River. Given its position near the top of the ridge, much of the water flow in Mill Creek is likely to be dependent on rainfall within the immediate area. As such, Mill Creek in the project footprint is not likely to be a groundwater inflow dependent ecosystem.

Downslope of the dam, flows were generally absent, but intermittent pools were present. This suggests that groundwater inputs into Mill Creek may be negligible, however, as a precaution for the purposes of this study, aquatic flora and fauna in Mill Creek downslope of the study area are considered to be potentially dependent on groundwater inflow.

4.2.5 Fauna species

A moderate diversity of fauna species were recorded in the proposal footprint, likely due in part to the presence of impacts from a highly modified environment arising from the landfill works and historical clearing. A total of 54 native species were recorded, which included 33 bird species, eight mammal species, seven reptile species and six frog species. The full list of species is included in Appendix D.

No threatened species have been positively recorded in the proposal footprint. One threatened species, the Greater Broad-nosed Bat (*Scoteanax rueppellii*) was possibly recorded during anabat surveys. The calls of this species overlap with those of the common Gould's Wattled Bat (*Chalinolobus gouldii*), which was also positively identified in the study area by analysis of calls. The calls of these species are difficult to distinguish if call quality is not good. There are a small number of records of the Greater Broad-nosed Bat in the locality, and it could occur in the study area.

A higher diversity of fauna species was recorded in the good quality woodland and forest habitats to the east of the proposal footprint surveyed in 2010 (GHD 2011). This included an additional 49 species. Of these four threatened fauna species were recorded the Black-chinned Honeyeater (*Melithreptus gularis*), Scarlet Robin (*Petroica boodang*), Grey-headed Flying-fox (*Pteropus poliocephalus*) and Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*), all of which are listed as 'Vulnerable' under the TSC Act. The Grey-headed Flying-fox (*Pteropus poliocephalus*) is also listed as a vulnerable species under the EPBC Act. These threatened species could occur within the proposal footprint on occasion.

Threatened fauna species are discussed in more detail in section 4.3.

Feral species observed in the study area include Red Foxes (*Vulpes vulpes*), Feral Cats (*Catus familiaris*), European Rabbits (*Oryctolagus cuniculus*) and House Mice (*Mus musculus*). Fox numbers are controlled by Sutherland Shire Council with shooting and baiting.

4.2.6 Fauna habitats

Four broad fauna habitats were recorded within the study area:

- Grassland on landfill
- Native woodland, including regrowth
- Upland Swamps
- Dams and creeks

Grassland on landfill

Exotic grassland within the study area occurs across much of the southern portion of the landfill, and alongside an access track within the area proposed for the ARRT and GO facilities. The exotic grassland did not contain any mid-storey or canopy species.

Exotic grasses and weeds within the study area provide foraging resources for opportunistic insectivorous and granivorous bird species typical of open grassland. Such species recorded during the survey include the Australian White Ibis (*Threskiornis molucca*), Australian Raven (*Corvus coronoides*), Australian Magpie (*Cracticus tibicen*), Australian Pipit (*Anthus novaeseelandiae*), Welcome Swallow (*Hirundo neoxena*) and Masked Lapwing (*Vanellus miles*). Larger predatory raptor species such as the Black-shouldered Kite (*Elanus axillaris*) were also recorded foraging over this habitat type. Some threatened microbats (such as the Eastern Bentwing Bat) may forage over these areas, as may threatened birds such as the Little Eagle (*Hieraaetus morphnoides*) and Masked Owl (*Tyto novaehollandiae*).

Exotic grassland provides habitat for small mammals and the House Mouse (*Mus musculus*) was recorded. Eastern Grey Kangaroos (*Macropus giganteus*) were regularly observed foraging in these areas. The European Rabbit (*Oryctolagus cuniculus*) was also observed in exotic grassland throughout the study area. Threatened microbats such as the Eastern Bentwing Bat (*Miniopterus schreibersii oceanensis*) and Greater Broad-nosed Bat (*Scoteanax ruepellii*) may forage over these areas on occasion.

Grassland is also likely to provide habitat for a range of reptile species, including snakes and small lizards. Common Eastern Froglets (*Crinia signifera*) were heard calling from small soaks in grassland areas.

Woodland

Native woodland comprises a mix of heathy woodland of varying structural complexity dependant on past disturbance history such as clearing, planting and even fire events. A moderate diversity of species is expected to utilise this habitat type given the varied structural complexity.

Myrtaceous trees provide foraging resources for a range of birds, including cockatoos, parrots and honeyeaters, and arboreal mammals. The Common Ringtail Possum (*Pseudocheirus peregrinus*) was observed in a number of locations within this vegetation during spotlighting surveys. Sugar Gliders (*Petaurus breviceps*) were observed in vegetation to the east of the landfill during previous surevys (GHD 2011). Nectivorous birds such as Lewin's Honeyeater (*Meliphaga lewinii*), the Little Wattlebird (*Anthochaera chrysoptera*), Noisy Friarbird (*Philemon corniculatus*) and Yellow-faced Honeyeater (*Lichenostomus chrysops*) were recorded foraging within the canopies of this vegetation type. Smaller gregarious bird species such as the Brown

Thornbill (*Acanthiza pusilla*), Buff-rumped Thornbill (*Acanthiza reguloides*) and Red-browed Finch (*Neochmia temporalis*) were also recorded in this habitat type.

Dominant canopy species such as Red Bloodwood (*Corymbia gummifera*), may provide winter foraging habitat for the threatened Swift Parrot (*Lathamus discolor*) and Grey-headed Flying Fox (*Petropus poliocephalus*). Additional myrtaceous species such as Coast Banksia (*Banksia integrifolia*), Old-man Banksia (*Banksia serrata*) and planted Grey Gum (*Eucalyptus punctata*) may also provide foraging habitat for the Grey-headed Flying-fox.

The Koala (*Phascolarctos cinereus*) is known to occur in Heathcote National Park and Holsworthy army base which occur adjacent to the study area. Only limited, poor quality, foraging habitat for this species is present in the proposal footprint. Much of the native vegetation comprises recent regrowth and plantings dominated by *Allocasuarina* species, following clearing between 1947 and 1961. No preferred feed trees listed for the 'Central Coast Koala Management Area' (DECC 2008) are present in the proposal footprint. One secondary species (DECC 2008), the Grey Gum (*Eucalyptus punctata*), has been planted near the large northern dam (western sediment control and water reuse basin) near the gun club boundary. Narrow-leaved Stringybark (*Eucalyptus oblonga*), a supplementary feed tree species, is present in low numbers. Broad-leaved Scribbly Gum (*Eucalyptus haemostoma*), a feed tree listed under NSW State Environmental Planning Policy 44 (Koala habitat protection), occurs in very low densities in the southern portion of the proposal footprint, near Heathcote Road. This species is not listed as a feed tree for the 'Central Coast Koala Management Area' (DECC 2008).

The habitat in the proposal footprint is not considered habitat critical to the survival of the Koala according to the referral guidelines (DotE 2014). Impact areas that score five or more using the habitat assessment tool for the Koala contain habitat critical to the survival of the species. Impact areas that score four or less using the Koala habitat assessment tool do not contain habitat critical to the survival of the species. Habitat within the proposal footprint scored 3 (see Table 4.4).

Table 4.4 Assessment of Koala habitat in the proposal footprint

Attribute	Score	Habitat appraisal	
Koala occurrence	+0	Desktop	EPBC PMST report identified the koala as 'known to occur' in the study area. There are no records of Koalas within 2 km of the proposal footprint from the last 5 years (OEH 2014b).
		On-ground	Nocturnal spotlighting and scat surveys were carried out in the impact area over four days in December 2014 and January 2014, covering approximately 13 ha. No Koala scats or Koalas were recorded.
Vegetation structure and composition	+1	Desktop	Vegetation mapping by Tozer et al (2010) identifies Coastal Sandstone Ridgetop Woodland in the proposal footprint. No primary or secondary feed trees identified for the Central Coast Management Area in DECC (2008) are listed as occurring in this community. A number of stringybarks that are supplementary feed trees do occur in this community.
		On-ground	Vegetation surveys identified a low incidence of supplementary feed trees within the proposal footprint. A small number of planted Grey Gums (secondary feed trees) are planted in one localised area.
Habitat connectivity	+1	The proposal footprint is part of a mostly contiguous landscape. A three lane, 100 km/hr road is located immediately to the west of the proposal, and an 80 km/hr two lane road is located to the south of the proposal footprint.	
Key existing threats	+1	Koalas are known to be killed by vehicle strike along Heathcote Road on occasion.	

Attribute	Score	Habitat appraisal
Recovery value	0	Vegetation in the proposal footprint is unlikely to be important for achieving recovery objectives. No primary feed trees are present. A low number of planted secondary feed trees are present. Supplementary food trees have a low incidence. Large areas of connected habitat occur near the proposal footprint that are likely to support better quality habitat for the species.
Total	3	Decision: The total habitat score for the proposal footprint is 3 and therefore the habitat is not critical to the survival of the koala.

Extensive stands of *Allocasuarina* spp. occur throughout the study area in native woodland and generally occur in regrowth. The Glossy Black-cockatoo (*Calyptorhynchus lathami*) is likely to forage in Black Oak (*Allocasuarina littoralis*) where they are fruiting or have cones. No chewed cones were observed during surveys, despite the large quantities of fallen cones present in the proposal area.

The native woodland provides foraging habitat for a variety of microchiropteran bat species. This includes common species such as Gould's Wattled Bat (*Chalinolobus gouldii*) and the White-striped Freetail Bat (*Tadarida australis*). Long-eared bats (*Nyctophilus* spp.), forest bats (*Vespadelus* spp.) and possibly also the Eastern Freetail Bat (*Mormopterus ridei*) and the threatened Greater Broad-nosed Bat (*Scoteanax rueppellii*) were also recorded, however calls of these species were not of a quality to accurately assign to a particular species. The threatened Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*) was recorded to the east of the proposal footprint during previous surveys (GHD 2011), and would also likely forage in the proposal footprint on occasion.

The absence of senescent or mature trees within the native woodland reduces the number of hollow-bearing trees and fissure-bearing trees available for nesting or denning by fauna. Around 300 vertebrate species use tree hollows and shedding bark in Australia, and the shelter provided by these habitat features is essential for the survival of many of these species (Gibbons & Lindenmayer 2002). Only five hollow-bearing trees were recorded in the proposal footprint, and these only contained small hollows suitable for species such as the Eastern Pygmy Possum and Sugar Glider. No hollows suitable for larger species such as Brush-tailed Possums (*Trichosurus vulpecula*), owls or cockatoos were recorded in the proposal footprint. The small size of the hollows present also reduces the likelihood of microbats using them for roosting, as these species often roost in colonies in larger hollows.

Terrestrial mammals observed in woodland in the study area included the Swamp Wallaby (*Wallabia bicolor*) and Eastern Grey Kangaroo (*Macropus giganteus*). These species would shelter in the woodland and forage in the adjacent grassland. Diggings and a jaw bone of the Long-nosed Bandicoot (*Perameles nasuta*) were observed in woodland areas, with diggings observed particularly in areas dominated by *Allocasuarina* trees. A Bush Rat (*Rattus fuscipes*) was recorded to the east of the landfill during previous surveys, and the skull of a rat, possibly either this species or the introduced Black Rat (*Rattus rattus*) was found near a rock outcrop in the proposal footprint.

Two rock outcrops containing many crevices are present within the isolated patch of intact vegetation south of the western sediment control and water reuse basin. Many fauna carcasses were observed near these rock outcrops, including those of the Australian White Ibis, Australian Raven, European Rabbit, macropods, Common Ringtail Possum, Red Fox and the rat noted above. These are likely to be or have been fox dens, given the presence of these carcasses. These rock outcrops are also potential den habitat for the threatened Spotted-tailed Quoll (*Dasyurus maculatus*) however the presence of foxes is likely to make these unsuitable for this

species. Spotted-tailed Quolls tend to prefer mature wet forests and gullies (Belcher 2000), and habitat in the study area is thus not optimal for the species.

A number of termite mounds were observed within the proposal footprint. These showed some evidence of disturbance, most likely from Echidnas (*Tachyglossus aculeatus*) as disturbance was generally on the surface only, and no deep holes were observed. Termite mounds can provide nesting habitat for the threatened Rosenberg's Goanna (*Varanus rosenbergi*). No evidence of this species was recorded during camera surveys in the proposal footprint or during previous cage trapping surveys to the east of the landfill. The common Lace Monitor (*Varanus varanus*) was recorded in the proposal area.

Groundcover within the native woodland varies, with some patches of woodland high in floristic diversity where *Allocasuarina* species were less dominant. Fallen debris and leaf litter is present in the less disturbed areas of the proposal footprint. Dark-flecked Garden Sunskinks (*Lampropholis delicata*) were regularly observed in the leaf litter. Eastern Water Skinks (*Eulamprus quoyii*) were observed basking on fallen timber and rocky outcrops. Diggings of a bandicoot (most likely the Long-nosed Bandicoot *Perameles nasuta*) were observed throughout this habitat type and a jaw of this species was also recovered. The threatened Giant Burrowing Frog (*Heleioporus australiacus*) could forage and shelter in this vegetation. This species is known to travel more than 500 metres from water (Lemckert and Brassil 2003). The Mountain Dragon (*Rankinia diemensis*) was observed basking in rocky habitat within the disturbed vegetation.

Upland Swamp

Upland swamp habitat occurs in the north-west of the study area and contains small semi-permanent pools among a thick sedge understorey cover. A healthy midstorey is present in some areas of the outlying swamp habitat and provides foraging resources when flowering for species such as the New Holland Honeyeater (*Phylidonyris novaehollandiae*) and Noisy Friarbird (*Philemon corniculatus*). A Brown Goshawk (*Accipiter fasciatus*) was observed foraging above the swamp during the survey.

The Brown Striped Frog (*Limnodynastes peronii*) and Common Eastern Froglet were heard calling during surveys at the Needlebush - Banksia wet heath. No other frogs were heard or observed at this location. Potential habitat for the threatened Giant Burrowing Frog (*Heleioporus australiacus*) and Red-crowned Toadlet (*Pseudophryne australis*) is present at this swamp, although neither species was recorded during targeted surveys in appropriate conditions. Red-crowned Toadlets require a pH range between 5.5 and 6.5. The recorded pH was 5.87 meaning that the species could potentially utilise the ephemeral waterbodies in this swamp.

Existing and previous disturbance may reduce habitat quality for these frog species. High levels of lead shot from the adjacent clay target club are present within the swamp and surrounding area. Lead concentrations from lead shot in soil are particularly high in skeet and shooting ranges, where lead concentrations within the soil and surface water recorded up to 1000 fold higher than at control sites (Stansley and Roscoe 1996). When lead shot is deposited on the soil, lead compounds are oxidised and released into the soil (Jorgensen and Willems 1987), where they become bioavailable for a range of flora and fauna within the ecosystem (Ma 1989). The effects of lead intake on fauna can result in histopathological indications of lead poisoning, and reduced haemoglobin levels (Stansley and Roscoe 1996). Lead uptake in frogs has been poorly researched, but elevated levels of lead have been recorded in a number of frog species outside Australia (Stansley and Roscoe 1996, Niethammer et al. 1985, Stansley et al 1997). An elevated lead level in frogs is known to significantly affect the mortality of some species (Stansley et al 1997) and can inhibit the growth and development of frogs (Power et al 1989). The effect of lead on the Giant Burrowing Frog and Red-crowned Toadlet is not known, however could reduce the habitat quality present at this swamp.

4.2.7 Aquatic habitats and species

Dams

Two dams are located along the previously realigned Mill Creek. The dam in the south (outside the proposal footprint) is heavily vegetated at its southern end with a dense patch of Broad-leaved Cumbungi (*Typha orientalis*). The dam in the area proposed for the ARRT facility has no emergent vegetation, but does contain extensive beds of opportunistic submerged and emergent macrophytes. Fringing vegetation includes *Allocasuarina* and eucalypts, as well as grasses.

Typical common wetland bird species such as the Pacific Black Duck (*Anas superciliosa*), Dusky Moorhen (*Gallinula tenebrosa*) and Chestnut Teal (*Anas castanea*) were observed on open water in these dams. Semi aquatic species such as the Eastern Water Dragon (*Physignathus lesueurii*) are present, and dam habitat and is also likely to be used by the Red-bellied Black Snake (*Pseudechis porphyriacus*).

Common frogs such as the Eastern Dwarf Tree Frog (*Litoria fallax*), Peron's Tree Frog (*Litoria peronii*) and Smooth Toadlet (*Uperoleia laevis*) were heard calling in these dams. The Broad-palmed Frog (*Litoria latopalmata*), was heard and observed at the dam within the area proposed for the ARRT facility. These two dams provide breeding habitat for these frog species.

Common families of dragonfly (Aeshnidae, Libellulidae) and damselfly (Zygoptera, Coenagrionidae, Megapodagrionidae) were observed flying above Mill Creek and the artificial dams.

Mill Creek in the study area

Mill Creek in the proposal footprint is a first order stream. As noted elsewhere, Mill Creek has previously been realigned within the study area and does not follow its natural course. The creek width varies between about 1-2 metres wide along much of its length. In the southern portion of the study area, the creek has a generally natural form, with planted vegetation present in the riparian zone (Photograph 13). This includes a range of eucalypts and dense thickets of tea-tree (*Leptospermum* spp.). Leaf litter is present in the riparian zone in this area. Occasional patches of emergent vegetation including *Typha* are present. Much of the creek habitat has overhanging vegetation in the form of native shrubs and low trees which provide a great deal of organic matter input to the creek. The Dusky Moorhen and Eastern Water Dragon were observed in larger pools in this section of the creek. The aquatic habitat generally resembles an upland ephemeral waterway with some persistent waterholes that are likely to provide habitat for a moderately diverse aquatic fauna.

In the proposal footprint (near the proposed ARRT and GO facilities), Mill Creek typically occurs over sandstone bedrock with a number of small, shallow pools present. Steep banks occur between the creek and the adjacent landfill at this location (Photograph 14). Adjacent vegetation includes *Allocasuarinas* and heathy shrubs and there is limited leaf litter. Occasional patches of emergent vegetation were observed. The aquatic habitats present in the proposal footprint are dominated by shallow pools over bedrock, with overlaying sand and clay/silt sediments. Eastern Water Skinks were observed on exposed bedrock at this location.



Photograph 13: Mill Creek upstream of the proposed GO facility



Photograph 14: Mill Creek within the proposal footprint

Near the northern border of the proposed ARRT facility Mill Creek is located in an artificial drain, and travels through short pipes in some locations. Emergent vegetation is often present at the interface between the drain and the pipes (Photograph 15). Common Eastern Froglets (*Crinia signifera*) and Brown-striped Frogs (*Limnodynastes tasmaniensis*) were heard calling in these areas. Further downstream, the dirty water drain is located adjacent to Mill Creek (Photograph 16). This drain directs dirty water away from Mill Creek.



Photograph 15: Mill Creek downstream of the proposed ARRT facility, showing the unnatural creek bed and banks



Photograph 16: Mill Creek (on the left) downstream of the proposed ARRT facility, with the dirty water drain on the right (area with black plastic)

A previous record of the Giant Burrowing Frog exists along the southern section of Mill Creek in the study area. This species could forage and shelter in the riparian leaf litter, and also potentially breed in ephemeral ponds. The species may use Mill Creek and adjacent vegetation to disperse between better quality vegetation to the south and north, although the unnatural stream bed to the north of the proposed ARRT facility is likely to limit the movement of the species in this location. Preferred breeding habitat includes ephemeral pools and soaks formed in eroded sandstone drainage lines, and is rarely associated with permanent ponds or streams (Mahony 1993, Watson & Martin 1973). Tadpoles have been recorded in clear water with a pH 4.3–6.5 (Recsei 1997). Measurements of pH in the study area found the pH in Mill Creek and the two dams to range between pH 6.87-9.7, averaging around pH 8. Not including the dams, the pH of Mill Creek averaged at 7.19. This may mean that Mill Creek is unsuitable for breeding for the Giant Burrowing Frog.

The Red-crowned Toadlet breeds in ephemeral feeder creeks or flooded depressions, requiring unpolluted water between 5.5 and 6.5 pH. The pH levels recorded along Mill Creek make this

waterway unsuitable for this species. Given the disturbance of vegetation in the study area, high pH levels recorded, and lack of evidence of the species during targeted surveys, this species is unlikely to occur in the proposal footprint.

Common families of dragonfly (Aeshnidae, Libellulidae) and damselfly (Coenagrionidae, Megapodagrionidae) were observed flying above Mill Creek. In addition, adult Mayflies (Ephemeroptera) were observed, although less commonly. Hemipteran water bugs were commonly present where standing water occurred including families such as Gerridae and Veliidae (Water Striders) and the diving taxa such as Notonectidae and Corixidae (Backswimmers and Water Boatmen). These are all common taxa found in surface waters across NSW and are taxa generally tolerant of changes in water and habitat quality.

Macroinvertebrates were collected at one site (MCUP) within the study area as part of the aquatic ecosystem investigation (GHD 2015d). This site is located at water quality site 6 as mapped on Figure 3.1. A total of 24 macroinvertebrate taxa were collected at this site. SIGNAL 2 scores for this site suggest elevated salinity or nutrient levels, however the site's physical conditions are sufficient to support diverse macroinvertebrate life. The AUSRIVAS results suggest that this site is in good condition (GHD 2015d). As this site is above much of the LHRP and near the top of the ridge, this is to be expected, as there are likely to be less disturbance or pollutants at this location.

The realigned creek and artificial dams are not likely to be potential habitat for Adam's Emerald Dragonfly (*Archaeophya adamsi*), listed as endangered under the FM Act. This species is known only from four locations in the Sydney Basin, none being in southern Sydney. Preferred habitat for this species includes small creeks with gravel or sandy bottoms, in narrow, shaded riffle zones with moss and rich riparian vegetation. No riffle habitats were present at any of the surveyed sites during the survey, and if they became present during higher rainfall/surface flow events, they would be highly unlikely to persist for a period of time long enough for colonisation by this species.

No habitat for the Sydney Hawk Dragonfly (*Austrocordulia leonardi*), listed as endangered under the FM Act, is present in the study area. This species has specific habitat requirements, and has only ever been collected from deep and shady riverine pools with cooler water. While the species has been collected from the nearby Woronora River, their habitat preference suggests larger, cooler waters of higher order streams, than those present within Mill Creek. The current known distribution of the Sydney Hawk Dragonfly may include areas adjacent to the SITA Mill Creek sites although the habitat required by this species is highly unlikely to occur and persist, sufficient for colonisation.

No habitat for threatened fish species predicted to occur in the Sydney Metro CMA is present in the study area. Threatened fish species predicted to occur in the CMA include marine and estuarine species only (DPI 2015a). Mill Creek in the study area is not mapped as key fish habitat.

Water Quality

provides the results of the water quality sampling along Mill Creek and the two online dams in the study area. Conditions outside the ANZECC (2000) Guidelines, 95% protection levels for slightly disturbed lowland ecosystems of south-east Australia, are highlighted. Although portions of the Mill Creek catchment are at an altitude above 150 m, the majority is below 150 m, therefore the ANZECC guidelines applied were for lowland ecosystems.

Table 4.5 *In situ* water quality observed at sites where surface water was present during the field survey in January 2015

Site No.	Site name	Time	Temperature (°C)	Conductivity (µS/cm)	pH	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%sat)
1	MC-Swamp	9:20	20.04	505	5.87	3.34	36.5
2	MC-AE1	9:50	23.11	696	6.87	5.64	65.9
3	MC-Dam1	10:05	26.42	320	9.7	14.06	175.2
4	MC-AE2	10:20	22.72	533	7.68	6.92	80.2
5	MC-Dam2	10:35	26.63	248	8.94	13.67	171.2
6	MC-AE3	10:50	23.71	448	7.03	1.63	19.0
	Guideline	N/A	N/A	2200	6.5-8.0	N/A	85-110

The water quality results indicate that water quality conditions across the site are highly variable, particularly pH and dissolved oxygen levels. The measured pH ranged from a low of 5.87 at the swamp site to a high of 9.7 at the dam where the ARRT facility is proposed. Sites which were generally in a more natural riverine state (sites 2, 4 and 6) were within the pH guideline limits, while the two dam sites were above the upper limit. There was no apparent trend in pH conditions across an altitudinal gradient.

Dissolved oxygen (DO) values varied across the sites with the lowest value of 19% occurring at site 6, the most upstream site sampled, and the highest value of 175% occurring at the dam where the ARRT facility is proposed. While there were no obvious trends in DO with increasing distance upstream, the two dam sites observed high levels suggesting excessive chemical or biological activity in these constructed water bodies. High cover of algae and macrophytes were observed at these two sites which may be contributing factors, however the levels observed imply irregular conditions may be occurring. Furthermore, the cause of the fluctuating DO values may be attributable to leachate entering the surface water and/or the oxidation of iron species in the groundwater which are naturally occurring in the groundwater which is entering the surface water as baseflow. Ongoing monitoring of leachate indicators (as currently occurs and will continue) will provide a suitable basis for assessing whether the DO variation is due to the landfilling of waste at the site.

Mill Creek below the LHRRP

All sites downstream of the LHRRP assessed for the aquatic ecosystem investigation (GHD2015d) had a mostly natural and continuous riparian vegetation zone almost completely dominated by native species. A healthy mix of ground cover, shrub layer and over story trees was present at all sites. The macrophytes in the riparian zone were generally emergent forms and were predominantly natives with cover ranging between 5-20% of the available habitat across the sites.

The geomorphic nature of the sites was generally similar and characteristic of a small coastal lowland (below 150 m altitude) catchment. The active channel was well defined. Substrates were a mix of bedrock, boulder, gravel, sand and clay/silt, but predominantly bedrock and clay/silt. Flow habitat types were generally half pool and half run with some riffle occurring at the site furthest downstream (MC4) (GHD 2015d).

Disturbance to the ground surface associated with recreational vehicle activities was observed at MC3. These activities appear to be causing an influence on the integrity of the stream banks and causing increased levels of sediment deposition (eroded from unsealed dirt tracks) in close proximity to this monitoring location. The general habitat condition at this site was rated as good. Other monitoring sites below the LHRRP were in excellent (MC4) or very good condition (MC 1 and MC2).

A total of 46 macroinvertebrate taxa were identified across the five monitoring locations assessed for the aquatic ecosystem investigation (GHD2015d). Site MCUP is the site located upstream of the proposed ARRT and GO facilities (described above). The other four sites are located downstream of the LHRRP. A full discussion of macroinvertebrate results is provided in GHD (2015d), however a summary is provided here:

- Lower taxa richness and SIGNAL 2 richness were observed at sites MC 3 and MC 4, located furthest from the LHRRP, suggesting some impact from the LHRRP or other disturbance (eg pollutants from Heathcote Road).
- SIGNAL 2 biotic index scores indicated that all sites are subject to elevated salinity or nutrient levels. These elevated levels may occur naturally or as a result of human activities. Whatever the source, the relatively high number of macroinvertebrate taxa identified across the monitored locations suggests that physical conditions are sufficient to support diverse macroinvertebrate life.
- The Signal 2 taxa richness scores for the three monitoring locations closest to the LHRRP are higher than those for the two locations furthest away from the LHRRP, but the SIGNAL 2 Biotic Index scores were higher at the downstream sites. This demonstrates that the sensitivity to pollution of the taxa at the sites closer to the LHRRP is lower than those further downstream. This suggests that while some nutrient enrichment may be occurring at the higher elevation sites near the LHRRP, it could be reducing by dilution downstream.
- Assessment of the pollution tolerances of taxa present found most monitoring locations had communities dominated by pollution tolerant taxa, although some sensitive taxa were present. While this may seem a cause for concern these ratings are relatively good. Recent studies of the Georges River catchment found that urban streams throughout the catchment contain macroinvertebrate communities dominated by pollution tolerant species with little or no pollution sensitive species present (Tippler *et al.*, 2014). This suggests that macroinvertebrate communities present at the monitoring locations were generally in a healthy condition given the extent of catchment disturbance associated with a development such as the LHRRP.
- AUSRIVAS assessment of macroinvertebrate communities' rated MCUP as in 'Reference condition' (Band A), MC3 as 'Severely impaired' (Band C) and the remainder as 'Significantly impaired' (Band B). The decline from Band A to Band B immediately downstream of the LHRRP (MC1) is not unexpected given the change in catchment landuse associated with the LHRRP. The decline to Band C at MC3 is likely due to a decline in taxonomic diversity, also displayed in the richness results discussed above. This may be attributed to several factors but is likely due to the decline in aquatic and riparian habitat condition that may be linked to nearby recreational vehicle use. Condition improves again at MC4, which is furthest from the LHRRP. Note that MC1, 2 and 4 were all in the upper levels of Band B, close to Band A (reference condition).

No dragonflies of the family Corduliidae (the family in which the threatened Sydney Hawk Dragonfly and Adam's Emerald Dragonfly are placed) or Petaluriidae (the family in which the threatened Giant Dragonfly is placed) were recorded during the macroinvertebrate surveys (GHD 2015d).

4.2.8 Habitat connectivity

Assessment of habitat connectivity and the proposal's impacts on habitat connectivity is provided in the assessment of landscape value according to the FBA that is provided in Section 7.2.

4.3 Conservation significance

4.3.1 Threatened ecological communities

No TECs have been identified within the proposal footprint. Two TECs have been recorded in or near the study area:

- Coastal Upland Swamp: Needlebush - Banksia wet heath on sandstone plateaux (ME015) and Hairpin Banksia - Slender Tea-tree heath (ME013) are commensurate with Coastal Upland Swamps in the Sydney Basin Bioregion, listed as an endangered ecological community under the TSC Act and EPBC Act. This community is located about 40 m downslope of the proposed detention pond that will be located north of the ARRT facility, and about 70 m to the east of the existing landfill (see Figure 4.1).
- Shale-Sandstone Transition Forest: Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest (ME021) is commensurate with this critically endangered ecological community CEEC. A narrow strip of this CEEC is located to the north-east of the existing landfill, outside the proposal footprint. This extends into a large stand further to the east of the proposal footprint. A second stand is mapped by SCC to the north of this stand (see Figure 4.1).

4.3.2 Threatened flora species

The Protected Matters Search predicts 25 threatened flora species that may occur in the locality. Of these, 11 species have been previously recorded in the locality (OEH 2014a). One threatened flora species was recorded in the proposal footprint during surveys:

- *Acacia bynoeana*, listed as an endangered species under the TSC Act and a vulnerable species under the EPBC Act. One individual was recorded alongside the boundary track in the area proposed as the ARRT facility (see Figure 4.1). This species appears to prefer open, sometimes slightly disturbed sites such as trail margins, edges of roadside spoil mounds and in recently burnt patches (OEH 2015b). No other individuals have been recorded in the disturbed native vegetation within the proposal footprint. *Acacia bynoeana* has previously been recorded between 3 and 5 km to the north-east of the study area (Cumberland Ecology 2012), in the land proposed as the Menai Ridge development.

Three threatened flora species occur near the study area. These comprise:

- *Eucalyptus camfieldii* (listed as a vulnerable species under the TSC Act and EPBC Act). A stand of *E. camfieldii* (including hybrid specimens) was identified about 100 metres to the east of the proposal footprint during surveys in this area in 2010 (GHD 2011) (see Figure 4.1). This species was identified within Hairpin Banksia - Slender Tea-tree heath. No individuals of this species have been recorded in the proposal footprint.
- *Melaleuca deanei* (listed as a vulnerable species under the TSC Act and EPBC Act). Two *M. deanei* were recorded about 200 metres to the east of the proposal footprint during surveys in this area in 2010 (GHD 2011). One individual was recorded about 200 metres to the south of the proposal footprint near Heathcote Road (GHD 2012) and one individual was recorded during the March 2015 survey on the western side of Heathcote Road approximately 400m to the north-west of the intersection with New Illawarra Road. All records are located in areas of Red Bloodwood - Scribbly Gum heathy woodland. This species has also previously been recorded within 500 metres of the proposal footprint to the north and to the south (OEH 2014a). No individuals of this species have been recorded in the proposal footprint.
- *Melaleuca biconvexa* (listed as a vulnerable species under the TSC Act and EPBC Act). One individual was recorded during the March 2015 survey on the eastern side of

Heathcote Road, on slopes leading down to a culvert and a tributary of Mill Creek. This individual is growing on a section of road reserve within occasionally mown grassland, adjacent to a dense patch of *Allocasuarina littoralis*.

During the March 2015 survey, incidental searches were carried out for appropriate habitat for the threatened terrestrial orchid *Genoplesium baueri* (Brittle Midge Orchid). The Brittle Midge Orchid occurs in heathy eucalypt forests and in "...moss gardens in sandy soils on sandstone..." (Bishop 2000). The flowering time for this species is February to May, and because there has been adequate rainfall over the previous summer, it may be assumed that if this species were present on the site, some individuals would be visible in March. No flowering terrestrial orchids, and no *Genoplesium* species were recorded on the subject site during the March 2015 survey.

The study area and proposal footprint contain broadly suitable habitat for a number of other threatened plants that are known or predicted to occur in the locality based on the results of the desktop assessment (see Appendix B) and/or the FBA credit calculations (see Table 4.1). Based on the historical clearing, small area of native vegetation and natural soil profiles that could comprise threatened plant habitat in the proposal footprint, and the survey effort employed, these species can be reliably discounted as occurring in the proposal footprint or being affected by the proposal.

4.3.3 Threatened flora populations

Allocasuarina diminuta subsp. *mimica*

One threatened flora population has been identified within the proposal footprint. *Allocasuarina diminuta* subsp. *mimica*, listed as an endangered population under the TSC Act, is restricted to the Sutherland and Liverpool LGAs, with most of the population records occurring in land alongside Heathcote Road (OEH 2015b).

About 200 ramets *Allocasuarina diminuta* subsp. *mimica* were recorded during the March 2015 targeted survey for the species, of which 58 were in the proposal footprint. The 200 stems of *Allocasuarina diminuta* subsp. *mimica* are described as ramets, because it is possible that many of the stems have reproduced apomictically after damage to the roots and stems of the original plants. Because some ramets were recorded along the fence between the proposal footprint and Heathcote Road, surveys were also carried out along both sides of a section of road reserve adjacent to the proposal footprint. At least 24 ramets were recorded on the eastern side of Heathcote Road, and more than 100 in the drainage line and slopes along the western road reserve. Surveys were also conducted in open woodland and heath areas of the SICTA land to the north of the proposal footprint. About 24 ramets were recorded in disturbed vegetation immediately to the north of the proposal footprint (see Figure 4.1).

Female flowers were recorded on several stems and cones were common on stems within most patches of this species, therefore it is possible that viable seed has been produced. It was, however, noted that some cones are beginning to open. Seed collection by the on-site nursery volunteers was recommended and preliminary seed collection has been undertaken (see section 6.3).

The proposed Heathcote Ridge development located about 1 km to the north of the LHRRP is expected to impact about 188 ha of the heath and open woodland of the *Angophora hispida/Eucalyptus haemastoma* community which contains *Allocasuarina diminuta* subsp. *mimica*. About 22% of the community containing this endangered population at the Heathcote Ridge site will be retained (Graham, B. in NSW Scientific Committee 2014). Other records are present in a Council Reserve, to the north of the LHRRP, Holsworthy army base and within ANSTO land south of New Illawarra Road (OEH 2015b).

A more detailed description of the occurrence of this endangered population is provided in section 7.4.3.

Prostanthera saxicola

The SEARs highlighted the *Prostanthera saxicola* endangered population in the Sutherland and Liverpool LGAs as an endangered population of possible concern for the proposal. This population occurs mainly between Holsworthy station and Sutherland station, north from Lucas Heights and south of the Georges River. It grows primarily in eucalypt forest, heath and low shrubland, often in damp or moist sites. Woodland in the proposal footprint has been heavily disturbed, with much of it being regrowth on skeletal soils. Intact vegetation is dry, with few, if any, damp or moist sites. This species was not recorded during surveys in the proposal footprint and adjacent areas. No individuals of this species have been observed in the study area by the nursery volunteers. Given the lack of preferred habitat and lack of any evidence of its occurrence, this population is unlikely to be present in the proposal footprint.

4.3.4 Threatened fauna species

Only one threatened fauna species was possibly recorded during the field surveys:

- The Greater Broad-nosed Bat (*Scoteanax rueppellii*), listed as a vulnerable species under the TSC Act, was possibly recorded during anabat surveys (see section 4.2.4). The calls of this species are similar to those of Gould's Wattled bat (*Chalinolobus gouldii*) which was definitely recorded on site. Call characteristics overlap making it too difficult to distinguish between species if call quality is not good, or if enough calls are not recorded. There are a small number of records of the Greater Broad-nosed Bat in the locality, and it could occur in the study area. This species is known from a wide variety of habitats, including open woodland and tree-lined creeks in open areas (Churchill 2008).

Four threatened species have been recorded to the east of the study area during previous surveys (GHD 2011), and could occur on occasion in the proposal footprint:

- Grey-headed Flying-fox (*Pteropus poliocephalus*), listed as a vulnerable species under the TSC Act and the EPBC Act, was recorded flying over the study area. This species could forage in flowering myrtaceous trees in the study area on occasion. There are no roost camps in the proposal footprint or broader study area.
- Black-chinned Honeyeater (*Melithreptus gularis*), listed as a vulnerable species under the TSC Act, was recorded in Red Bloodwood – Scribbly Gum heathy woodland east of the proposal footprint and could forage in the proposal footprint on occasion. Breeding is unlikely in the proposal footprint due to the generally disturbed nature of the vegetation.
- Scarlet Robin (*Petroica boodang*), listed as a vulnerable species under the TSC Act, was recorded in woodland east of the proposal footprint and could forage in the proposal footprint on occasion. Breeding is unlikely in the proposal footprint due to the generally disturbed nature of the vegetation.
- Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*), listed as a vulnerable species under the TSC Act, was recorded near a dam to the east of the proposal footprint. This species could forage above the proposal footprint on occasion. No breeding habitat (maternity caves) is present.

The study area contains suitable habitat for a number of additional fauna species that have been recorded in the locality within the last 20 years. Threatened fauna species that are known or have the potential to occur in the study area based on the habitat resources present and recent records in the locality are listed in Table 4.6.

No suitable habitat is present for threatened aquatic fauna species listed under the FM Act (see section 4.2.7).

4.3.5 Migratory species

The desktop analysis highlighted a number of migratory species with potential to occur in the locality. The proposal footprint does not contain habitat for marine migratory species, and contains no areas that are unlikely to represent important habitat for wetland bird species. The Rainbow Bee-eater (*Merops ornatus*), Satin Flycatcher (*Myiagra cyanoleuca*) and Rufous Fantail (*Rhipidura rufifrons*) are nomadic woodland birds that disperse widely across south-eastern Australia in response to seasonal cues and food availability. Accordingly, individuals of these species could occur within the woodland habitats in the study area on a seasonal or opportunistic basis. However, their occurrence on the site is likely to be transient and the site would represent only marginal foraging habitat for these highly mobile species. Vegetation within the study area is highly modified, fragmented and would have only limited value for migratory species listed under the EPBC Act. Habitat in the study area is not likely to support an ecologically significant proportion of the population of any of these species, be of critical importance to the species at particular life-cycle stages, located at the limit of any of the species' range, and/or be located within an area where the species is declining. As such, potential habitat in the study area is not 'important habitat' for any of these species, as defined in DotE (2013).

4.3.6 Other Matters of National Environmental Significance

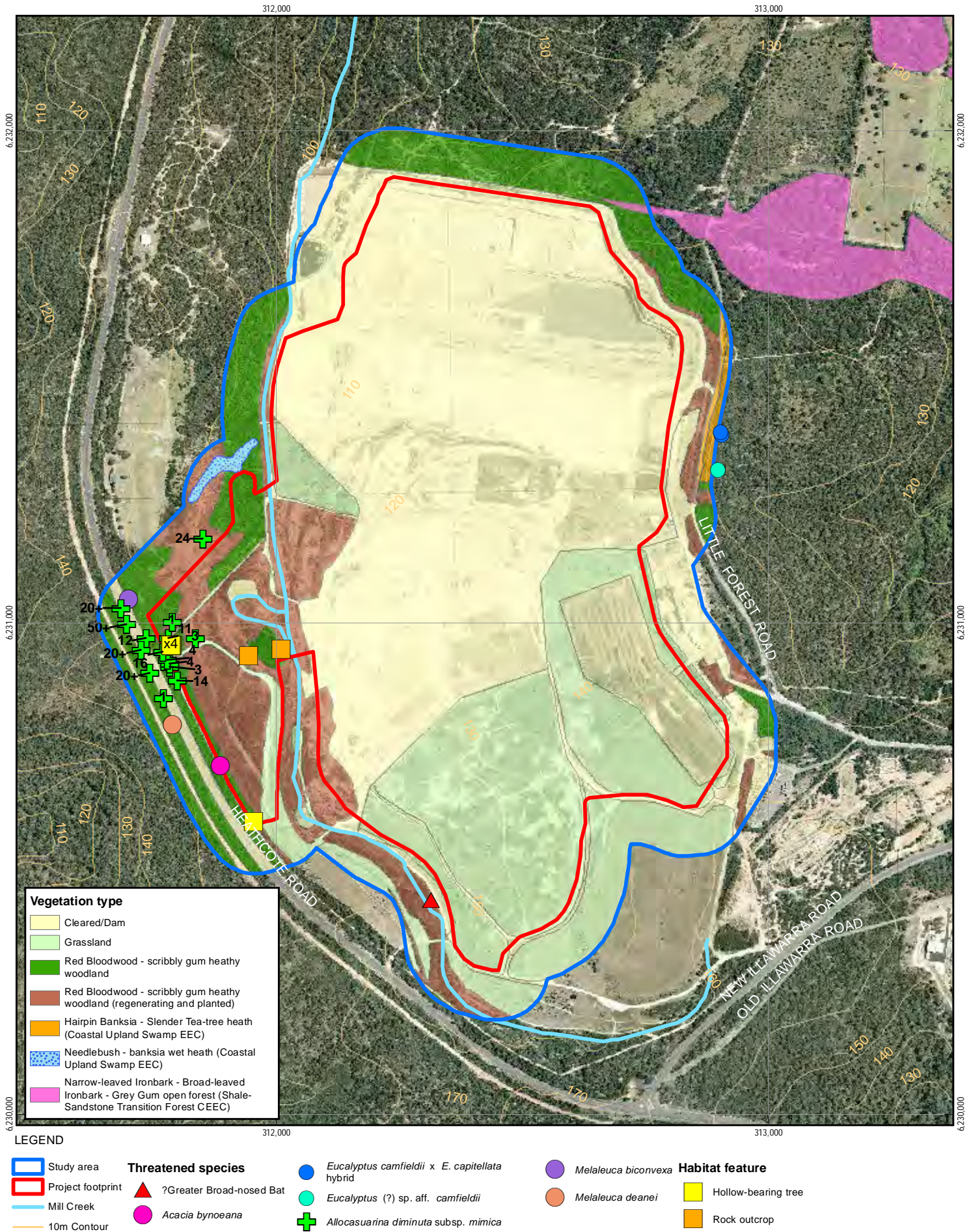
The protected matters search (DotE 2014b) identified one National Heritage Place and Wetland of International Importance in the locality. The National Heritage Place is not relevant to this biodiversity assessment report. Towra Point Wetland is located in Botany Bay. Botany Bay is within the same catchment as the study area and is located 20km downstream of the site on the Kurnell Peninsula. Towra Point Wetland is unlikely to be impacted by the proposal due to its distance from the proposal and appropriate environmental management measures will be implemented to protect water quality in Mill Creek. These additional MNES are not considered further in this report.

Table 4.6 Likelihood of occurrence of threatened fauna species in the proposal footprint

Common Name	Scientific Name	TSC Act Status	EPBC Act Status	Likelihood of Occurrence/Habitat in the proposal footprint
MAMMALS				
Eastern Pygmy-possum	<i>Cercartetus nanus</i>	V		Likely. Suitable foraging and nesting habitat present in native vegetation in the proposal footprint.
Koala	<i>Phascolarctos cinereus</i>	V	V	Possible. Poor quality foraging habitat present only. No primary feed trees present. Occasional secondary feed trees are present. May forage in the proposal footprint on occasion when moving between other areas of better quality habitat. Unlikely to breed in the proposal footprint. Proposal footprint is not considered an important habitat area for the Koala. No habitat critical for the survival of the species is present in the proposal footprint.
Spotted-tailed Quoll	<i>Dasyurus maculatus</i>	V	E	Possible. May utilise the project footprint for dispersal and foraging. Two small rock outcrops and fallen timber are present, representing potential den habitat. The rock outcrops appear to be currently used by foxes and are thus unlikely to be den sites for the Spotted-tailed Quoll. Tree hollows present are very small (~5cm diameter) and are not suitable denning habitat. No moist forest (preferred habitat) present. A range of prey species, including the Common Ringtail Possum, are present.
Grey-headed Flying-fox	<i>Pteropus poliocephalus</i>	V	V	Likely. Would forage in flowering eucalypts on occasion.
Eastern Bentwing Bat	<i>Miniopterus schreibersii oceanensis</i>	V		Possibly recorded. Could forage in native vegetation and cleared areas within the proposal footprint. Suitable roosting habitat not present. Preferred breeding habitat includes caves, culverts and buildings.
Eastern False Pipistrelle	<i>Falsistrellus tasmaniensis</i>	V		Possible. May forage on occasion in native vegetation within the proposal footprint. No suitable roosting habitat present. Prefers tall moist forest for foraging and breeding which is not present in the proposal footprint.
Eastern Freetail-bat	<i>Mormopterus norfolkensis</i>	V		Likely. May forage on occasion in native vegetation within the proposal footprint. May roost/breed in hollow-bearing trees in the study area, although hollows present are very small.
Greater Broad-nosed Bat	<i>Scoteanax rueppellii</i>	V		Likely. Could forage in native vegetation and cleared areas within the proposal footprint. May roost/breed in hollow-bearing trees in the study area, although hollows present are very small.
Large-eared Pied Bat	<i>Chalinolobus dwyeri</i>	V	V	Possible. Limited suitable forested foraging habitat present. No breeding habitat (sandstone caves and crevices) present.

Common Name	Scientific Name	TSC Act Status	EPBC Act Status	Likelihood of Occurrence/Habitat in the proposal footprint
Large-footed Myotis	<i>Myotis macropus</i>	V		Likely. May forage above dams and Mill Creek on occasion. Suitable roosting habitat not present. Preferred roosting habitat includes caves, culverts and bridges.
Little Bentwing Bat	<i>Miniopterus australis</i>	V		Likely. May forage on occasion in native vegetation within the proposal footprint. No suitable roosting habitat present. Preferred roosting habitat includes caves, culverts and buildings.
Yellow-bellied Sheath-tail-bat	<i>Saccolaimus flaviventris</i>	V		Likely. Could forage in native vegetation and cleared areas within the proposal footprint. May roost/breed in hollow-bearing trees in the study area, although hollows present are very small.
BIRDS				
Black-chinned Honeyeater	<i>Melithreptus gularis gularis</i>	V		Likely. May forage on occasion in the proposal footprint. Unlikely to breed in the proposal footprint due to disturbed nature of the vegetation.
Flame Robin	<i>Petroica phoenicea</i>	V		Possible. May forage in the proposal footprint on occasion. Preferred breeding habitat not present.
Gang-gang Cockatoo	<i>Callocephalon fimbriatum</i>	V		Likely. Could forage in the study area on occasion. No breeding habitat present in the proposal footprint.
Glossy Black-Cockatoo	<i>Calyptorhynchus lathami</i>	V		Likely. Could forage in the study area on occasion. No breeding habitat present in the proposal footprint.
Little Eagle	<i>Hieraaetus morphnoides</i>	V		Possible. May forage on occasion in the study area. No breeding habitat (tall trees) present in the proposal footprint.
Little Lorikeet	<i>Glossopsitta pusilla</i>	V		Possible. May occur on occasion, although previous clearing may have reduced structural complexity required for this species. Good quality habitat present in adjacent areas. No breeding habitat present in the proposal footprint.
Masked Owl	<i>Tyto novaehollandiae</i>			Possible. May forage on occasion in the study area. No breeding habitat present.
Powerful Owl	<i>Ninox strenua</i>	V		Likely. Could forage in the study area on occasion. No breeding habitat present in the proposal footprint.
Scarlet Robin	<i>Petroica boodang</i>	V		Possible. May forage in the proposal footprint on occasion. Preferred breeding habitat not present.
Square-tailed Kite	<i>Lophoictinia isura</i>	V		Possible. May forage on occasion in the study area. No breeding habitat (tall trees) present in the proposal footprint.
E	<i>Lathamus discolor</i>	V		Possible. May forage on occasion in the study area. <i>Corymbia gummifera</i> , a preferred forage species, is the dominant eucalypt in the

Common Name	Scientific Name	TSC Act Status	EPBC Act Status	Likelihood of Occurrence/Habitat in the proposal footprint
				proposal footprint. Does not breed on the Australian mainland. Few local records.
Varied Sittella	<i>Daphoenositta chrysoptera</i>	V		Possible. May occur on occasion, although previous clearing may have reduced structural complexity required for this species. Good quality habitat present in adjacent areas.
REPTILES				
Rosenberg's Goanna	<i>Varanus rosenbergi</i>	V		Possible. Potential foraging and breeding habitat present in the proposal footprint. No evidence of the species during camera surveys or previous trapping surveys (GHD 2011).
FROGS				
E	<i>Heleioporus australiacus</i>	E	V	Possible. May shelter in woodland habitat and along riparian zone. May breed in swamps and ephemerals pools along Mill Creek, although previous and ongoing disturbance may have reduced habitat quality for the species. A previous record exists in the study area (OEH 2014). Not recorded during targeted survey in appropriate conditions.
Red-crowned Toadlet	<i>Pseudophryne australis</i>	V		Unlikely. Few ephemeral streams present in the proposal footprint. This species requires unpolluted water between 5.5 and 6.5 pH. The pH levels recorded along Mill Creek make this waterway unsuitable for this species.



5. Impact assessment

5.1 Construction and operation of the proposal

5.1.1 Direct impacts

Clearing of vegetation

The majority of the proposal is to be undertaken in areas which have previously been disturbed (see Figure 4.1). The landfill reprofiling will take place above the existing landfill. No potential habitat for threatened biota is present in this area. The construction of the ARRT and GO facilities, including construction of the access road and realignment of Mill Creek, would mainly occur in areas that are currently vegetated, but have previously been disturbed. Historical aerial photographs showed that the GO facility and ARRT facility area appeared vegetated in the earliest available photograph (1947) before being largely cleared of vegetation at some stage between 1947 and 1961. The GO facility and ARRT facility area remained predominantly cleared until the 1982 photograph where vegetation was observed. Mill Creek was previously located further to the east of the proposed GO facility and ARRT facility area, within the area currently occupied by the landfill. It was realigned to its present location in the late 1980s.

The proposal would directly affect up to 13.03 hectares of mainly regenerating Red Bloodwood - Scribbly Gum heathy woodland for the construction of the ARRT and GO facilities, access road and realignment of Mill Creek. Of this, only 2.55 hectares is in good condition. Due to the construction of these facilities, a small section of Mill Creek would be realigned. Details regarding the Mill Creek realignment involved as part of this proposal are described in Chapter 6 of the EIS main document.

There would be no direct impacts on any threatened ecological communities (TECs). The sediment pond adjacent to the ARRT facility is located about 6 metres from the Needlebush - Banksia wet heath on sandstone plateaux of the Sydney Basin (ME015) (Coastal Upland Swamp).

The proposal would remove one *Acacia bynoeana* individual (listed as an endangered species under the TSC Act and the EPBC Act) for construction of the ARRT and GO facilities (see Figure 4.1). This individual was inspected during the March 2015 survey and was found to be mostly necrotic, despite the protection of fencing. No other individuals were recorded in the proposal footprint.

The proposal would remove up to 58 ramets of *Allocasuarina diminuta* subsp. *mimica* (listed as an endangered population under the TSC Act) for construction of the ARRT and GO facilities (see Figure 4.1). Further assessment of impacts on this endangered population are provided in section 7.4.3.

The proposal would not directly impact any individuals of *Eucalyptus camfieldii*, *Melaleuca deanei* or *Melaleuca biconvexa* recorded outside the proposal footprint. No individuals were recorded in the proposal footprint despite targeted surveys. No other threatened flora species are likely to occur within the proposal footprint given the historical clearing and disturbance, and lack of evidence of any individuals.

Table 5.1 Proposed removal of vegetation within the proposal footprint

Vegetation Community	PCT / NSW Veg. Type ID (OEHL, 2014d)	Condition	Area within the proposal footprint (ha)
Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux	ME014	Moderate/good	2.55
Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux (regenerating and planted)	ME014	Moderate/good (low)	10.48
Total native vegetation			13.03
Exotic grassland			26.68
Total vegetation			39.71
Cleared land			71.77
Total area			111.48

Note: Vegetation to be removed is inclusive of Asset Protection Zones (APZ).

A total of 13.03 hectares of remnant native and regrowth/planted native vegetation would be removed within the proposal footprint. This reduction in the extent of native vegetation in the locality would not threaten the persistence of local populations of native plants. The proposal would remove a small number of individuals of plant species. Flora populations would persist within adjoining areas of alternative habitat outside the site. This reduction in extent is also highly unlikely to affect the viability of remnant vegetation in the study area or locality or reduce the extent of habitat below a minimum size required for any fauna species. Further, much of the vegetation is disturbed, and has a much lower diversity than the adjacent intact native vegetation.

Construction within the remainder of the site would remove non-threatened native plants and noxious and environmental weeds within highly modified habitat that does not support a native vegetation community.

Removal of habitat resources

The proposal footprint provides habitat resources for native fauna species and contains mainly foraging and shelter resources for common native fauna. The 13.03 ha of native vegetation that would be removed provides foraging, breeding, roosting and nesting resources for a range of fauna species, including threatened species. Eucalypts and other native canopy species would provide nectar resources as well as foraging substrate for a diverse range of arboreal species, such as birds, reptiles (varanids), arboreal mammals and bats. The magnitude of impact is likely to be low given extensive areas of similar habitat in surrounding protected areas.

The proposal would remove five hollow-bearing trees containing very small hollows (~ 5cm diameter). These may be utilised by mammal species such as the Eastern Pygmy Possum and Sugar Glider and some microbat species, as well as tree frogs. The removal of these trees within the construction footprint is unlikely to comprise the removal of a significant proportion of the total resource, such that any local populations of fauna would experience significant negative impacts, given the expansive tracts of vegetation containing hollow-bearing trees that are present in the locality.

The proposal would remove fallen logs and rock outcrops, and termite mounds, which represent potential den habitat for the Spotted-tailed Quoll and potential nest sites for Rosenberg's Goanna, respectively. The removal of vegetation would also lead to the loss of potential foraging habitat for these and other ground-dwelling species.

The realignment of Mill Creek would result in the loss of riparian, stream and dam habitat for a range of frog, reptile and macroinvertebrate species. This potentially includes the loss of breeding habitat for the Giant Burrowing Frog, although this habitat is likely to be suboptimal, given the surrounding disturbance.

The proposal would also involve the removal of 26.68 ha of exotic grassland, which provides foraging habitat for common birds and mammals, as well as shelter and foraging habitat for reptiles and frogs.

Fauna injury and mortality

As described above, the proposal footprint provides habitat resources for native fauna species and would contain mainly foraging and shelter resources for common native fauna. Ringtail Possums are present, and some common bird species may also nest in native vegetation. Groundcover vegetation, leaf litter and woody debris would provide shelter and foraging substrate for mammals (such as bandicoots), reptiles, frogs and invertebrates. Construction is likely to result in the injury or mortality of some individuals of these less mobile fauna species and other small terrestrial fauna that may be sheltering in vegetation within the proposal footprint during clearing activities. There are few hollow-bearing trees in the proposal footprint, and hollows are very small, which reduces the risk of injury or mortality of larger arboreal mammals or hollow-nesting birds. Alternative habitat resources and refuge from construction activities is available in native vegetation adjoining the site. The potential injury or mortality of individuals within a maximum of 39.71 hectares of habitat (including 26.68 ha of exotic grassland), is highly unlikely to affect an ecologically significant proportion of any local populations. More mobile native fauna such as native birds, bats, terrestrial and arboreal mammals that may be sheltering in vegetation in the proposal footprint are likely to evade injury during construction activities by moving into adjacent areas of habitat. However, displaced individuals may suffer stress, increased energy costs or increased risk of predation.

Recommendations have been made in Section 6.3 to minimise the risk of vegetation clearing activities resulting in the injury or mortality of resident fauna.

Fragmentation or isolation of habitat

The removal of native vegetation would occur to the west of the existing cleared landfill. There would be no isolation of habitat as a result of the proposal. A narrow band of vegetation (up to 10m wide) would remain along the road reserve of Heathcote Road. This would connect to the existing narrow band of vegetation to the south of the study area along Heathcote Road. Large expanses of vegetation occur on the western side of Heathcote Road. There would be negligible impact on the movement of mobile species such as the Grey-headed Flying-fox and Swift Parrot. Koalas may utilise the road the road reserve on occasion for dispersal. There would be no isolation of habitat for these species as a result of the proposal. The realignment of Mill Creek would allow continued connectivity along the creekline. Giant Burrowing Frog (if present) would be able to continue to move along Mill Creek, although the unnatural creek bed and bank downstream of the proposed ARRT facility may limit this movement. Fish passage is already interrupted by pipes and weirs in the study area. A narrow band of riparian vegetation along Mill Creek would continue to link vegetation to the north with vegetation to the south, although regeneration of riparian vegetation may take time.

Aquatic habitats

The proposal would remove a section of the previously realigned Mill Creek and a dam. Mill Creek is already highly modified through previous realignment and disturbance. These aquatic habitats are not potential habitat for threatened fish or dragonflies and are not classified as Key Fish Habitat (see section 4.2.7). Indirect impacts may include the disturbance of large woody

debris, and changes to water quality downstream of realignment works. Note that Mill Creek immediately downstream of the proposed ARRT facility has an unnatural bed and bank and has limited aquatic habitats present. Once outside the LHRRP Mill Creek reverts to a natural creek.

5.1.2 Indirect and operational impacts

Weed invasion and edge effects

'Edge effects' refers to factors including increased noise and light, weed invasion, tree failure or erosion and sedimentation at the interface of intact vegetation and cleared areas. Edge effects may result in impacts such as changes to vegetation type and structure, increased growth of exotic plants, increased predation of native fauna or avoidance of habitat by native fauna. Edge effects would result from construction activities and then continue to affect vegetation and habitats adjoining the proposal footprint.

Altered environmental conditions along new edges can allow invasion by pest animals specialising in edge habitats and/or change the behaviour of resident animals. Edge zones can be subject to higher levels of predation by introduced mammalian predators and native avian predators. Edge effects have mainly been recorded adjacent to roads and at distances greater than 1,000 metres from the road surface (Forman et al. 2000). However, Bali (2005), in a comparison of edge effects in a variety of different habitat types, estimated that average edge effects generally occur up to 50 metres away from the road edge.

The impacts of edge effects are visible across much of the western portion of the proposal footprint due to the presence of existing clearings for access tracks, as well as the adjoining landfill and Heathcote Road. Existing edge effects include light, noise, and weeds. The proposal would create a new edge around the proposed ARRT and GO facilities. Construction activities may, in general, increase the degree of weed infestation through dispersal of weed propagules (seeds, stems and flowers) into areas of native vegetation via erosion (wind and water), via workers shoes and clothing or through construction vehicles. The majority of the existing edge is already impacted by edge effects from Heathcote Road and disturbed areas within the SICTA area. The proposal is not likely to substantially increase the existing edge effects at this location.

There is potential for edge effects on Coastal Upland Swamp, as this is located about 6 m from the proposal at its closest. This small swamp is already subject to existing edge effects due to adjacent cleared areas to the west and east. The swamp may be impacted by erosion and sedimentation during construction due to the proximity of the construction area.

Shale-Sandstone Transition Forest is located near the existing landfill. No additional edge effects would occur in this location. Similarly, known individuals of *Eucalyptus camfieldii*, *Melaleuca deanei* and *Melaleuca biconvexa* are unlikely to be impacted due to the distance from the proposal footprint or the presence of existing edge effects.

Allocasuarina diminuta subsp. *mimica* in the study area was recorded in disturbed edges, including along tracks and the edges of Heathcote Road. The proposal would increase edge effects on the retained population within SICTA land and the adjacent individuals retained in the Heathcote Road reserve. This species likely benefits from disturbances, and possibly from increased light levels afforded along an edge, therefore it is possible that some edge effects are beneficial to the survival of *Allocasuarina diminuta* subsp. *mimica*.

Impacts from edge effects on wide-ranging species such as the Grey-headed Flying-fox, Swift Parrot and Spotted-tailed Quoll are unlikely due to the small area of impact, the already disturbed nature of much of the native vegetation, and the existing edge effects in adjacent areas. Edge effects may reduce the habitat quality in vegetation adjacent to newly cleared areas for smaller species such as the Eastern Pygmy-possum and Giant Burrowing Frog.

Given the level of existing disturbance, the proposal would have a minor impact on the degree of weed infestation in the study area. Recommendations have been made in Section 6.3 to minimise the spread of weeds.

Surface water

The major potential indirect impacts of the proposal relating to surface water include:

- The proposal includes a number of best practice erosion and sediment control measures to achieve compliance with the EPA's surface water discharge requirements. It is noted that discharge of sediment laden waters during large storms is unavoidable however the impact of such discharges is minimised through appropriate erosion and sediment control. Qualitative analysis of monitored downstream total suspended solids (TSS) concentrations suggests that the current operation of the LHRRP is not resulting in a significant impact to TSS levels in the downstream waterway. Mitigation measures are proposed in Section 4 in accordance with *Managing Urban Stormwater: Soils and Construction, Volume 1* (Landcom 2004) and *Managing Urban Stormwater, Soils and Construction, Volume 2b, Waste Landfills* (DECC 2008) which are expected to result in a further improvement in erosion and sediment control outcomes. Water actively managed for erosion and sediment control in the main sediment and water reuse basin will be treated and discharged off site in accordance with the quality limits applying to the facility (GHD 2015a). Impacts on downstream aquatic habitats are likely to be minimal.
- Increase in the peak rate of discharge from the site during flood events due to changing catchment conditions within the site. The resulting change in flood conditions could result in increasing flooding risks downstream. The results of the modelling show that the proposal will increase the peak flow rate discharged from the site by up to approximately 1%. This level of increase is not expected to have a significant effect on downstream flood conditions, particularly considering that additional runoff from adjacent catchments begins entering Mill Creek immediately downstream of the site, further reducing the expected increase proportion of the total flows. The removal of the western sediment control and water reuse basin as a component of the GO/ARRT facilities construction is not expected to have a significant impact on peak flow rates or velocities in the downstream waterway as this dam is currently regularly full and overflowing and in its current state it provides minimal flood protection through detention storage (GHD 2015a).
- Discharge of leachate. The total quantity of leachate stored within the landfill is kept to a minimum through extraction, storage in dedicated leachate ponds and treatment for discharge to sewer. In areas to be re-profiled, the existing cover and capping system will be stripped to promote leachate percolation from the new waste into the existing waste and to the existing leachate collection system. The GO / ARRT facilities and leachate ponds are not expected to be inundated during the 100-year ARI event. As such, the proposal is not expected to result in unacceptable flood risk from water inundating these facilities (GHD 2015a). Downstream aquatic and terrestrial habitats are unlikely to be negatively impacted by discharge of leachate.
- Reduction in surface water reaching adjacent vegetation through reduction in catchment area as a result of clearing of vegetation for construction of facilities. The construction of the ARRT and GO facilities will slightly reduce the catchment area of the tributary of Mill Creek located in the SICTA area to the north of these facilities. The majority of the catchment of this swamp is located to the west, with only a small area to the south contributing to its water levels. There would be no change in surface runoff to the east of the landfill, as these areas are already impacted by the existing landfill.

The Coastal Upland Swamp located about 6 m downslope of the detention pond that will be located north of the ARRT facility may be indirectly impacted by changes to water regimes. The majority of the catchment of this swamp is located to the west, and would not be impacted by the proposal. There would be a small reduction in water flow from the south due to the construction of the ARRT facility and detention pond. The risk of overflow from the adjacent detention pond is very low. Water balance modelling carried out for various meteorological conditions found that overflow is not expected (GHD 2015c). The Coastal Upland Swamp located to the east of the landfill is unlikely to be impacted by the proposal, as the existing landfill would have already impacted surface flow in this location.

A narrow strip of the critically endangered Shale-Sandstone Transition Forest is located to the north-east of the existing landfill. The majority of the stand is located over 200 metres from the proposal footprint. This community is unlikely to be impacted by changes to water regimes. Stands of Red Bloodwood - Scribbly Gum heathy woodland are located between the proposal footprint and much of this TEC. The existing landfill would have already impacted surface flow to this CEEC. Additional impacts from construction are unlikely. The perimeter drain would prevent contamination from leachate reaching this community following reprofiling.

Indirect impacts on *Melaleuca deanei*, *Melaleuca biconvexa* or *Eucalyptus camfieldii* are unlikely due to the distance between these individuals and the proposal. *Melaleuca deanei* individuals are located about 200 m from the proposal footprint to the south and east, and on the opposite side of Heathcote Road. One *Melaleuca biconvexa* is located in the Heathcote Road reserve about 50 m from the proposal boundary. *Eucalyptus camfieldii* individuals are located about 100 m from the proposal footprint.

Aquatic disturbance

The aquatic ecosystem assessment (GHD 2015d) assessed the magnitude and extent of any impacts on Mill Creek resulting from the existing operations at the LHRRP. The assessment found that while the LHRRP may be having an influence on the aquatic and riparian habitat, the water quality and macroinvertebrate communities are only showing minimal signs of impairment. It also found that the recovery of habitat condition at the downstream site suggests that any impacts are spatially limited and decrease with distance.(see section 4.2.7).

The introduction of pollutants and sediments from the proposal footprint into the surrounding environment, if uncontrolled, could potentially impact on water quality and aquatic habitats. The potential for water quality impacts on Mill Creek outside the proposal footprint are likely to continue to be low, as discussed above in the assessment of surface water impacts. Potential water quality impacts during construction would be managed through the implementation of mitigation measures, including the provision of sedimentation basins, silt fences and other structures to intercept runoff. The existing dirty water drain diverts dirty water away from Mill Creek to treatment ponds. This would be extended as required during reprofiling of the landfill. There would be complete containment of leachate from the landfill, GO and ARRT facilities, which would exclude this leachate from the surface water system water that is able to be discharged off-site. The proposed staging for reprofiling the landfill will progressively cap and revegetate areas which are currently not capped and revegetated. The cap will consist of a low permeability compacted clay layer (or an EPA approved alternative) which will reduce the generation of leachate through reduced rainfall infiltration and the ability to more effectively shed surface water off the site. These actions will also reduce the potential risk of leachate entering surface water and being discharged off-site (GHD 2015b).

Based on the details above, and the limited impacts the existing LHRRP is currently having on downstream environments, the proposal is likely to have a minor impact on aquatic habitats within the immediate area only. There would be no impact on Key Fish Habitat as a result of the proposal. No endangered aquatic communities, aquatic fauna or marine vegetation listed under

the FM Act or EPBC Act occur in the study area and no significant impacts on riparian vegetation or habitats downstream of the proposal footprint are anticipated as a result of the proposal.

Groundwater impacts

As discussed in section 4.2.4, vegetation within the proposal footprint and adjacent areas is likely to be groundwater dependent to some degree. In particular, Coastal Upland Swamps located outside the proposal footprint are highly likely to be groundwater dependent. The impacts to sub-surface groundwater dependent ecosystems (vegetation communities) and the potential groundwater inflow dependent ecosystems (such as Mill Creek, Deadmans Creek and Woronora River) due to operation of the ARRT and GO facilities are expected to be localised and minor. The reasons for this conclusion are discussed below.

The construction of the new ARRT facility and detention pond and the relocation of the GO facility would involve excavation works but these works are not expected at depths that would intercept groundwater. 1992 data for BH07 located near to the proposed ARRT and GO site and surrounding wells suggests that the flow direction is generally eastward toward Mill Creek. Given that this site is located near to the top of a ridgeline and that there is no groundwater elevation data further to the west, groundwater flow could quite plausibly be to the west toward Deadmans Creek (GHD 2015b). As such, the Coastal Upland Swamp located north of the proposed ARRT facility is unlikely to be impacted by construction in this area.

A reduction in groundwater infiltration associated with the facility will reduce groundwater elevations locally within the vicinity of Mill Creek and potentially reduce baseflow to these creeks. This could subsequently impact GDEs and aquatic ecosystems in these creeks. Impacts are likely to be negligible as the size of the ARRT and GO facilities relative to the Mill Creek and Deadmans Creek Catchments is negligible. Flows in Mill Creek appear to be intermittent, which suggests that there is a low reliance on groundwater inflow for flow maintenance. While there are pools present that may be reliant on surrounding groundwater it is unlikely that the project will result in groundwater elevation reduction below the base of the creek systems, especially downslope of the site where instream ecosystems are less disturbed and the stream bed is lower than the minimum elevations of the landfill. Given the presence of downward hydraulic gradients created by very low permeability lithological units in this area, it is not expected that groundwater elevations will change substantially, however, localised/isolated flow reductions to seeps and stream baseflow may occur (GHD 2015b). These localised flow reductions are likely to have a negligible impact on any downstream GDEs.

Once in operation the ARRT facility will potentially have infrastructure that could have the following interactions with groundwater (GHD 2015b):

- Infiltration of dirty waste streams into the underlying groundwater systems. This could occur via leakage to groundwater through the waste collection and treatment scheme. This may primarily occur in areas of waste storage such as detention basins and leachate ponds. It is expected that all these systems will be lined with impermeable infrastructure.
- Reduction in groundwater recharge associated with the emplacement of impermeable surfaces such as buildings and impermeable surfaces for processing waste. This may result in a decrease in groundwater elevations beneath the site.

The migration of impacts to underlying groundwater during both construction and operation could result in impacts to GDEs and aquatic ecosystems present downstream of the project within Deadmans Creek or Mill Creek (GHD 2015b). Impacts are expected to be negligible as the ARRT waste stream will be impermeable and sealed and will prevent migration to groundwater.

The existing landfill footprint is unlikely to change. Excavation of the site historically would have already impacted groundwater in the vicinity. Water quality data suggests that there is a limited hydraulic connection between the landfill and underlying groundwater, which therefore suggests changes in leachate generation, will not result in significant changes to groundwater discharge to creeks and groundwater elevations near potentially dependent vegetation further downslope.

The geometry of the current approved final landform in places allows ponding of rainwater, increases the potential for increased infiltration into the waste and results in additional leachate generation. The proposed re-profiling of the landform would reduce the potential for rainfall infiltration and thereby reduce leachate generation. The intention is to further reduce the potential risk of leachate impacting on groundwater at the site. Leachate is unlikely to impact GDEs downstream of the proposal footprint.

Post closure, the potential for degradation of groundwater quality by site activities would be negligible as potentially contaminating site activities would no longer be taking place. Any reduction in infiltration rates to groundwater and associated impacts would be less than or similar to those that will be incurred during operation when rainfall and surface water management systems on the site are in place (GHD 2015b).

Pests and pathogens

Construction activities within the proposal footprint have the potential to introduce or spread pathogens such as Phytophthora (*Phytophthora cinnamomi*), Myrtle Rust (*Uredo rangelii*) and Chytrid fungus (*Batrachochytrium dendrobatidis*) into adjacent native vegetation through vegetation disturbance and increased visitation. There is little available information about the distribution of these pathogens within the locality, and no evidence of these pathogens was observed during surveys. Phytophthora and Myrtle Rust may result in the dieback or modification of native vegetation and damage to fauna habitats. Chytrid fungus affects both tadpoles and adult frogs and can cause 100% mortality in some populations once introduced into an area.

Mitigation measures would be included in the CEMP to prevent the introduction or spread of disease that could potentially impact threatened biota in the study area (see Section 6.3).

Dust generation

Dust as a result of wind and vehicle movement may currently affect native vegetation located adjacent to the existing landfill, however there was little evidence of dust in adjacent vegetation. Dust is likely to be generated during clearing and construction activities. High dust levels could reduce habitat quality for flora and fauna species by reducing plant and animal health in areas of retained vegetation. The proposal would include paved roads and buildings, thus generation of dust would be minimised. Some dust transfer could occur during reprofiling of the landfill.

Mitigation measures would be included in the CEMP to minimise impacts of dust (section 7). Dust is unlikely to substantially impact habitat for any threatened biota due to the mitigation measures proposed.

Noise

There would be noise impacts during the construction and operation phases as a result of vegetation clearing, the movement of vehicles and operation of plant. The proposal footprint currently experiences ongoing noise from vehicles travelling along Heathcote Road, and from the activities in the landfill. There is the potential for individuals that nest in trees that are close to the proposal edge abandoning their nests as a result of noise during construction and operation. Noise may also affect general fauna activity in these areas. Given the existing noise

levels in the vicinity of the proposal, any localised and temporary increase in noise levels during the construction activities are unlikely to substantially impact on native biota.

Vibration

Vibration impacts may result from works associated with the proposal, such as heavy vehicle movement and construction and operational activities. Vibration may deter native fauna from using the area surrounding the source of vibration. This may potentially interrupt dispersal within the locality if an individual is unwilling to travel through an area where vibration is detectable, or may cause some species to abandon an area in search of areas where vibration is not detectable.

Within the proposal footprint, some level of vibration is already present as a result of vehicles travelling along Heathcote Road and within the adjacent landfill. The proposal has the potential to increase vibration throughout the proposal footprint and adjacent areas during construction. Impacts would be localised and temporary during construction. No works would be conducted at night, and thus construction is unlikely to impact the behaviour of nocturnal fauna.

5.2 Cumulative impacts

The proposal would increase the extent of vegetation clearing in the locality, and increase the removal of habitats for flora and fauna species, including threatened species. Other developments in the locality would also lead to a reduction in vegetation and habitats available. One large development is currently proposed north of the LHRRP at Heathcote Ridge. This is described below.

The Gandangara Local Aboriginal Land Council (GALC) is proposing a development at Heathcote Ridge in the West Menai area. This proposal has not yet been assessed under NSW legislation, although a strategic assessment (Cumberland Ecology 2012) has been approved by the Commonwealth. As such, the status of this proposal is not known. The Heathcote Ridge site contains 849 ha of mostly undeveloped land, covering parts of Menai, Barden Ridge and Lucas Heights. The site is currently zoned '1(b) Rural (Future Urban)' under the Sutherland Shire LEP 2000. The western boundary of the proposed development is Heathcote Road and the site extends east across Mill Creek to the edge of the existing Menai residential area close to New Illawarra Road. The southern boundary of this development is located about 1 km to north of the proposal footprint.

The GALC is seeking to list the Heathcote Ridge site as a State Significant Site and rezone the land to allow for:

- 566 ha of conservation land
- 182.7 ha of residential land, proposed to accommodate approximately 2,400 dwellings
- 51.4 ha of employment land, proposed to provide up to 4,700 jobs
- 17.2 ha of sports fields and other open space
- New roads, bridges and community facilities.

This proposal is currently being assessed by the Department of Planning and Environment and would have the following impacts on biodiversity values (Cumberland Ecology 2012):

- Translocation of 21 individuals of *Acacia bynoeana*. Approximately 51.24ha of suitable habitat, including seven known individuals, will be conserved within the project area.
- Removal of potential habitat for a range of flora and fauna species. Up to 566 ha of potential habitat will be conserved within the conservation land.

In addition, 78% of the vegetation type containing the endangered population of *Allocasuarina diminuta* subsp. *mimica* at this site would be lost (Graham, B. in NSW Scientific Committee 2014).

The Heathcote Ridge development would impact similar vegetation types to those present in the proposal footprint being assessed in this Biodiversity Assessment Report, further reducing habitats available for flora and fauna in the area. In particular, as highlighted above, it would also result in the loss of individuals of the threatened flora species *Acacia bynoeana* and *Allocasuarina diminuta* subsp. *Mimica*, and would further remove habitat for a range of threatened fauna species, if approved.

5.3 Key threatening processes

A key threatening process (KTP) is defined in the TSC Act (DEC 2005) as an action, activity or proposal that:

- Adversely affects two or more threatened species, populations or ecological communities
- Could cause species, populations or ecological communities that are not currently threatened to become threatened.

There are currently 38 KTPs listed under the TSC Act and eight listed under the FM Act. A number of KTPs are listed under more than one Act. Those potentially relevant to this proposal are listed in Table 5.2 below. Mitigation measures to limit the impacts of these KTPs are discussed in Chapter 6.

Table 5.2 Key Threatening Processes of relevance to the proposal

KTP	Status	Comment
Clearing of native vegetation	TSC Act EPBC Act	The proposal includes the clearing of 13.03 hectares of native vegetation, much of which is disturbed from previous clearing. Vast areas of intact native vegetation are present in the locality. This minor reduction in extent is highly unlikely to affect the viability of remnant vegetation in the study area or locality or reduce the extent of habitat below a minimum size required for any fauna species. The implementation of vegetation management procedures is recommended to limit impacts on vegetation (see Section 6.3.1).
Clearing of hollow-bearing trees	TSC Act	A low number of trees with suitable hollows for small birds or mammals are likely to be removed by the proposal. No large hollows suitable for species such as cockatoos and forest owls will be removed. The implementation of habitat management procedures is recommended to limit impacts on fauna and their habitats (see Section 6.3.1).
Removal of dead wood and dead trees	TSC Act	The proposal footprint contains areas of fallen timber. The proposal will result in the removal of this timber during construction of the proposal. The implementation of habitat management procedures is recommended to limit impacts on fauna and their habitats (see Section 6.3.1).
Invasion of plant communities by perennial exotic grasses	TSC Act	The proposal footprint features large areas of exotic grassland. There is the potential for perennial exotic grasses to invade adjacent native vegetation through disturbance during construction of the proposal and a shift of the disturbed edge into intact native vegetation. The proposal would include environmental management measures, including weed management and specific consideration of potential impacts on soil, water and native vegetation (see Section 6.3.1).
Infection of native plants	TSC Act;	Construction activities have the potential to introduce

KTP	Status	Comment
by <i>Phytophthora cinnamomi</i>	EPBC Act	Phytophthora into the study area, through the transport and movement of plant, machinery and vehicles, as well as through any landscaping works following construction. The proposal would include environmental management measures, including specific consideration of measures to reduce potential impacts on soil, water and native vegetation (see Section 6.3.1).
Introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae	TSC Act	Construction activities have the potential to introduce Myrtle Rust to the study area. The proposal would include environmental management measures, including specific consideration of measures to reduce potential impacts on soil, water and native vegetation (see Section 6.3.1).
Infection of frogs by amphibian chytrid causing the disease chytridiomycosis	TSC Act; EPBC Act	Construction activities have the potential to introduce amphibian chytrid to the study area, which could lead to death of local frogs. The proposal would include environmental management measures including specific consideration of measures to reduce potential impacts on soil, water and native vegetation (see Section 6.3.1).
The degradation of native riparian vegetation along NSW water courses	FM Act	The proposal will require the realignment of a section of Mill Creek, which was previously realigned for the existing landfill. Realignment and construction activities could have indirect impacts on riparian vegetation downstream of the study area. Mitigation measures are recommended to limit the potential for adverse impacts on riparian vegetation (see Section 6.3.1).
The removal of large woody debris from NSW rivers and streams	FM Act	The realignment of a section of Mill Creek may result in the disturbance of large woody debris, although few large snags were observed in this section of the creek. Removal of large woody debris could reduce habitat for aquatic fauna. Any woody debris present in the section to be removed should be relocated to the newly aligned section to maintain habitat values for aquatic fauna (see Section 6.3.1).
Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands	TSC Act; FM Act	The hydrology of the study area is already substantially modified by the existing landfill and previous realignment of Mill Creek. The proposal would realign a section of this creek. The proposal would alter the natural landform through placement of fill, increase the proportion of hardstand surfaces in the study area and modify surface water flows. Mitigation measures are recommended to limit the potential for adverse impacts on aquatic habitats (see Section 6.3.1).
Human-caused climate change	TSC Act EPBC Act	Combustion of fuels associated with construction and operation of the proposal would contribute to anthropogenic emissions of greenhouse gases. Operational emission sources include fuel consumption by vehicles, fugitive emissions from the waste disposal area, the collection and combustion of biogas and electricity imported from the grid. The increase in greenhouse gases could impact average temperatures, rainfall patterns and bushfires, which can impact vegetation and habitats for flora and fauna.

5.4 Impacts on threatened biota listed under NSW legislation

5.4.1 Direct impacts

The proposal may result in direct and indirect impacts on threatened biota listed under the TSC Act, including the removal of one individual of *Acacia bynoeana*, up to 58 ramets of *Allocasuarina diminuta* subsp. *minica*, and potential habitat for a range of fauna species (see section 5.1). There would be no direct impact on any threatened ecological communities.

Impacts on threatened biota listed under the TSC Act have been assessed through the FBA calculations included in Chapter 7.

No aquatic threatened biota listed under the FM Act or their habitats are likely to occur in the study area or to be affected by the proposal.

5.4.2 Indirect impacts on threatened biota located outside the proposal footprint

Threatened ecological communities

The proposal could indirectly impact the small Coastal Upland Swamp located about 40 m downslope of the detention pond that will be located north of the ARRT facility. The proposal has the potential to change water regimes of this swamp. The majority of the catchment of this swamp is located to the west, and would not be impacted by the proposal. There would be a small reduction in water flow from the south due to the construction of the ARRT facility. This is not likely to substantially change the species composition or extent of this community. The Coastal Upland Swamp located to the east of the landfill is unlikely to be impacted by the proposal. The existing landfill is likely to have already impacted surface and groundwater flow in this location. Given the distance between the boundary and this vegetation (about 50m), further impacts from reprofiling are unlikely.

A narrow strip of the critically endangered Shale-Sandstone Transition Forest is located to the north-east of the existing landfill, outside the proposal footprint. The majority of the stand is located over 200 metres from the proposal footprint. This community is unlikely to be indirectly impacted by changes to water regimes. Stands of Red Bloodwood - Scribbly Gum heathy woodland are located between the proposal footprint and much of this TEC. The existing landfill would have already impacted surface and groundwater flow to this CEEC. Additional impacts from construction are unlikely. The final re-profiling of the landfill may again allow surface water flow to this area, as the land surface would be reprofiled to a more natural position.

Threatened flora species and populations

No individuals of *Acacia bynoeana* were recorded in the study area outside the proposal footprint. The loss of one individual is not likely to indirectly impact the population in the locality through changes to pollination or genetic diversity. Changes to edges and water flows are not likely to impact the population in the locality given the distance between known individuals and the proposal boundary.

Indirect impacts on *Melaleuca deanei*, *Melaleuca biconvexa* or *Eucalyptus camfieldii* are unlikely due to the distance between these individuals and the proposal. *Melaleuca deanei* individuals are located about 200 m from the proposal footprint to the south and east, and on the opposite side of Heathcote Road. One *Melaleuca biconvexa* is located in the Heathcote Road reserve about 50 m from the proposal boundary. *Eucalyptus camfieldii* individuals are located about 100 m from the proposal footprint.

The proposal would remove up to 58 ramets of *Allocasuarina diminuta* subsp. *mimica* (listed as an endangered population under the TSC Act) (see Figure 4.1). About 24 ramets would be

retained in SICTA land and about 120 ramets would be retained along Heathcote Road. A detailed assessment of direct and indirect impacts on this endangered population is provided in section 7.4.3.

Threatened fauna species

The Giant Burrowing Frog has previously been recorded along Mill Creek (OEH 2014a) south of where the GO facility is proposed to be located, and may forage and breed in the proposal footprint and adjacent areas. The Coastal Upland Swamp located to the north of the proposed ARRT facility, which is potential breeding habitat, may be indirectly impacted by changes to hydrology. There may be a small reduction of water catchment for the swamp, however the majority of this swamp's catchment would remain unaffected. This swamp has high levels of lead shot present from the adjacent clay target club, which may reduce habitat quality for this species. When lead shot is deposited on the soil, lead compounds are oxidised and released into the soil (Jorgensen and Willems 1987), where they become bioavailable for a range of flora and fauna within the ecosystem. Elevated lead levels in frogs is known to significantly affect the mortality of some species (Stansley et al 1997) and can inhibit the growth and development of frogs (Power et al 1989). Further research is required to assess the impacts of accumulated lead intake from shooting ranges on Australian frog species and specifically threatened species such as the Giant Burrowing Frog. Better quality habitat for the species is present outside the proposal footprint, in more intact vegetation and natural swamps and creeks. Direct impacts on potential habitat for this species in the proposal footprint have been assessed through the FBA calculations included in Chapter 7.

As discussed in section 5.1.2, the proposal may indirectly impact threatened fauna species through noise, vibration, and dust. Given the existing levels of these disturbances in the vicinity of the proposal, any increases during the construction activities are unlikely to substantially impact on threatened species.

5.5 Impacts on matters of national environmental significance

Potential impacts on matters of national environmental significance, including threatened and migratory biota, have been assessed via a referral for the proposal (GHD 2015b). The referral was assessed by the Department of the Environment. On 13 April 2015 a decision was recorded that the proposal is not a controlled action and that no further assessment and approval under the EPBC Act is required before it can proceed (EPBC Ref: 2015/7432). Since this decision was received, the proposed stormwater pond to the north of the ARRT facility has been extended to the north slightly, and the Commonwealth Department of the Environment was advised in writing and given opportunity to respond. To date, no further advice has been received to contradict this original ruling. As the changes to pond size and shape were minor, it is concluded that the proposal continues not to be considered a controlled action. Should this not be the case, and advice is received from the Department to this effect following or during exhibition of the EIS, this will be noted in the Submissions Report.

The majority of the study area is located within the existing landfill, and thus has minimal value for threatened or migratory biota listed under the EPBC Act. A small area of native vegetation (comprising 2.4 ha of good quality vegetation and 10.5 ha of regenerating and planted native vegetation) would need to be removed for the construction of the ARRT and re-profiling of the landfill. About 300 metres of Mill Creek would be removed for the realignment of the creek, which will be realigned along a shorter, more direct length. The proposal footprint provides known habitat for *Acacia bynoeana*, and potential habitat for the Grey-headed Flying-fox, Koala, Swift Parrot, Spotted-tailed Quoll, Giant Burrowing Frog and a number of migratory bird species listed under the EPBC Act. The area of vegetation to be removed is very small compared to large expanses of native vegetation present in the locality and given its small extent and

modified nature is not considered habitat critical to the survival of any local populations of these threatened species.

The proposal is not likely to impose a significant impact on any relevant matters of national environmental significance listed under the EPBC Act. Assessments of significance, according to the Significant Impact Guidelines 1.1 (DotE 2013) were prepared for the threatened and migratory biota listed above that are known or may occur in the proposal footprint and be impacted by the proposal and were included in the referral. The conclusion of these assessments was that the proposal would not significantly impact any of these biota.

6. Mitigation and management measures

6.1 Introduction

The general principle to minimise impacts to biodiversity, should in order of consideration, endeavour to:

- avoid impacts on habitat, through the planning process
- mitigate impacts on habitat, through the use of a range of mitigation measures
- offset any residual impact that can not be avoided or mitigated.

Impact avoidance and mitigation is discussed in sections 6.2 and 6.3. Offsets are discussed in section 8.

6.2 Avoidance of impacts

The proposal is largely contained within the existing landfill. The area proposed for the ARRT and GO facilities falls within land which has been previously modified by clearing. Impacts on native flora and fauna are substantially less than would be associated with an undisturbed 'green field' site. Development of the proposal layout was based on an initial constraints assessment of the site. The proponent has recognised the importance of retaining good quality native vegetation and known occurrences of threatened species where possible.

The key impact avoidance measures for the proposal include:

- Locating the footprint of the ARRT and GO facilities to the west of the existing landfill in vegetation that has been previously cleared and disturbed, and generally avoiding impacts on large stands of good quality vegetation.
- Locating access roads within already disturbed areas of the existing landfill.

Siting of construction compounds and other construction infrastructure in already cleared areas would also avoid impacts on native biodiversity values.

6.3 Mitigation of impacts

6.3.1 Construction

In order to address the potential impacts of the proposal on biodiversity as discussed in Chapter 5, the mitigation and management measures outlined in Table 6.1 would be implemented as part of the Construction Environment Management Plan (CEMP) for the site.

Table 6.1 Mitigation measures (construction)

Impact	Mitigation
General	<ul style="list-style-type: none">• Ensure all workers are provided an environmental induction prior to starting work on site. This would include information on the ecological values of the site, protection measures to be implemented to protect biodiversity and penalties for breaches.• Prepare a flora and fauna management sub-plan as part of the CEMP, incorporating recommendations below, and expanding where necessary.• Measures to suppress dust would be put in place during clearing, construction and operation.• Removal of lead shot in the SICTA area should be carried out prior to construction to ensure no additional lead shot enters adjacent vegetation, including the upland swamp.
Flora species	<ul style="list-style-type: none">• Collection of seeds of the <i>Acacia bynoeana</i> individual should be carried out in the appropriate season (September to January) prior to vegetation

Impact	Mitigation
	<p>clearing occurring. Seeds should be planted in the nursery and any individuals grown used for on site plantings. Propagation of all <i>Acacia</i> speices is from scarified seed or using boiling water treatment (Wrigley and Fagg 2007). Cuttings may also be an option for propagation.</p> <ul style="list-style-type: none"> • The <i>Acacia bynoeana</i> individual should be carefully removed and transferred to the on-site nursery. Soil adjacent to the individual should also be transferred as this species has little local dispersal of seed and presumably a long-term soil seed bank (Benson and Macdougall 1996). Efforts should be made to translocate this individual and soil to the on-site nursery for care before being replanted at the proposed offset site or other suitable location (see Section 8). The location of this proposed offset site will be discussed with OEH during the preparation of the offset strategy. • Collection of seeds and propagules of <i>Allocasuarina diminuta</i> subsp. <i>mimica</i> should be carried out in March prior to vegetation clearing occurring. Seeds should be planted in the nursery and any individuals grown used for on site plantings. Species of this genus can be propagated from seed (Wrigley and Fagg 2007). Preliminary seed collection was carried out in March 2015 by the on-site nursery staff. • Ramets of <i>Allocasuarina diminuta</i> subsp. <i>mimica</i> and associated soil should be collected prior to vegetation clearing and transferred to the on-site nursery for propogation and replanting. Replanting should be undertaken in areas that are not likely to be impacted by future development, including the proposed offset site. The location of the proposed offset site will be discussed with OEH during the preparation of the offset strategy. Planting of ramets along the realigned Mill Creek where the ironstone soil is present is recommended. No <i>Allocasuarina littoralis</i> should be planted near these plants as this species can shade out <i>Allocasuarina diminuta</i> subsp. <i>mimica</i> and mycorrhizial associations may be different. Any removal and replanting should be carried out with input from the Sutherland Shire Council bushcare staff. • A management plan for the collection of seed and translocationof plants would be prepared as part of the CEMP for the proposal (see section 6.3) and would include monitoring and assessment of the success of the program.
Vegetation clearing	<ul style="list-style-type: none"> • Limit disturbance of vegetation to the minimum necessary to construct the proposal. • Vehicles must be appropriately washed prior to work on site to prevent the potential spread of Cinnamon Fungus (<i>Phytophthora cinnamomi</i>) and Myrtle Rust (Pucciniales fungi) in accordance with the national best practice guidelines for Phytophthora (DEH 2006) and the Myrtle Rust factsheet (DPI 2011c) for hygiene control. • Where the proposal footprint adjoins native vegetation mark the limits of clearing and install fencing around the construction footprint area prior to the commencement of construction activities to avoid unnecessary vegetation and habitat removal. • Stockpiles of fill or vegetation should be placed within existing cleared areas (and not within areas of adjoining native vegetation). • Sediment fences should be installed to prevent transfer of sediments into adjacent vegetation.
Weeds	<ul style="list-style-type: none"> • Develop weed management actions to manage weeds during the construction phase of the proposal. This would include the management and disposal of the weeds that were recorded within the proposal footprint, including the noxious weeds listed in Table 4.2 in accordance with the NW Act. • Vehicles and other equipment to be used on site should be cleaned to minimise seeds and plant material entering the site to prevent the introduction of further exotic plant species or disease. • Incorporate control measures in the design of the proposal to limit the spread of weed propagules downstream of study area. Sediment control devices, such as silt fences, would assist in reducing the potential for

Impact	Mitigation
	spreading weeds.
Fauna habitat	<ul style="list-style-type: none"> • Protocols to prevent introduction or spread of chytrid fungus should be implemented following Office of Environment and Heritage Hygiene protocol for the control of disease in frogs (DECCW, 2008). • A trained ecologist should be present during the clearing of native vegetation or removal of potential fauna habitat to avoid impacts on resident fauna and to salvage habitat resources as far as is practicable. Clearing surveys should include: <ul style="list-style-type: none"> – Staged vegetation clearing, commencing in the south of the GO facility and progressing northwards to increase the opportunity for fauna to vacate the site and move into areas of 'secure' habitat to evade injury. – Any hollow-bearing trees to be felled should be marked prior to clearing of vegetation. The removal of hollow bearing trees is to be undertaken in accordance with a hollow-bearing tree management protocol and would include the presence of a qualified ecologist or wildlife expert experienced in the rescue of fauna. – Habitat features (fallen logs and tree hollows) removed from site would be salvaged and relocated within adjacent areas of vegetation. – Inspections of native vegetation for resident fauna and/or nests or other signs of fauna occupancy – Deferral of vegetation removal and associated construction activity in areas occupied by more mobile threatened fauna until the fauna has vacated the proposal footprint • An ecologist should be present during works along Mill Creek to rescue and relocate any frogs to other locations along Mill Creek. Any handling of frogs should be undertaken with respect to the Office of Environment and Heritage Hygiene protocol for the control of disease in frogs (DECCW, 2008).
Water Quality and aquatic habitats	<ul style="list-style-type: none"> • Erosion and sediment control plans should be prepared in accordance with Volume 2D of Managing Urban Stormwater: Soils and Construction (DECC 2008). The erosion and sediment control plans would be established prior to the commencement of construction and be updated and managed throughout as relevant to the activities during the construction phase. • Erosion and sediment control measures should be established prior to construction. • Erosion and sediment control measures would be regularly inspected, particularly following rainfall events, to ensure their ongoing functionality. • Stabilised surfaces should be reinstated as quickly as practicable after construction. • Water should be applied to exposed surfaces that are causing dust generation. Surfaces may include unpaved roads, stockpiles, hardstand areas and other exposed surfaces (for example recently graded areas). • Vehicles must follow appropriate speeds to limit dust generation. • All stockpiled material should be stored in bunded areas and kept away from waterways to avoid sediment entering the waterway. • Spill kits would be made available to construction vehicles. A management protocol for accidental spills would be put in place. • Plague Minnow (if present) must not be released into local waterways as a result of draining of dams or realignment of Mill Creek. Plague Minnow should be eradicated from dams prior to decommissioning using humane methods and under an appropriate licence from NSW Primary Industries (Animal Welfare branch and Fishing and Aquaculture branch). • Any large woody debris removed from the realigned Mill Creek should be salvaged and placed in the new alignment to maintain habitat values. • The new section of Mill Creek should be constructed to mimic a natural ecosystem and revegetated with locally endemic species. Consideration should be given to using propagated <i>Allocasuarina diminuta</i> subsp.

Impact	Mitigation
	<i>mimica.</i>

6.3.2 Operation

A comprehensive list of prevention, mitigation and rectification measures has been identified and they are detailed in the LHRRP Operational Environment Management Plan (SITA, 2014). The identified mitigation and rectification measures would be implemented as required and their exact details would be based on a case by case situation depending on the issue and technical solutions available at the time. The operations of the GO facility is not expected to increase the presence of weeds in the riparian zone as materials are tipped and processed inside the facility in accordance with strict guidelines for compost production. The operations of the LHRRP ARRT facility is not expected to increase the presence of weeds in the riparian zone as materials are tipped and processed inside the facility in accordance with strict guidelines for compost production. The ARRT facility is also fully enclosed and constructed on hardstand. Pest, vermin and weed management measures for the whole LHRRP are detailed in the LHRRP OEMP.

Examples of key measures that are included in the OEMPs are provided below:

- A joint noxious weed control program with SSC which provides a cooperative approach to weed control
- A feral animal control program (in place since 2008)
- Engage specialist contractor to control noxious weeds
- Engage registered pest exterminator to inspect the LHRRP annually and carry out any recommended actions

As described in Section 5.1.2, the proposal would have a minor increase in existing impacts on native biodiversity values during operation. Little mitigation of the proposal is therefore likely to be required for biodiversity during this phase. Mitigation measures are provided in Table 6.1.

Table 6.2 Mitigation measures (operation)

Impact	Mitigation
Vegetation and weeds	<ul style="list-style-type: none"> • Ongoing management of noxious weeds according to legislative requirements. • Ongoing suppression of dust within the landfill and ARRT and GO facilities. • Ongoing water quality management. • Monitoring of revegetation of realigned Mill Creek to ensure planted individuals are thriving.
Feral animals	<ul style="list-style-type: none"> • Ongoing control of feral animals. • Minimise sources of food and habitat for pest species.

6.3.3 Post closure

A post closure environmental management plan (EMP) has been prepared for the project (GHD 2014). As part of this EMP, the site would be landscaped and there would be management of surface water, leachate and gas. Mitigation measures proposed for biodiversity are provided in Table 6.3.

Table 6.3 Mitigation measures (post closure)

Impact	Mitigation
Vegetation and weeds	<ul style="list-style-type: none"> Exposed soil should be sown with native seed immediately to prevent colonisation by weeds. Revegetation should use locally sourced native species. Use of propagated individuals of <i>Allocasuarina diminuta</i> subsp. <i>mimica</i> from the site should be incorporated into the landscaping plan. Ongoing management of noxious weeds according to legislative requirements. Revegetation areas, including planted <i>Allocasuarina diminuta</i> subsp. <i>mimica</i>, should be monitored and managed as per the EMP.

7. FBA Calculations

7.1 Introduction

The FBA credit calculations were performed by Kirsten Crosby (assessor accreditation number 160) using credit calculator Version 4.0. The credit calculations will be submitted to OEH and the biodiversity credit report is included in Appendix A.

The data and assumptions used to perform the FBA credit calculations are summarised below according to the structure and information requirements outlined in Appendix 7 of the FBA (OEH, 2014a).

7.2 Landscape features

The FBA requires the assessment of landscape features to help describe the biodiversity values of the study area and assess the impacts of the proposal. Landscape features relevant to the FBA calculations are shown on Figure 7.1 and summarised in Table 7.1.

Table 7.1 Landscape features

Landscape feature	Proposal footprint
Interim Biogeographic regionalisation of Australia (IBRA) bioregion and IBRA subregions	The proposal footprint is located entirely within the 'Sydney Basin' IBRA bioregion and Sydney Cataract – Sydney Metro IBRA subregion.
Mitchell landscapes	The proposal footprint is located on the Woronora Plateau Mitchell landscape (DECC 2008a).
Rivers, streams and estuaries	The proposal footprint contains a first order stream, Mill Creek, which has historically been realigned to its current position within the proposal footprint.
Wetlands	The proposal footprint does not contain any important or local wetlands as defined in the FBA (OEH, 2014a).
% Native vegetation cover	The outer assessment circle is 1000 hectares in area and the inner assessment circle is 100 hectares.
	The current percent native vegetation cover in the outer assessment circle is 71-75% (around 754 hectares out of the 1000 hectare circle).
	The future percent native vegetation cover in the outer assessment circle remains 71-75% (around 741 hectares out of the 1000 hectare circle, given the removal of only 13.03 hectares of remnant, regrowth or planted native vegetation for the proposal).
	The current percent native vegetation cover in the inner assessment circle is 71-75% (around 75 hectares out of the 100 hectare circle).
	The future percent native vegetation cover in the inner assessment circle is 61-65% (around 62 hectares out of the 100 hectare circle, given the removal of 13.03 hectares of remnant, regrowth or planted native vegetation for the proposal).
Connectivity value - class	The proposal would affect only a local area biodiversity link, because it affects vegetation in a link that is <1000 ha in area.
Connectivity value - width	The primary link for the proposal before development is located in the adjacent Holsworthy army base and is over 1 km wide (>500m linkage width class).
	The primary link for the proposal remains in the adjacent Holsworthy army base and will remain over 1 km wide (>500m linkage).
Connectivity value - condition	The projective foliage cover (PFC) of over storey and mid storey vegetation in the primary link before development is at benchmark values.

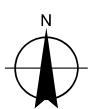
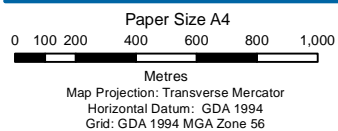
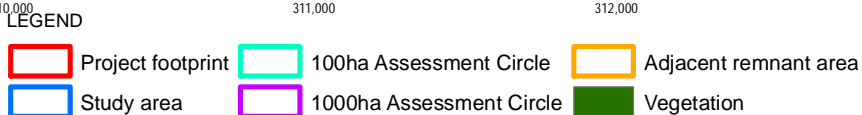
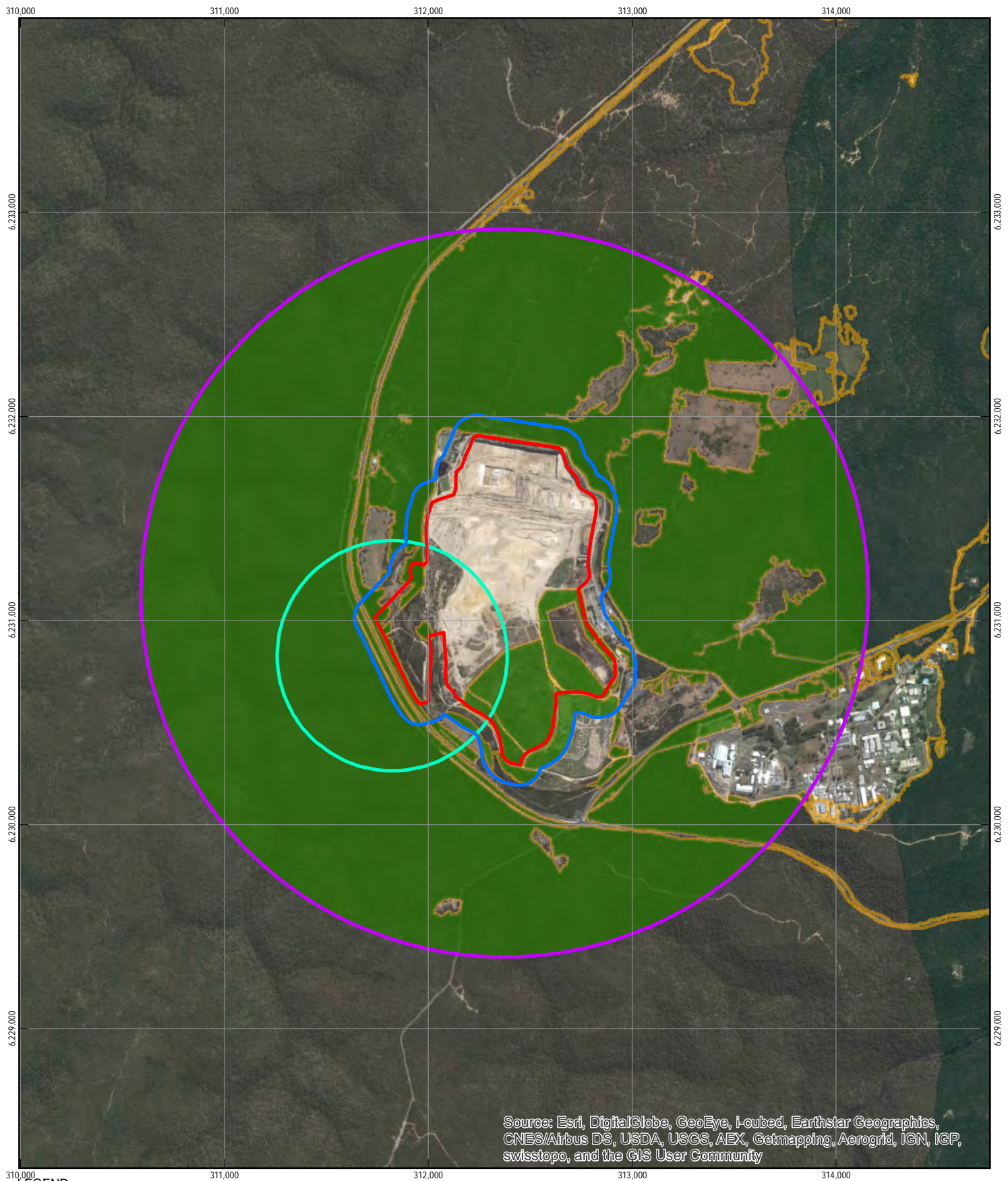
Landscape feature	Proposal footprint
	The average projective foliage cover (PFC) of over storey and mid storey vegetation in the primary link after development would be at benchmark values because the proposal would affect only a 200 metre wide strip out of the >1km link.
	The patch size is 500 hectares, comprising the remnant vegetation in Holsworthy army base and other adjacent areas.

7.1 Native vegetation

One vegetation zone and threatened species sub zone was created for each plant community type (PCT) and broad condition state in the proposal footprint. The area of each zone was calculated using GIS. Site score values (out of 100) reflect the disturbed nature of much of the native vegetation within the proposal footprint. Vegetation zones within the proposal footprint are summarised in Table 7.2.

Table 7.2 Vegetation zones

Vegetation Zone ID	PCT	Condition	Area (ha)	Site score	Patch size (ha)	Extent cleared in the CMA sub region	Plot / transects required	Plot / transects completed
1	Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux (ME014)	Moderate to good (moderate)	2.55	65.28	500	25	2	Plot/transect 2 Plot/transect 5
2	Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux (regenerating and planted) (ME014)	Moderate to good (poor)	10.48	47.05	500	25	3	Plot/transect 3 Plot/transect 4 Plot/transect 6



SITA Australia
Lucas Heights Resource Recovery Park

Job Number	21-23482
Revision	A
Date	09 Apr 2015

Landscape features

Figure 7.1

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Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

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Data source: Google Earth: Imagery- May 2014, NSW Department of Lands: contours - Jan 2012. Created by: MWVeerakoon

7.2 Threatened species

7.2.1 Predicted threatened species

The credit calculator reports the suite of threatened fauna species that are predicted to be associated with ecosystem credits generated for the proposal. That is, the threatened fauna species that are predicted to use habitat within the vegetation types in the proposal footprint. Each of these species has a 'threatened species multiplier' that feeds into the ecosystem credit calculations. If that fauna species or specific habitat resources for that species are not present at the development site, then the threatened species multiplier score may be adjusted.

The suite of threatened species associated with ecosystem credits for the development is shown in Table 7.3 along with an assessment of whether habitat components for these threatened species are present in the vegetation zones within the proposal footprint. The highest threatened species multiplier for the assessment was associated with the life cycle multiplier for the Masked Owl (*Tyto novaehollandiae*) and Powerful Owl (*Ninox strenua*) (3.0) which is based on the assumption that the proposal would remove suitable nest hollows for these threatened forest owls. The proposal site does not contain any large hollow-bearing trees that would comprise suitable nesting habitat for the Masked Owl and Powerful Owl. Therefore the threatened species multiplier for these species was adjusted to their 'effective management / rare populations' score (1.3) which meant that the highest threatened species multiplier for the assessment was associated with the Spotted-tailed Quoll (*Dasyurus maculatus maculatus*) (2.6). The Spotted-tailed Quoll is likely to occur in the proposal footprint and to be affected by the proposal and so the credit calculations for threatened species were not adjusted further

Table 7.3 Predicted threatened species (ecosystem credit species)

Common name	Scientific name	Threatened species multiplier	Habitat components present in vegetation zones ?	Justification
Eastern Freetail-bat	<i>Mormopterus norfolkensis</i>	2.2	Yes	
Gang-gang Cockatoo	<i>Callocephalon fimbriatum</i>	2.0	Yes	
Greater Broad-nosed Bat	<i>Scoteanax rueppellii</i>	2.2	Yes	
Little Eagle	<i>Hieraaetus morphnoides</i>	1.4	Yes	
Masked Owl	<i>Tyto novaehollandiae</i>	1.3*	Yes	No large hollow-bearing trees are present in the proposal footprint.
New Holland Mouse	<i>Pseudomys novaehollandiae</i>	2.6	No	No suitable coastal heath habitat is present in the proposal footprint.
Powerful Owl	<i>Ninox strenua</i>	1.3*	Yes	No large hollow-bearing trees are present in the proposal footprint.
Scarlet Robin	<i>Petroica boodang</i>	1.3	Yes	
Spotted-tailed Quoll	<i>Dasyurus maculatus</i>	2.6	Yes	
Varied Sittella	<i>Daphoenositta chrysoptera</i>	1.3	Yes	

*Tg value altered as no breeding habitat is present (original value of 3).

7.2.2 Species credits

The credit calculator references geographic, vegetation and habitat data for the proposal footprint to generate a list of the species credit-type threatened species predicted to occur and requiring targeted survey.

Two flora species identified as requiring survey are unlikely to occur in the proposal footprint and targeted surveys were not conducted in the flowering season. These comprise:

- *Pterostylis* sp. Botany Bay (Botany Bay Bearded Orchid). This species is currently only known to occur within coastal heath on the Kurnell Peninsula. It historically occurred at Maroubra. There are no local records of this species. No suitable habitat is present in the study area. No targeted surveys have been conducted for this species.
- *Calladenia tessellata* (Thick-lip Spider Orchid). This species usually occurs in grassy dry sclerophyll woodland, and occasionally in heathland on sandy loam soils. Limited potential habitat is present in the proposal footprint. No grassy woodland is present. Previous clearing is likely to have removed any individuals if present. There have been no records of this species in the greater Sydney region in the last 20 years. No targeted surveys have been conducted for this species.

No targeted surveys were conducted for the Eastern Pygmy-possum. This species is considered likely to occur based on habitat present and local records.

Surveys were conducted in the appropriate season for remaining species credit-type flora species (see Table 4.1). Only *Acacia bynoeana* was recorded in the proposal footprint. Given the lack of evidence of other threatened flora species and existing disturbance in the proposal footprint, no other threatened flora species are likely to occur.

Surveys were conducted in the appropriate season for the Spotted-tailed Quoll, Giant Burrowing Frog, Rosenberg's Goanna and Koala. As described in section 4.2.6, habitat for the Koala is very poor, and is not included in the credit calculations.

The endangered population of *Allocasuarina diminuta* subsp. *mimica* is a new listing under the TSC Act and is not yet included in the credit calculator. No credits can be calculated for this endangered population as its threatened species multiplier is not known. A detailed discussion of impacts on this endangered population is provided in section 7.4.3. The proposal would remove about 58 ramets and about 24 ramets would be retained on the adjacent SICTA land, which may be used as part of the offset for the proposal. Credit calculations for this endangered population will be finalised when it is added to the credit calculator.

A table of 'Threatened species survey / time matrix and survey effort' in accordance with the FBA is included in Appendix C.

7.3 Avoid and minimise impacts

7.3.1 Impact avoidance

The majority of the proposal is to be undertaken in areas which have previously been disturbed. The landfill re-profiling will take place above the existing landfill. The construction of the ARRT and GO facilities, including construction of the access road and realignment of Mill Creek, would mainly occur in areas that have previously been disturbed but are currently vegetated. The proposal would remove 13.03 ha of native vegetation in total, of which 10.48 ha is regenerating and planted.

7.3.2 Final proposal footprint

The final proposal footprint is shown on Figure 1.1 along with details of the proposal design and construction areas. The proposal footprint along with vegetation, threatened biota and habitat resources is shown on Figure 4.1.

7.3.3 Direct impacts

The proposal would result in direct impacts within the final proposal footprint shown on Figure 7.1 comprising:

- Disturbance of an overall construction footprint of 111.48 ha of which 71.77 ha is cleared land associated with the landfill and associated infrastructure.
- Removal or modification of 13.03 ha of native vegetation and associated habitat resources for threatened species and other native biota.
- Removal or modification of 26.68 ha of exotic grassland that does not comprise native vegetation or habitat for threatened species according to the FBA and has minimal value for native biota.
- Generation of noise, light, traffic and altered environmental conditions associated with the final proposal layout and operation of the landfill, ARRT and GO facilities which would comprise a minor impact on biodiversity values in the context of the landfill operations and the surrounding road network.

A more detailed description of direct impacts and the likely effect on the biodiversity values of the study area is provided in Chapter 5.

7.3.4 Indirect impacts

The impact mitigation and environmental management measures specified in Chapter 6 are likely to ensure that the majority of construction impacts are restricted to the proposal footprint. There are unlikely to be any substantial indirect impacts associated with construction activities (see section 5.1.2). As described in Section 5.1.2 the proposal would not result in any substantial operational impacts. Given the proposed mitigation measures, adjoining land uses, existing activities in the proposal footprint, the proposal would not result in any tangible indirect impacts.

Therefore no additional, indirect impacts have been included in the credit calculations.

7.4 Impact summary

7.4.1 Areas not requiring assessment

An assessor is not required to assess areas in a proposal footprint without native vegetation unless the SEARs for the proposal specifically require it.

The majority of the proposal footprint contains cleared land or exotic grassland that does not comprise native vegetation within the meaning of the FBA. These areas comprise 'cleared land' according to the FBA and the BioBanking methodology (DECC, 2009) because they contain no native over storey or mid storey vegetation and greater than 50% exotic ground cover or >90% bare earth. Further, the majority of exotic grassland present is located on fill material associated with unnatural landforms.

There are also small areas of planted trees in the proposal footprint (eg near the existing site buildings) that do not comprise native vegetation within the meaning of the FBA. These also comprise 'cleared land' according to the FBA and the BioBanking methodology (DECC, 2009).

These areas of cleared land within the proposal footprint were not sampled with plot/transects. A more detailed description of this vegetation and justification for the decision for no further assessment under the FBA is provided in Section 4.2.2.

The proposal footprint also includes gravel tracks, hardstand areas and other infrastructure with occasional plants associated with cracks or shallow soil deposits that clearly do not comprise native vegetation within the meaning of the FBA and therefore do not require assessment.

7.4.2 Areas not requiring offset

The majority of the proposal footprint is cleared land according the FBA. These areas have not been identified as native vegetation by Tozer (2010).

One exotic grassland area was sampled using a plot/transect and compared with benchmark values for the PCTs that were likely to have formerly occurred in such areas (see Appendix C). The plot/transect data confirms that this area is in substantially poorer condition than intact native vegetation.

None of this vegetation comprises a local occurrence of a TEC or contains species credit type threatened species or their habitats. Therefore impacts on cleared land as defined in the FBA in the proposal footprint do not require the calculation of offsets according to the FBA.

A more detailed description of this vegetation and justification for the decision for no further assessment under the FBA is provided in Section 4.2.2.

7.4.3 Impacts requiring further consideration

Certain impacts on biodiversity values of a major proposal require further consideration by the consent or approval authority. These are impacts that are particularly complicated or severe. A decision will be made by the consent or approval authority on whether it is appropriate for these impacts to occur or whether modifications to the major proposal are required to avoid or minimise the impact.

Impacts that require further consideration include:

- Significant impacts on landscape features.
- Impacts on CEECs or impacts on EECs that are likely to significantly affect the persistence or viability of an EEC.
- Impacts on critical habitat or on threatened species that are likely to significantly affect the persistence or viability of a population of a threatened species.

If a Major Project proposal includes an impact on biodiversity that requires further consideration it is recommended that a proponent discuss the impact with the NSW Department of Planning and Environment (DP&E) prior to lodging the EIS to avoid uncertainty and potential delays to project approval (OEH, 2014a).

The proposal has been purposefully designed to avoid impacts on biodiversity values as far as is practicable (see Section 7.3).

OEH specifically identified these matters as impacts requiring further consideration:

- Shale Sandstone Transition Forest CEEC
- *Allocasuarina diminuta* subsp. *mimica* L.A.S.Johnson endangered population in the Sutherland and Liverpool local government areas
- *Prostanthera saxicola* endangered population in the Sutherland and Liverpool local government areas.

These are discussed below.

Shale Sandstone Transition Forest

A narrow strip of this CEEC is located to the north-east of the existing landfill, outside the proposal footprint (see Figure 4.1). The majority of the stand is located over 200 metres from the proposal footprint. A second, smaller stand is located further to the north. These stands have been mapped by Sutherland Shire Council and have a combined area of 19.10 ha. The stand near the proposal footprint is in good condition, based on surveys carried out by GHD (2011). Shale Sandstone Transition Forest has also been mapped within Holsworthy army base by French et al (2000). About 1706 ha of plateau forest, including both Shale Sandstone Transition Forest and Shale Plateau Forest, were mapped in this area (French et al 2000). These communities could not be separated by this study, and thus the total area of Shale Sandstone Transition Forest cannot be provided. Much of this vegetation type in Holsworthy army base is likely to be in good condition, due to relatively little disturbance. A total of 7.2 ha of Shale Sandstone Transition Forest is mapped by Tozer et al (2010) within the 1000ha circle in which the proposal is located and a total of 11.95 ha of this community is mapped by Tozer et al (2010) within the 10,000ha circle in which the proposal is located. This mapping is broad-scale, based on a combination of remote sensing and on-ground surveys, and does not necessarily identify all vegetation communities present in a particular location. Based on other vegetation mapping described above, this is likely to be an underestimate of the total area of this CEEC in the assessment circles.

Shale Sandstone Transition Forest is located outside of the proposal footprint, to the north-east of the existing landfill, and would not be directly affected by the proposal. The existing approved landfill boundary had been located to avoid impacts on this community, and there would be no change to this boundary. No additional areas of vegetation would be cleared from near this community. Large tracts of vegetation are present to the northeast, south and east of the site, and connectivity with these areas would not be affected.

The edge of the stand of Shale Sandstone Transition Forest is located adjacent to the existing landfill void. Currently this is approximately 40 m deep. The landfill will eventually be reprofiled, with the surface matching nearby areas in about 2025. There will be no additional impacts on groundwater and surface water related to the proposal that could impact this CEEC.

The proposal footprint contains four species declared as noxious weeds in the Sutherland Local Government Area: *Ludwigia* (*Ludwigia peruviana*), Pampas Grass (*Cortaderia selloana*), Lantana (*Lantana camara*) and Fireweed (*Senecio madagascariensis*). These noxious species occurred in disturbed areas of the proposal footprint. Given that the existing landfill void is located about 40 m below the surface, and the majority of construction work will occur well to the south-west, there is minimal risk of weeds becoming established in the Shale Sandstone Transition Forest as a result of the proposal. There is some risk of weed spread occurring once the landfill has been reprofiled, if surfaces are not stabilised promptly with native species. Mitigation measures to prevent the spread of weeds are included in the proposal (see section 6.3).

European Foxes, Feral Cats, Rabbits and introduced mice and rats are present in the proposal footprint and surrounds. The proposal is unlikely to increase the incidence of these species in this community. No additional invasive fauna species are likely to become established as a result of the proposal.

The proposal is unlikely to interfere with the recovery of the community given that:

- there would be no direct impacts on this community
- there would be no additional clearing of nearby vegetation that would result in edge effects on this community
- there would be no fragmentation or isolation of this community

- any impacts on groundwater and surface water have already occurred and there would be no additional groundwater and surface water impacts relating to the proposal
- the proposal is unlikely to increase the incidence of weeds and feral animals.

There would be no change in extent or condition of the community within the IBRA subregion as a result of the proposal. Given the lack of impacts resulting from the proposal, no specific measures are proposed to contribute to the recovery of the CEEC in the INBRA subregion.

***Allocasuarina diminuta* subsp. *mimica* population**

(a) the size of the local population directly and indirectly impacted by the development

A population of *Allocasuarina diminuta* subsp. *mimica*, listed as an endangered population under the TSC Act, was identified in the proposal footprint during the January 2015 surveys. Targeted surveys were conducted on 2 February 2015 to map the extent of the population within the proposal footprint and adjacent areas. This population is restricted to the Sutherland and Liverpool LGAs, with most of the population records occurring in land alongside Heathcote Road (OEH 2015b).

About 58 ramets were recorded, mostly along track edges, at nine locations in the proposal footprint (see Figure 4.1). The stems are described as ramets, because it is possible that most stems have developed vegetatively after previous disturbances. Cones and female flowers were recorded on many ramets, however, so it is likely that there is also sexual reproduction within this sub-population. A sub-population of about 24 ramets was recorded in SICTA land north of the proposal boundary. Sub-populations of *Allocasuarina diminuta* subsp. *mimica* were also recorded on both sides of Heathcote Road, between the intersection with New Illawarra Road and the Mills Creek crossing (see Figure 4.1). About 12 ramets were recorded on the eastern side of Heathcote Road. The larger sub-populations (>100 ramets) were recorded on the western side of Heathcote Road, especially along drainage lines and associated slopes. There is also a conserved population of *Allocasuarina diminuta* subsp. *mimica* in a Council Reserve, just to the north of the LHRRP, which has many hundreds of ramets present (B. Graham, SSC, pers. comm.). A large proportion of the known population may be removed for the proposed Heathcote Ridge development further to the north, however this proposal has not yet been assessed under NSW legislation, although a strategic assessment (Cumberland Ecology 2012) has been approved by the Commonwealth. As such, the status of this proposal is not known.

The proposal would remove up to 58 ramets of *Allocasuarina diminuta* subsp. *mimica*. At some locations ramets were growing on the outside of the SITA boundary fence, and may not be removed by the proposal, however their roots may be physically damaged. As a precaution, all ramets growing along the fence are included in the number to be removed (ie. 58 ramets). The 24 ramets growing north of the boundary fence would not be removed, but may be indirectly impacted by the proposal by edge effects and changes to surface water flow. Ramets present along the edges of Heathcote Road (~112 ramets) are unlikely to be impacted by the proposal. Further discussions of direct and indirect impacts are provided below.

Details of stands of *Allocasuarina diminuta* subsp. *mimica* recorded during the targeted survey, associated species, soil and other comments is provided in Table 7.4.

Table 7.4 *Allocasuarina diminuta* subsp. *mimica* in the study area

Way point	No. of ramets	Associated species	Tallest ramet (M)	Soil and other comments
Proposal footprint				
1	4	<i>Petrophile pulchella</i> <i>Allocasuarina littoralis</i> <i>Acacia suaveolens</i> <i>Xanthorrhoea resinifera</i> <i>Actinotus minor</i> <i>Grevillea sericea</i> subsp. <i>sericea</i> <i>Anisopogon avenaceus</i>	1.3	Only females evident High ironstone presence 2m to north of track edge, in intact heathy woodland
2	4 (3 in proposal footprint, 1 on other side of fence)	Bare soil apart from some patches of <i>Eragrostis benthamii</i> and <i>Leptospermum juniperinum</i> . Dense mid-canopy of <i>Allocasuarina littoralis</i> on other side of fence.	1.76	Stems growing on both sides of fence Track edge Only females evident
3	4 (1 in proposal footprint, 3 on other side of fence)	Bare soil apart from some patches of <i>Eragrostis benthamii</i> . Dense mid-canopy of <i>Allocasuarina littoralis</i> on other side of fence.	1.72	Stems growing on both sides of fence Track edge Only females evident
4	15	Mostly bare soil, <i>Allocasuarina littoralis</i> , <i>Banksia marginata</i> , <i>Petrophile pulchella</i> , <i>Acacia obtusifolia</i> , <i>Persoonia levis</i> , <i>Panicum simile</i> , <i>Eragrostis benthamii</i>	1.60	Between fence and track Leaf litter, fine scattering of ironstone 11m long strip Only females evident
5	6	<i>Allocasuarina littoralis</i> , <i>Banksia marginata</i> , <i>Petrophile pulchella</i> , <i>Acacia obtusifolia</i>	1.41	6m x 3m patch close to track edge, some stems growing other side of fence; leaf litter and ironstone Only females evident
6	7	<i>Allocasuarina littoralis</i> , <i>Eragrostis benthamii</i> , <i>Lepyrodia scariosa</i> , <i>Caustis pentandra</i>	1.10	8m strip close to track edge; leaf litter and ironstone
7	3	<i>Persoonia lanceolata</i> , <i>Petrophile pulchella</i> , <i>Leptospermum juniperinum</i> , <i>Allocasuarina littoralis</i>	0.80	Dense layer of Black Oak needles Only females evident
9	14 (10 in proposal footprint, four on other side of fence)	<i>Allocasuarina littoralis</i> , <i>Banksia marginata</i> , <i>Petrophile pulchella</i> , <i>Acacia obtusifolia</i> , <i>Persoonia levis</i> ,	1.40	6m x 2m patch On raised band between track and fence Ironstone common

Way point	No. of ramets	Associated species	Tallest ramet (M)	Soil and other comments
		<i>Panicum simile</i> , <i>Eragrostis benthamii</i>		
11	1	<i>Allocasuarina littoralis</i> , <i>Lambertia formosa</i> , <i>Persoonia linearis</i> , <i>Persoonia lanceolata</i> , <i>Petrophile pulchella</i> , <i>Angophora hispida</i> , <i>Actinotus minor</i> , <i>Panicum simile</i> , <i>Grevilla sericea</i> subsp. <i>sericea</i>	1.40	Single stem in regenerating heathy woodland Ironstone scattered over sandy soil No cones or flowers
SICTA land, outside proposal footprint				
10	24	<i>Kunzea ambigua</i> , <i>Lambertia formosa</i> , <i>Allocasuarina littoralis</i> , <i>Ptilothrix deusta</i> , <i>Angophora hispida</i> , <i>Banksia ericifolia</i> , <i>Banksia marginata</i> .	1.65	14 x 4m patch, many stems at south end necrotic (dying back). Dense cover of Black Oak needles at north end and shotgun pellets at south end Only females evident
Heathcote Road, Eastern side				
12	12	<i>Allocasuarina littoralis</i> , <i>Lambertia formosa</i> , <i>Persoonia levis</i> , <i>Acacia suaveolens</i> , <i>Petrophile pulchella</i> , <i>Angophora hispida</i> , <i>Kunzea ambigua</i>	1.75	4m x 4m patch Ironstone common Large numbers of female flowers and cones
Heathcote Road, Western side				
14	23	<i>Eucalyptus oblonga</i> , <i>Eucalyptus racemosa</i> subsp. <i>racemosa</i> , <i>Allocasuarina littoralis</i> , <i>Banksia marginata</i> , <i>Banksia ericifolia</i> , <i>Lambertia formosa</i> , <i>Petrophile pulchella</i> , <i>Angophora hispida</i> , <i>Dodonaea triquetra</i> , <i>Panicum simile</i>	1.60	In drainage line and associated slopes 26 x 4m patch, Ironstone common
15	46	<i>Eucalyptus squamosa</i> , <i>Eucalyptus piperita</i> , <i>Allocasuarina littoralis</i> , <i>Kunzea ambigua</i> , <i>Lepyrodia scariosa</i> , <i>Petrophile pulchella</i> , <i>Grevillea sphacelata</i> .	1.66	In drainage line and associated slopes 40m x 4m patch Ironstone common
16	32	<i>Allocasuarina littoralis</i> , <i>Lambertia formosa</i> , <i>Persoonia levis</i> , <i>Acacia suaveolens</i> , <i>Petrophile pulchella</i> , <i>Angophora hispida</i> , <i>Kunzea ambigua</i> , <i>Petrophile pulchella</i> ,	1.44	In drainage line and associated slopes 21m x 4m patch Ironstone common

Way point	No. of ramets	Associated species	Tallest ramet (M)	Soil and other comments
		* <i>Eragrostis curvula</i>		

(b) the likely impact (including direct and indirect impacts) that the development will have on the habitat of the local population, including but not limited to:

(i) an estimate of the change in habitat available to the local population as a result of the proposed development

(ii) the proposed loss, modification, destruction or isolation of the available habitat used by the local population, and

(iii) modification of habitat required for the maintenance of processes important to the species' life cycle (such as in the case of a plant – pollination, seed set, seed dispersal, germination), genetic diversity and long-term evolutionary development.

Atlas records or other documented, quantifiable means must be used by the assessor to estimate what percentage of the species' population and habitat is likely to be lost in the long term within the IBRA subregion due to the direct and indirect impacts of the development.

The endangered population occurs along sandstone ridges and upper hillsides in the region northwest from Heathcote, towards Menai and Holsworthy, in heathy and low open woodland communities (OEH 2015c). In the study area it was observed to occur on trail margins (SITA land), in previously cleared areas (SICTA land) and along edges of woodland in the road reserve of Heathcote Road. All locations were on slopes, with the species not being recorded on the ridgetops. In all locations it was recorded in open areas, without a dense overstory. Parts of the proposal footprint have a dense overstory of *Allocasuarina littoralis* present. Further to the north, in the proposed Heathcote Ridge development area, it is known to occur heath and open woodland dominated by *Angophora hispida* and *Eucalyptus haemastoma* (Graham, B. in NSW Scientific Committee 2014), similar to the vegetation present in the study area.

The proposal would remove about 58 ramets and up to 13.03 ha of potential habitat for the species. Not all this habitat is suitable due to the presence of a closed overstorey in parts of the proposal footprint. Approximately 24 ramets would be retained on the SICTA land to the north of the proposal footprint, in similar open, disturbed land (see Figure 4.1). Greater than 100 ramets were also observed in the road reserve on the eastern and western sides of Heathcote Road (see Figure 4.1). Some ramets are growing adjacent to the fence and, when removed, it is possible that ramets that are connected to the same rootstock, but growing in the road reserve may be affected through physical damage.

The total size of the endangered population of is not known. No targeted surveys for the subspecies were conducted at the Heathcote Ridge site as the subspecies had not been listed as an endangered population at the time surveys were conducted by Cumberland Ecology (2012). The proposed Heathcote Ridge development (if approved by the NSW government) is expected to impact about 188 ha of known and potential habitat for *Allocasuarina diminuta* subsp. *mimica*, which equates to about 78% of the known and potential habitat present in this area (Graham, B. in NSW Scientific Committee 2014). A large population of many hundred of ramets is also present in the Council reserve north of the LHRRP (Graham, B, SCC, pers. comm.). Based on these numbers the subpopulation present in the proposal footprint is estimated to represent less than 3% of the total endangered population (including the Heathcote Ridge population). In the local context, the known habitats along both sides of Heathcote Road

and in the Council Reserve to the north of the LHRRP will not be affected by the proposed development.

The location of the core population of *Allocasuarina diminuta* subsp. *mimica* covers an area of approximately 32 km² on Heathcote Ridge. There are 15 database records for this subspecies, including sub-populations along Heathcote Road (NSW Scientific Committee 2014). The size of the sub-populations in the LHRRP are small and mostly consist of resprouted stems after initial damage during track maintenance and operation. The sub-population in the proposal footprint has a direct connection with sub-populations on the eastern road reserve of Heathcote Road. Large sub-populations were recorded on the western side of Heathcote Road. The sub-population on the eastern side of Heathcote Road will be reduced as a result of the proposal.

Preliminary seed collection was carried out by the on-site nursery staff in early March 2015, following the targeted survey, in order to propagate plants for future planting as part of the recommended mitigation for the proposal (see section 6.3). Further seed collection will be carried out prior to clearing. . Species of this genus can be propagated from seed (Wrigley and Fagg 2007). Efforts would also be made to translocate the ramets in the SITA site to the nursery for care and for future planting into areas of appropriate habitat which will not be disturbed or affected by the proposed development.

(c) the likely impact on the ecology of the local population. At a minimum, address the following:

(ii) for flora, address how the proposal is likely to affect the ecology and biology of any residual plant population that will remain post development including where information is available:

– **pollination cycle**

– **seedbanks**

– **recruitment, and**

– **interactions with other species (e.g. pollinators, host species, mycorrhizal associations).**

Little is known about the ecology of the species. Cone production in the species in central NSW appears to be linked to rainfall, with fewer cones produced in dry years. Drought conditions resulted in the failure of plants to produce seed and caused the death of significant numbers of plants (Cameron 2005). The subspecies in the locality may be similarly reliant on rainfall for cone production. *Allocasuarina* species are wind pollinated and their seeds are wind dispersed (Benson and McDougall 1995). Because of wind pollination, plants are generally outcrossing, and very little hybridisation occurs within the genus. *Allocasuarina diminuta* subsp. *mimica* is probably killed by fire, regenerating from seed with 90% seed is released within 1 week of fire (Benson and McDougall 1995). Regeneration from seed after fire has been observed (NSW Scientific Committee 2014). Other members of the species are however known to resprout after fire and it is possible that *A. diminuta* subsp. *mimica* has the same capacity. *Allocasuarina diminuta* subsp. *diminuta* may resprout after fire (Benson and McDougall 1995) and *A. diminuta* subsp. *annectans*, is known to resprout after fire (DECCW 2010). *Allocasuarina diminuta* subsp. *mimica* has a symbiotic relationship with the actinomycete *Frankia*, a nitrogen-fixing bacteria (Benson and McDougall 1995).

Upt o 58 ramets will be removed from the proposal footprint, therefore the number of female flowering stems in the endangered population will be reduced. No male flowering ramets were recorded on the in the proposal footprint or adjacent areas. Seedbanks, mycorrhizal associations and opportunity for recruitment in the proposal footprint would be removed. About 24 ramets would be retained in the SICTA land north of the proposal footprint. Seedbanks,

mycorrhizal associations and recruitment opportunities along Heathcote Road and the SICTA land to the north of the proposal footprint are unlikely to be impacted by the proposal. The stand of *Allocasuarina diminuta* subsp. *mimica* immediately to the north of the proposed ARRT facility may be impacted by changes to water flow at this location. This stand is located on skeletal soils in a previously cleared area, and a number of dead ramets were observed. Reduction in water could cause further death of ramets at this location. The pollination cycle, seedbank and recruitment opportunities of the larger subpopulation (>100 ramets) along the western side of Heathcote Road are unlikely to be impacted by the proposal. Mycorrhizal associations in these areas are unlikely to be disturbed. Smaller subpopulations on the eastern side of Heathcote Road and in SICTA land will be able to continue to interact genetically with this larger population and other populations in the area.

Ideally, all cones will be harvested from ramets prior to clearing and all rootstocks and ramets will be collected during clearing and translocated initially to the nursery for replanting in appropriate habitat in areas which will not be disturbed. This would be carried out with input from the Sutherland Shire Council bushcare staff.

(d) a description of the extent to which the local population will become fragmented or isolated as a result of the proposed development

The subpopulations in the proposal footprint are connected to or are located near subpopulations present along Heathcote Road. A narrow band of vegetation would remain along Heathcote Road, adjacent to the proposal site, providing connectivity between the main population to the north and records to the south. A subpopulation of about 12 ramets was recorded in this vegetation adjacent to the proposal footprint, and a subpopulation of over 100 ramets was recorded on the opposite side of Heathcote Road. Large areas of potential habitat exist in surrounding areas, such as Holsworthy Army Base, the ANSTO buffer zone and Heathcote National Park. Red Bloodwood - Scribbly Gum heathy woodland, the vegetation type in which this species occurs in the study area, is the dominant vegetation type in the surrounding study area and nearby areas in the locality. The vegetation to be removed is located adjacent to the already cleared landfill and Heathcote Road. No area of vegetation would be isolated as a result of the proposal. Vast expanses of vegetation are present on the western side of Heathcote Road, which may also provide habitat for this endangered population. The larger subpopulation along Heathcote Road is already fragmented from the populations along the eastern side of Heathcote Road and in the proposal footprint. The proposal is unlikely to fragment an important population of this species into two or more populations.

(e) the relationship of the local population to other population/populations of the species. This must include consideration of the interaction and importance of the local population to other population/populations for factors such as breeding, dispersal and genetic viability/diversity, and whether the local population is at the limit of the species' range.

The sub-population in the LHRRP is small and mainly occurs in disturbed locations. It is located near the southern end of the endangered population's range. Adjacent populations include those located alongside Heathcote Road. The loss of the subpopulation from within the proposal footprint will reduce genetic diversity to a small degree. These subpopulations in the proposal footprint are likely to represent less than 3% of the total population currently present in the locality. Pollination between the Heathcote Road populations and the population retained within SICTA land to the north of the proposal footprint could continue to occur following construction as these stands occur in contiguous vegetation. There are also conserved populations to the north-east of the LHRRP, in a Council Reserve and in the Holsworthy army base. The loss of the ramets in the proposal footprint is not likely to reduce the genetic viability or diversity of the endangered population as a whole. In addition, propagation of individuals

from seed and relocated stock will assist with the preservation of the genetic present in the proposal footprint. In the long-term there is potential to increase the size of this subpopulation through propagation.

(f) the extent to which the proposed development will lead to an increase in threats and indirect impacts, including impacts from invasive flora and fauna, that may in turn lead to a decrease in the viability of the local population

This endangered population is threatened by destruction of habitat, fragmentation, changes to fire regimes, fragmentation and weeds (OEH 2015c). The likely impacts from the loss of habitat and fragmentation are discussed above. The proposal is unlikely to alter fire regimes in the surrounding area. There is unlikely to be an increase in fire frequency that could lead to insufficient seed production and loss of mature individuals in the surrounding area as a result of the proposal. Weeds such as African Lovegrass (*Eragrostis curvula*) which can affect the intensity of fire as well as be an impediment to recruitment (OEH 2015c) are present in the proposal footprint and in SICTA land to the north. The proposal is unlikely to result in increases in the incident of weed species. Mitigation measures are proposed to manage weeds during construction and operation (see section 6.3).

Possible changes to hydrology resulting from clearing of vegetation from the site may impact small areas of vegetation immediately adjacent to and downslope of the proposal. Construction of the ARRT facility would result in changes to surface water flow in the immediate vicinity. The construction of the new ARRT facility and the relocation of the GO facility would involve excavation works but these works are not expected at depths that would intercept groundwater. The stand of *Allocasuarina diminuta* subsp. *mimica* immediately to the north of the proposed ARRT facility may be impacted by changes to water flow at this location. This stand is located on skeletal soils in a previously cleared area, and a number of dead ramets were observed. Reduction in water could cause further death of ramets at this location. The proposal may also lead to a reduction in water reaching stands of the subspecies located between the proposal footprint and Heathcote Road. These would also receive runoff from Heathcote Road and are not likely to rely on water seeping from the proposal footprint. The large stands located on the western side of Heathcote Road would not be impacted by the proposal.

Edge effects could impact potential habitat for this species. Edge effects (changes in environmental conditions) occur in zones of vegetation on the edges of fragments. The edge affected zone is generally taken to be 50 m from the disturbed edge (Bali 2005). The proposal footprint is already highly disturbed. The impacts of edge effects are also visible across much of the area where the species occurs due to the presence of existing clearings for access tracks, as well as the landfill and Heathcote Road. The proposal would create a new edge around the proposed ARRT and GO facilities, however the majority of this edge is already impacted by edge effects from Heathcote Road and disturbed areas within the SICTA area. Specimens recorded outside the footprint were located alongside Heathcote Road and adjacent to cleared areas within SICTA land, all of which are already edge-effected. This species prefers disturbed edges and is unlikely to be impacted by changes to edges resulting from the proposal.

(g) the measure/s proposed to contribute to the recovery of the species in the IBRA subregion.

Despite the removal of stands of *Allocasuarina diminuta* subsp. *mimica*, the proposal should also contribute to the recovery of the species. The on-site nursery will assist with the cultivation of individuals of the species, through collection of seed prior to clearing, and propagation of plants from seed and collection of ramets from the proposal footprint. Preliminary seed collection took place in early March 2015, following the targeted survey. Ideally, all cones will be harvested from ramets prior to clearing and all rootstocks and ramets will be collected during clearing and translocated initially to the nursery for replanting in appropriate habitat in areas

which will not be disturbed. This would be carried out with input from the Sutherland Shire Council bushcare staff. Plants would be propagated for eventual planting elsewhere on the LHRP where appropriate soil and vegetation type is present, and where the plants are unlikely to be impacted by future development. Soil should also be translocated to preserve associated mycorrhizia. Seedlings would also be provided to Sutherland Council for planting in other suitable areas.

A management plan for the collection of seed and translocation would be prepared as part of the CEMP for the proposal (see section 6.3) and would include monitoring and assessment of the success of the program. Any planting carried out in the proposed offset site would be included in the Management Action Plan for the offset site (see section 8).

***Prostanthera saxicola* population**

This population occurs mainly between Holsworthy station and Sutherland station, north from Lucas Heights and south of the Georges River (OEH 2015b). Five records of the species are mapped in the Atlas of NSW Wildlife. Four records are located north of the study area in land adjacent to Heathcote Road, and one is located to the east at Woronora Heights (OEH 2015a). The closest record is located over 1 km to the north of the study area boundary.

This species grows primarily in eucalypt forest, heath and low shrubland, often in damp or moist sites (OEH 2015a). Woodland in the proposal footprint has been heavily disturbed, with much of it being regrowth on skeletal soils. Intact vegetation is dry, with few, if any, damp or moist sites. This species was not recorded during surveys in the proposal footprint and adjacent areas. Given the lack of preferred habitat and lack of any evidence of its occurrence, this population is unlikely to be present in the proposal area.

The proposal would remove 13.03 of woodland habitat from the locality. Large areas of woodland habitat are located within the locality, including within Holsworthy army reserve (where individuals of this species have been recorded), Heathcote National Park, Georges River National Park and the Royal National Park. The loss of vegetation from the proposal footprint is not likely to affect the available habitat for the species, as no individuals were recorded in the proposal footprint and preferred habitat is not present. Vegetation to be removed as a result of the proposal is located alongside the existing landfill and Heathcote Road. The proposal will not isolate any habitat for the species. The proposal would cause an incremental increase in fragmentation in the locality. Given the distance of the proposal from the known population and comparatively small area of vegetation that would be removed, the proposal is unlikely to interfere with the pollination cycle, local seedbanks, recruitment, and interactions with pollinators.

The proposal is unlikely to increase threats or result in indirect impacts on this species, given the closest record is located over 1 km from the study area.

7.4.4 Biodiversity credits

The data from the fieldwork and mapping was entered into Version 4.0 of the BioBanking credit calculator as a 'Major Project' assessment to determine the number and type of biodiversity credits that would be required to offset impacts at the proposal footprint. The Biodiversity credit report is included in Appendix A and summarised below.

A total of **459** ecosystem credits would be required to offset the impacts of the proposal as shown in Table 7.5.

Table 7.5 Ecosystem credits required to offset impacts of the proposal

Plant community type	Area (ha)	Loss in landscape value	Loss in site value score	TEC offset multiplier	Threatened species with highest credit requirement	Threatened species offset multiplier	Ecosystem credits required
Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux (ME014)	2.55	9.6	65.28	1	Spotted-tailed Quoll	2.6	114
Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux (regenerating and planted (ME014)	10.48	9.6	47.05	1	Spotted-tailed Quoll	2.6	345

Species credits required to offset the impacts of the proposal are shown Table 7.6.

Table 7.6 Species credits required to offset impacts of the proposal

Scientific name	Common name	TS offset multiplier	Species credits required
<i>Acacia bynoeana</i>	Bynoe's Wattle	7.7	77
<i>Cercartetus nanus</i>	Eastern Pygmy-possum	2.0	261
<i>Heleioporus australiacus</i>	Giant Burrowing Frog	1.3	169
<i>Varanus rosenbergi</i>	Rosenberg's Goanna	3.3	430

8. Draft biodiversity offset strategy

This section presents the draft Biodiversity Offset Strategy, which outlines how the proponent intends to offset the impacts of the proposal. The precise quantum of biodiversity offsets required and the final approach to delivering offsets will be included in the final Biodiversity Offset Strategy. The offset strategy would require approval from the Sutherland Shire Council.

The credit calculator has been used in this Biodiversity Assessment Report to determine the number and type of biodiversity credits required to offset impacts of the proposal. The Biodiversity credit report is included in Appendix A.

The Biodiversity Offset Strategy for the proposal would include the purchase and retirement of the following biodiversity credits as calculated in accordance with the FBA:

- 459 ecosystem credits for impacts on Red Bloodwood - Scribbly Gum heathy woodland on sandstone plateaux (ME014).
- 77 species credits for *Acacia bynoeana*
- 169 species credits for the Giant Burrowing Frog
- 430 species credits for Rosenberg's Goanna
- 261 species credits for the Eastern Pygmy-possum.

The matching suite of biodiversity credits is listed in the biodiversity credit report, which is included in Appendix A. As noted earlier, *Allocasuarina diminuta* subsp. *mimica* is not yet included in the credit calculator. Once this endangered population is added, credits will be calculated.

The proponent will finalise the Biodiversity Offset Strategy that forms part of the final EIS in consultation with the determining authorities and SSC, either through:

- The survey and assessment of a suitable offset site in accordance with the BBAM, an application for a BioBanking agreement and then the purchase and retirement of matching biodiversity credits.
- The purchase and retirement of matching biodiversity credits from an established biobank.
- The provision of supplementary measures if appropriate biodiversity credits or appropriate like for like offsets are not available.

The Biodiversity Offset Strategy would be developed in consultation with the determining authorities and SSC. The offset will be within Sutherland Shire where practicable.

The proponent is currently investigating using the SICTA land north of the proposed ARRT facility as a biobank site. It is anticipated that the survey and assessment of the preferred biobank site in accordance with the BBAM, and the application for a BioBanking agreement would occur within 12 months of the issuing of Conditions of Consent. The necessary credits would then be retired. Further consultation is expected with OEH during the assessment of the biobank site to agree on the exact number and type of species credits required to adequately offset the proposal.

An initial investigation of the unused sections of the SICTA site, the preferred biobank site for providing biodiversity credits for the project, have confirmed the site contains 'matching' vegetation for the ecosystem credits required and contains individuals of the endangered population of the *Allocasuarina diminuta* subsp. *mimica* as well as suitable habitat for the three threatened fauna species requiring offsetting. In regard to these species, it is expected that due

to the approach taken in this assessment to assume these species are present based on known records and habitat conditions, the same outcome would apply to the proposed biobank as it is located immediately adjacent to the development site in a contiguous patch of the same vegetation type and in the same or better condition. Further survey would be carried out after project approval to ascertain whether *Acacia bynoeana* is present at the site, and whether additional credits or supplementary measures are required to adequately offset impacts on this species. Additional credits would be sourced from within Sutherland Shire where possible. Consultation would be undertaken with Sutherland Shire Council to locate appropriate offset sites if additional credits are required.

The impacts on MNES have been assessed in a referral to the Commonwealth Government. The Minister for the Environment has determined that the proposal is not a controlled action under the EPBC Act. As such, there is no requirement for biodiversity offsets under the EPBC Act and associated offsets policy (DSEWPac, 2012).

9. Conclusions

9.1 Summary of key findings

This Biodiversity Assessment Report has been prepared in accordance with the FBA to describe the biodiversity values present within the proposal footprint, assess impacts of the proposal and determine the number of biodiversity credits required to offset impacts of the proposal.

The majority of the proposal footprint is located within the existing landfill, which has been cleared and substantially modified. The proposed ARRT and GO facility have been positioned within vegetated land of which much had been previously cleared but is now regenerating. The proposal's impacts are therefore substantially less than would be associated with an undisturbed 'green field' site. The proposal has been purposefully designed to avoid or further reduce impacts on biodiversity values as far as is practicable.

Specific mitigation measures are recommended to minimise impacts on the natural environment and threatened biota, including:

- Erosion and sediment control measures to avoid secondary impacts on surrounding native vegetation and aquatic habitats
- Restriction of access into adjacent remnant vegetation during construction and machinery hygiene protocols, washing of vehicles and erection of appropriate barriers to reduce the risk of transmission of weeds, contaminants or pathogens
- Management of noxious and environmental weeds.
- Pre-clearing surveys for fauna such as frogs and hollow-dependent species.
- Fauna management during clearing activities.

Despite measures taken to avoid and mitigate impacts, the proposal would result in some unavoidable residual adverse impacts imposed upon some elements of the natural environment, including removal of native vegetation, a threatened plant and ramets of a threatened population, fauna habitat resources and imposition of edge effects on adjoining areas of native vegetation. These residual impacts are small in extent and magnitude and would comprise a minor reduction in biodiversity values in the study area.

No threatened ecological communities would be directly impacted. The proposal may have a minor indirect impact on a nearby Coastal Upland Swamp, however this is unlikely to change the species composition of the community or reduce its extent. The stand of Shale Sandstone Transition Forest located to the north of the existing landfill is unlikely to be impacted by the proposal given its distance from the proposal footprint and lack of any clearing in this area.

One individual of the endangered plant *Acacia bynoeana* would be removed as a result of the proposal. 82 ramets of the *Allocasuarina diminuta* subsp. *mimica* that form part of the endangered population in the proposal footprint would be removed.

The proposal would remove a very small proportion of available habitat resources for local populations of native fauna. Impacts would include the removal of:

- 13.03 ha of potential foraging habitat for mobile threatened fauna species, including the Grey-headed Flying-fox, birds and microbats
- 13.03 ha of potential foraging, shelter and nest or den sites for the Eastern Pygmy-possum and the Spotted-tailed Quoll

- 13.03 ha of potential shelter, foraging and low quality potential breeding habitat for the Giant Burrowing Frog.
- The loss of five hollow-bearing trees and two rock outcrops
- The removal of one artificial dam and a section of Mill Creek. Mill Creek would be realigned to allow continued flow.

The proposal would not impact any threatened biota listed under the FM Act.

A FBA assessment and credit calculations have been performed in accordance with the methodology (OEH, 2014a) and using credit calculator Version 4.0. The FBA includes thresholds for assessing and offsetting impacts of development (see table 4 of OEH, 2014a). With reference to these thresholds the proposal:

- Would remove 82 ramets of the endangered population of *Allocasuarina diminuta* subsp. *mimica*. Note that this species has not yet been added to the credit calculator and thus no credits can be calculated for it.
- Includes a total of 13.03 hectares of impacts for which the assessor is required to determine an offset, comprising:
 - 459 ecosystem credits for impacts on Red Bloodwood - Scribbly Gum heathy woodland on sandstone plateaux (ME014).
 - 77 species credits for *Acacia bynoeana*
 - 169 species credits for the Giant Burrowing Frog
 - 430 species credits for Rosenberg's Goanna
 - 261 species credits for the Eastern Pygmy-possum.
- Includes a total of 98.45 hectares of impacts for which the assessor is not required to determine an offset, comprising the removal of exotic grassland and cleared land.

The Biodiversity Offset Strategy for the proposal would include the purchase and retirement of biodiversity credits as calculated in accordance with the FBA.

9.2 Meets identified objectives

This report addresses the Secretary's Environmental Assessment Requirements (Section 1.6) and concludes that the proposal would meet the following objectives as identified in Section 1.2:

- No significant impacts on the natural environment and threatened biota
- Avoid or further reduce impacts on biodiversity values as far as is practicable
- Minimise the occurrence of pests, vermin and noxious weeds

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11. Limitations

This report: has been prepared by GHD for SITA Australia Pty Ltd and may only be used and relied on by SITA Australia Pty Ltd for the purpose agreed between GHD and the SITA Australia Pty Ltd as set out in Section 1.1 of this report.

GHD otherwise disclaims responsibility to any person other than SITA Australia Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

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

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

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer Section 3.6 of this report). GHD disclaims liability arising from any of the assumptions being incorrect. Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Appendices

Appendix A Final credit report

Biodiversity credit report



This report identifies the number and type of biodiversity credits required for a major project.

Date of report: 11/05/2015

Time: 3:39:03PM

Calculator version: v4.0

Major Project details

Proposal ID:	0160/2015/1590MP
Proposal name:	Lucas Heights Resource Recovery Project
Proposal address:	Little Forest Road Lucas Heights NSW
Proponent name:	SITA Australia
Proponent address:	Level 3 3 Rider Boulevard Rhodes NSW 2138
Proponent phone:	
Assessor name:	Kirsten Crosby
Assessor address:	Level 15 133 Castlereagh Street Sydney NSW 2000
Assessor phone:	02 9239 7225
Assessor accreditation:	0160

Summary of ecosystem credits required

Plant Community type	Area (ha)	Credits created
Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion	13.03	460.00
Total	13.03	460

Credit profiles

1. Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion, (ME014)

Number of ecosystem credits created	460
IBRA sub-region	Sydney Cataract - Sydney Metro

Offset options - Plant Community types	Offset options - IBRA sub-regions
<p>Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin Bioregion, (ME012)</p> <p>Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion, (ME014)</p> <p>Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion, (ME029)</p> <p>Red Bloodwood - Smooth-barked Apple shrubby forest on shale or ironstone of coastal plateaux, Sydney Basin Bioregion, (ME039)</p>	<p>Sydney Cataract - Sydney Metro and any IBRA subregion that adjoins the IBRA subregion in which the development occurs</p>

Summary of species credits required

Common name	Scientific name	Extent of impact Ha or individuals	Number of species credits created
Eastern Pygmy-possum	Cercartetus nanus	13.03	261
Bynoe's Wattle	Acacia bynoeana	1.00	77
Giant Burrowing Frog	Heleioporus australiacus	13.03	169
Rosenberg's Goanna	Varanus rosenbergi	13.03	430

Appendix B Desktop assessment of threatened biota

Threatened ecological communities that occur in the study area

Name	TSC Act Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
Coastal Upland Swamp in the Sydney Basin Bioregion	EEC	EEC	Community known to occur within locality (OEH 2015a) Community recorded east of the site by GHD (2011)	Includes open graminoid heath, sedgeland and tall scrub associated with periodically waterlogged soils on the Hawkesbury sandstone plateaus. Generally associated with soils that are acidic and vary from yellow or grey mineral sandy loams with a shallow organic horizon to highly organic spongy black peat soils with pallid subsoils. May include tall open scrubs, tall closed scrubs, closed heaths, open graminoid heaths, sedgelands and fernlands.	Present. Occurs about 40 m north of the proposed pond to the north of the ARRT facility.	Nil. Community not identified in the proposal footprint.	No direct impacts. Potential for indirect impacts as the community is located downslope of the proposal.
Shale/Sandstone Transition Forest	CEEC	CEEC	Community known to occur within locality (OEH 2015a); community likely occur within locality (DotE 2015a) Community recorded to the north of the proposal footprint by Sutherland Shire Council.	Occurs on the edges of the Cumberland Plain where clay soils on shale intergrade with sandstone soils, or where shale caps overlay sandstone. Species composition variable depending on soil influences. Dominant tree species include <i>Eucalyptus tereticornis</i> , <i>E. punctata</i> , <i>E. globoidea</i> , <i>E. eugenioides</i> , <i>E. fibrosa</i> and <i>E. crebra</i> . Areas with a low sandstone influence have an understorey closer to Cumberland Plain Woodland.	Present. Occurs to the north-east of the proposal footprint (and the existing void).	Nil. Community not identified in the proposal footprint.	No direct impacts. Unlikely to be indirectly impacted by the proposal due to the distance from the proposal and lack of clearing activities nearby .

Threatened flora species and populations known or predicted to occur in the locality

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
<i>Acacia bynoeana</i>	Bynoe's Wattle	E	V	1 record within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a)	Endemic to central eastern NSW, currently known from only 34 locations, many of only 1-5 plants. Grows mainly in heath/ dry sclerophyll forest on sandy soils, prefers open, sometimes slightly disturbed sites such as trail margins, road edges, and in recently burnt open patches. Flowers September to March, and fruit matures in November.	Likely. Records exist within the locality and suitable habitat occurs throughout native vegetation in the study area.	Present. One individual recorded in woodland vegetation within the area proposed for the ARRT facility. No additional specimens recorded during surveys.	One individual would be removed. No other individuals have been recorded in the proposal footprint.
<i>Acacia pubescens</i>	Downy Wattle	V	V	118 records within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a)	Occurs mainly in Bankstown-Fairfield-Rookwood and Pitt Town areas, with outliers at Barden Ridge, Oakdale and Mountain Lagoon. Grows on alluviums, shales and shale/sandstone intergrades. Soils characteristically gravelly, often with ironstone. Occurs in open woodland and forest, in communities including Cooks River/ Castlereagh Ironbark Forest, Shale/ Gravel Transition Forest and Cumberland Plain Woodland. Flowers August to October.	Likely. Records exist within the locality and suitable habitat occurs in good quality woodland in the study area.	Unlikely. Could theoretically occur in woodland vegetation within the area proposed for the ARRT facility, however none recorded during targeted surveys. Historical clearing in the study area likely to have substantially reduced habitat quality. Not recorded during November 2012/January 2015/March 2015 searches.	Impacts unlikely
<i>Allocasuarina diminuta</i> subsp. <i>mimica</i>	<i>Allocasuarina diminuta</i> subsp. <i>mimica</i> L.A.S.Johnson population in the Sutherland and Liverpool local government areas	EP		22 records within 10km (OEH 2015a)	Occurs along sandstone ridges and upper hillsides in the region northwest from Heathcote, towards Menai and Holsworthy, in heathy and low open woodland communities. It is restricted to the Local Government Areas listed in this instance (Sutherland and Liverpool).	Present. About 136 ramets recorded along Heathcote Road and in SICTA land to the north of the proposal footprint.	Present. 58 ramets recorded within the proposal footprint.	Proposal would remove 58 ramets.
<i>Allocasuarina glauca</i>		E	E	1 record within 10km (OEH 2015a); Species or species habitat	Primarily restricted to small populations in and around Castlereagh NR (NW Cumberland Plain), but with an outlier population at Voyager Point, Liverpool. Also	Unlikely. Potential habitat may be present, however no Castlereagh	Unlikely. Could theoretically occur in woodland vegetation within the	Impacts unlikely

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
				may occur within locality (DotE 2015a)	reported from Holsworthy Military Area. Grows on tertiary alluvial gravels, with yellow clayey subsoil and lateritic soil. Occurs in Castlereagh open woodland.	woodland known from the study area.	area proposed for the ARRT facility, however none recorded during targeted surveys. Historical clearing in the study area likely to have substantially reduced habitat quality. Not recorded during November 2012/January 2015/March 2015 searches.	
<i>Asterolasia elegans</i>		E	E	Species or species habitat likely to occur within locality (DotE 2015a)	Occurs north of Sydney, in the Baulkham Hills, Hawkesbury and Hornsby LGAs, may also occur in the western part of Gosford LGA. 7 known populations. Occurs on Hawkesbury sandstone, commonly amongst rocky outcrops and boulders in sheltered forests on mid- to lower slopes and valleys.	Nil. Outside known distribution.	Nil. Outside known distribution.	Nil
<i>Astrotricha crassifolia</i>	Thick-leaf Star-hair	V	V	Species or species habitat likely to occur within locality (DotE 2015a)	Occurs near Patonga (Gosford LGA), and in Royal NP and on the Woronora Plateau (Sutherland and Campbelltown LGAs). There is also a record from near Glen Davis (Lithgow LGA). Grows on dry ridgetops to 300 m altitude, associated with very rich heath, or dry sclerophyll woodland on sandstone.	Possible. Suitable habitat exists in good quality woodland in the study area.	Unlikely. Could theoretically occur in woodland vegetation within the area proposed for the ARRT facility, however none recorded during targeted surveys. Historical clearing in the study area likely to have substantially reduced habitat quality. Not recorded during November 2012/January 2015/March 2015 searches.	Impacts unlikely
<i>Caesia parviflora</i> var. <i>minor</i>	Small Pale Grass-lily	E		1 record within 10km (OEH 2015a)	In NSW occurs in Barcoongere State Forest between Grafton and Coffs Harbour. May be more widely distributed as not often identified to subspecies level. Grows in	Nil. Outside known distribution.	Nil. Outside known distribution.	Nil

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					damp open places in open forest on sandstone.			
<i>Caladenia tessellata</i>	Thick Lip Spider Orchid	E	V	Species or species habitat likely to occur within locality (DotE 2015a)	Occurs from Central Coast NSW to southern VIC. Mostly coastal but extends inland to Braidwood in southern NSW. In NSW grows in grassy dry sclerophyll woodland on clay loam or sandy soils, and less commonly in heathland on sandy loam soils (Duncan 2010).	Possible. Potential habitat present in grassy woodland located to the north and east of the proposal footprint.	Unlikely. No grassy woodland present in the proposal footprint. Historical clearing in the study area likely to have substantially reduced habitat quality.	Impacts unlikely
<i>Callistemon linearifolius</i>	Netted Bottle Brush	V		7 record within 10km (OEH 2015a)	Recorded from the Georges to Hawkesbury Rivers in Sydney, and north to Nelson Bay. There is also a recent record from the northern Illawarra. In Sydney, recent records are limited to the Hornsby Plateau area near the Hawkesbury River. Grows in dry sclerophyll forest on the coast and adjacent ranges.	Possible. Suitable habitat occurs in low woodland in the study area, although outside the main distribution of the species.	Unlikely. Could theoretically occur in good quality woodland vegetation within the area proposed for the ARRT facility, however none recorded during targeted surveys. Historical clearing in the study area likely to have substantially reduced habitat quality. Not recorded during November 2012/January 2015 searches.	Impacts unlikely
<i>Cryptostylis hunteriana</i>	Leafless Tongue Orchid	V	V	Species or species habitat likely to occur within locality (DotE 2015a)	Occurs in coastal areas from East Gippsland to southern Queensland. Habitat preferences not well defined. Grows mostly in coastal heathlands, margins of coastal swamps and sedgelands, coastal forest, dry woodland, and lowland forest. Prefers open areas in the understorey and is often found in association with <i>Cryptostylis subulata</i> and the <i>Cryptostylis erecta</i> . Soils include moist sands, moist to dry clay loam and occasionally in accumulated eucalypt leaves. Flowers November-February.	Possible. Potential habitat occurs in low woodland in the study area.	Unlikely. Historical clearing in the study area likely to have substantially reduced habitat quality. No related orchids recorded in the proposal area. No moist soils present. Not recorded during November 2012/January 2015 searches.	Impacts unlikely

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
<i>Deyeuxia appressa</i>		E	E	Species or species habitat likely to occur within locality (DotE 2015a)	Known only from two pre-1942 records in Sydney, at Saltpan Creek and Killara. May be extinct in the wild. Thought to occur in moist conditions.	Nil. Outside predicted area of distribution.	Nil. Outside predicted area of distribution.	Nil
<i>Epacris purpurascens</i> var. <i>purpurascens</i>		V		1 record within 10km (OEH 2015a)	Occurs from Gosford in the north, Narrabeen in the east, Silverdale in the west and Avon Dam vicinity in the South. Grows in a range of sclerophyll forest, scrubs and swamps, most of which have a strong shale soil influence.	Possible. May occur in woodland in shale transition areas.	Unlikely. No shale soils present. Historical clearing in the study area likely to have substantially reduced habitat quality. Not recorded during November 2012/January 2015/March 2015 searches.	Impacts unlikely
<i>Eucalyptus camfieldii</i>	Camfield's Stringybark	V	V	17 records within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a) Species recorded immediately east of the site by GHD (2011)	Occurs from Raymond Terrace to Waterfall, with populations known from Norah Head (Tuggerah Lakes), Peats Ridge, Mt Colah, Elvina Bay Trail (West Head), Terrey Hills, Killara, North Head, Menai and the Royal NP. Occurs in exposed situations on sandstone plateaus, ridges and slopes near the coast, often on the boundary of tall coastal heaths or low open woodland. It grows in shallow sandy soils overlying Hawkesbury sandstone.	Present. Recorded in heath vegetation in the eastern portion of the study area. Potential habitat is restricted to heath and the edges of heath in the study area.	Unlikely. Could theoretically occur in woodland vegetation within the area proposed for the ARRT facility, however none recorded during surveys.	Low potential for indirect impacts
<i>Genoplesium baueri</i>	Bauer's Midge Orchid	E	E	Species or species habitat known to occur within locality (DotE 2015a)	Occurs from Ulladulla to Port Stephens, with only 13 known extant populations. Grows in sparse sclerophyll forest and moss gardens over sandstone. Flowers from February to March.	Possible. Potential habitat occurs in sandstone woodland in the study area. No local records.	Unlikely. Historical clearing in the study area likely to have substantially reduced habitat quality. Few orchids recorded in the proposal area. No moss gardens present. Not recorded during March 2015 searches. No orchids recorded during this survey	Impacts unlikely

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
							despite good growing conditions.	
<i>Grevillea parviflora</i> subsp. <i>parviflora</i>	Small-flower Grevillea	V	V	5 records within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a)	Occurs between Moss Vale/Bargo and lower Hunter Valley, with most occurrences in Appin, Wedderburn, Picton and Bargo. Broad habitat range including heath, shrubby woodland and open forest on light clay or sandy soils, and often in disturbed areas such as on the fringes of tracks.	Likely. Records exist within 10km and suitable habitat occurs in native vegetation in the study area.	Unlikely. Could theoretically occur in good quality woodland vegetation within the area proposed for the ARRT facility, however none recorded during targeted surveys. Historical clearing in the study area likely to have substantially reduced habitat quality. Not recorded during November 2012/January 2015/March 2015 searches.	Impacts unlikely
<i>Hibbertia stricta</i> subsp. <i>furcatula</i>		E		17 records within 10km (OEH 2015a)	2 known populations: one either side of the Woronora River gorge including the Menai-Bangor, Alfords Point and Illawong areas in the north and Maandowie Reserve, Loftus on the southern side; and west and southwest of Nowra. Occurs in dry sclerophyll forest and woodland. Northern metapopulation occurs on upper slopes and above the Woronora escarpment, at or near the interface of Hawkesbury sandstone and the Lucas Heights soil landscape. Southern population appears to occur in sandy soils on sandstone with one record from gravelly clay soil.	Likely. Records exist within 10km and suitable habitat occurs in native vegetation in the study area.	Unlikely. Could theoretically occur in good quality woodland vegetation within the area proposed for the ARRT facility, however none recorded during targeted surveys. Historical clearing in the study area likely to have substantially reduced habitat quality. Not recorded during November 2012/January 2015/March 2015 searches.	Impacts unlikely
<i>Leucopogon exolasius</i>	Woronora Beard-heath	V	V	7 records within 10km (OEH 2015a); Species or species habitat	Occurs along the upper Georges River and in Heathcote NP, Royal NP and is also known from the Blue Mountains along the Grose River. Grows in woodland on	Likely. Records exist within 10km and suitable habitat occurs in woodland in the	Unlikely. Could theoretically occur in good quality	Impacts unlikely

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
				likely to occur within locality (DotE 2015a)	sandstone and prefers rocky hillsides along creek banks up to 100 m altitude. Associated species include <i>Eucalyptus piperita</i> , <i>E. sieberi</i> , <i>Pultenaea flexilis</i> , <i>Leptospermum trinervium</i> and <i>Dillwynia retorta</i> .	study area.	woodland vegetation within the area proposed for the ARRT facility, however none recorded during targeted surveys. Historical clearing in the study area likely to have substantially reduced habitat quality. Not recorded during November 2012/January 2015/March 2015 searches.	
<i>Leucopogon fletcheri</i> subsp. <i>fletcheri</i>		E		1 record within 10km (OEH 2015a), last recorded 1989	Restricted to NW Sydney between St Albans and Annangrove, within the Hawkesbury, The Hills and Blue Mountains LGAs. Occurs in dry eucalypt woodland or shrubland on clayey lateritic soils, generally on flat to gently sloping terrain along ridges and spurs. Flowers August to September.	Nil. Outside known distribution.	Nil. Outside known distribution.	Nil
<i>Melaleuca biconvexa</i>	Biconvex Paperbark	V	V	Species or species habitat may occur within locality (DotE 2015a)	Scattered, disjunct populations in coastal areas from Jervis Bay to Port Macquarie, with most populations in the Gosford-Wyong areas. Grows in damp places, often near streams or low-lying areas on alluvial soils of low slopes or sheltered aspects.	Present. One individual recorded along Heathcote Road.	Unlikely. No suitable habitat present. Not recorded during November 2012/January 2015/March 2015 searches.	Impacts unlikely
<i>Melaleuca deanei</i>	Deane's Paperbark	V	V	31 records within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a) Species recorded immediately east of the site by GHD (2011)	Occurs from Nowra- St Albans and west to the Blue Mountains, with most records in Ku-ring-gai / Berowra and Holsworthy/Wedderburn areas. Mostly grows on broad flat ridgetops, dry ridges and slopes and strongly associated with low nutrient sandy loam soils, sometimes with ironstone. Grows in heath- open forest, often in sandstone ridgetop woodland communities.	Present. One individual recorded along Heathcote Road.	Unlikely. Could theoretically occur in good quality woodland vegetation within the area proposed for the ARRT facility, however none recorded during targeted surveys. Historical clearing in the study area likely to have substantially	Low potential for indirect impacts

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
							reduced habitat quality. Not recorded during November 2012/January 2015/March 2015 searches.	
<i>Pelargonium sp. striatellum</i> (G.W. Carr 10345)	Omeo Storksbill	E	E	Species or species habitat may occur within locality (DotE 2015a)	Omeo Storksbill is a tufted perennial forb known from only 3 locations in NSW, with two on lake-beds on the basalt plains of the Monaro and one at Lake Bathurst. It has a narrow habitat that is usually just above the high-water level of irregularly inundated or ephemeral lakes, in the transition zone between surrounding grasslands or pasture and the wetland or aquatic communities.	Nil. Outside known distribution.	Nil. Outside known distribution.	Nil
<i>Persoonia hirsuta</i>	Hairy Geebung	E	E	4 records within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a)	Occurs within the Blue Mountains, Southern Highlands and Sydney coastal regions from Hilltop to Glen Davis and Royal NP to Gosford. Population within the Hills Shire particularly important due to high density of plants. Grows on sandy soils in dry sclerophyll open forest, woodland and heath on sandstone up to 600m above sea level.	Possible. Records exist within 10km and suitable habitat occurs in native vegetation on site.	Unlikely. Could theoretically occur in good quality woodland vegetation within the area proposed for the ARRT facility, however none recorded during targeted surveys. Historical clearing in the study area likely to have substantially reduced habitat quality. Not recorded during November 2012/January 2015/March 2015 searches.	Impact unlikely
<i>Persoonia nutans</i>	Nodding Geebung	E	E	39 records within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a)	Occurs from Richmond to Macquarie Fields on the Cumberland Plain. Grows only on aeolian and alluvial sediments in sclerophyll forest and woodland vegetation communities. Largest populations occur in Agnes Banks Woodland or Castlereagh Scribbly Gum Woodland.	Unlikely. No suitable alluvial habitat present.	Unlikely. No suitable alluvial habitat present. Not recorded during November 2012/January 2015/March 2015 searches.	Impacts unlikely
<i>Pimelea curviflora</i> var.		V	V	Species or species habitat likely to	Confined to area between North Sydney in the south and Maroota in the north-west.	Nil.	Nil.	Nil

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
<i>curviflora</i>				occur within locality (DotE 2015a)	Former range extended to Parramatta River including Five Dock, Bellevue Hill and Manly. Grows on shaley/lateritic soils over sandstone and shale/sandstone transition soils on ridgetops and upper slopes amongst woodlands. Often grows amongst dense grasses and sedges. Flowers October to May.	Outside known distribution.	Outside known distribution.	
<i>Pimelea spicata</i>	Spiked Rice-flower	E	E	2 records within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a)	Disjunct populations within the Cumberland Plain (from Mount Annan and Narellan Vale to Freemans Reach and Penrith to Georges Hall) and Illawarra (from Mt Warrigal to Gerroa) (DEC 2005). In the Cumberland Plain region, restricted to areas which support or historically supported Cumberland Plain Woodland. Grows on well-structured clay soils derived from Wianamatta Shale. In the Illawarra, grows on variable soils in close proximity to the coast on hills or coastal headlands. Inhabits coastal woodland or grassland with emergent shrubs (DEC 2005).	Unlikely. Limited shale habitat present. Study area not within the Cumberland Plain.	Nil. No suitable shale habitat present. Not recorded during November 2012/January 2015/March 2015 searches.	Nil.
<i>Pomaderris brunnea</i>	Brown Pomaderris	V	V	Species or species habitat likely to occur within locality (DotE 2015a)	Mainly occurs in SW Sydney (Wollondilly and Camden LGAs), with other populations in the Hawkesbury-Wollemi region, near Walcha in the New England tablelands and Gippsland in VIC. In NSW, grows in moist woodland or open forest on clay and alluvial soils on flood plains and creek lines. Near Sydney occurs in open woodland dominated by <i>E. amplifolia</i> with <i>Allocasuarina</i> sp. and <i>Bursaria</i> sp. understorey, or on alluvial flats with eucalypts including <i>E. elata</i> , <i>E. piperita</i> and <i>E. punctata</i> (Sutter 2011).	Unlikely. Limited suitable moist woodland habitat present. Outside area of known distribution.	Unlikely. No suitable habitat present. Not recorded during November 2012/January 2015/March 2015 searches.	Nil.
<i>Prostanthera saxicola</i>	<i>Prostanthera saxicola</i> population in Sutherland and Liverpool local government areas	EP		3 records within 10km (OEH 2015a)	This population is restricted to the named local government areas (Liverpool and Sutherland) in the southern to south-western parts of Sydney. Grows in eucalypt forest and heath in association with <i>Hakea dactyloides</i> , <i>Brachyloma daphnoides</i> , <i>Banksia spinulosa</i> , <i>Baeckea brevifolia</i> , <i>Epacris pulchella</i> , <i>Acacia myrtifolia</i> and <i>Acacia ulicifolia</i> . Also occurs in heathy woodland of <i>Angophora hispida</i> , <i>Eucalyptus</i>	Possible. Suitable habitat occurs on sandstone outcrops in the study area. Not recorded during targeted November 2012/January 2015/ March 2015 searches.	Unlikely. No suitable sandstone rock habitat present. Not recorded during November 2012/January 2015/March 2015 searches.	Nil. No suitable habitat present.

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					<i>squamosa</i> and <i>Corymbia gummifera</i> .			
<i>Pterostylis gibbosa</i>	Illawarra Greenhood	E	E	Species or species habitat known to occur within locality (DotE 2015a)	Known from a small number of populations in the Illawarra, Nowra and Hunter regions. First collected in western Sydney. Only visible above the ground between late summer and spring, and only when soil moisture levels can sustain its growth. Grows in open forest or woodland, on flat or gently sloping land with poor drainage. In the Illawarra region, the species grows in woodland dominated by <i>Eucalyptus tereticornis</i> , <i>E. longifolia</i> and <i>Melaleuca decora</i> . Near Nowra, the species grows in an open forest of <i>Corymbia maculata</i> , <i>E. tereticornis</i> and <i>E. paniculata</i> . In the Hunter region, the species grows in open woodland dominated by <i>E. crebra</i> , <i>E. tereticornis</i> and <i>Callitris endlicheri</i> .	Unlikely. Outside area of known distribution.	Unlikely. Outside area of known distribution. Woodland not dominated by <i>Eucalyptus tereticornis</i> or <i>Corymbia maculata</i> . No orchid species recorded during March 2015 surveys despite good growing conditions.	Impacts unlikely.
<i>Pterostylis saxicola</i>	Sydney Plains Greenhood	E	E	16 records within 10km (OEH 2015a); Species or species habitat known to occur within locality (DotE 2015a)	Occurs in western Sydney between Picton and Freemans Reach. Grows in small pockets of shallow soil in depressions on sandstone rock shelves above cliff lines. Associated vegetation above these rock shelves is sclerophyll forest or woodland on shale or shale/sandstone transition soils. Flowers from October to December.	Possible. May occur in intact vegetation in the study area where sandstone rock shelves are present.	Unlikely. Historical clearing in the study area likely to have substantially reduced habitat quality. No sandstone rock shelves above cliff lines present. Not recorded during November 2012 searches.	Impacts unlikely.
<i>Pultenaea aristata</i>	Prickly Bush-pea	V	V	1 record within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a)	Restricted to the Woronora Plateau, a small area between Helensburgh, south of Sydney, and Mt Kiera above Wollongong (OEH 2012). Occurs in either dry sclerophyll woodland or wet heath on sandstone.	Unlikely. Outside area of known distribution.	Unlikely. Outside area of known distribution.	Impacts unlikely.
<i>Pultenaea pedunculata</i>	Matted Bush-pea	E		1 record within 10km (OEH 2015a)	3 disjunct populations in NSW: in the Cumberland Plains in Sydney, the coast between Tathra and Bermagui and the Windellama area south of Goulburn (where it is locally abundant). NSW populations typically among woodland vegetation but	Unlikely. Outside area of known distribution.	Unlikely. Outside area of known distribution.	Impacts unlikely.

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					also found on road batters and coastal cliffs. In Windellama it is largely confined to loamy soils in dry gullies.			
<i>Streblus pendulinus</i>	Siah's Backbone		E	Species or species habitat likely to occur within locality (DotE 2015a)	Siah's Backbone occurs from Cape York Peninsula to Milton, south-east New South Wales (NSW), as well as Norfolk Island (ATRP 2010; Jessup 2003; The Royal Botanic Gardens and Domain Trust 2011). Siah's Backbone is found in warmer rainforests, chiefly along watercourses. The species grows in well developed rainforest, gallery forest and drier, more seasonal rainforest (ATRP 2010).	Unlikely. No suitable habitat present.	Unlikely. No suitable habitat present.	Impacts unlikely.
<i>Syzygium paniculatum</i>	Magenta Lilly Pilly	E	V	1 record within 10km; Species or species habitat likely to occur within locality (DotE 2015a)	Occurs in narrow coastal strip from Bulahdelah to Conjola State Forest. Grows in rainforest on sandy soils or stabilised Quaternary sand dunes at low altitudes in coastal areas, often in remnant littoral or gallery rainforests.	Unlikely. No suitable habitat present.	Unlikely. No suitable habitat present.	Impacts unlikely.
<i>Thelymitra</i> sp. Kangaloon	Kangaloon Sun Orchid	CE	CE	Species or species habitat likely to occur within locality (DotE 2015a)	Only known from three locations near Robertson in the Southern Highlands. Grows in seasonally swampy sedgeland on grey silty clay loam at 600–700 m above sea level. Flowers in late October and early November.	Unlikely. Outside area of known distribution.	Unlikely. Outside area of known distribution.	Impacts unlikely.
<i>Thesium australe</i>	Austral Toadflax	V	V	Species or species habitat may occur within locality (DotE 2015a)	Found in small, scattered populations along the east coast, northern and southern tablelands. Occurs in grassland or grassy woodland, and is often found in association with Kangaroo Grass (<i>Themeda australis</i>).	Possible. Potential habitat present in the north-east of the study area.	Unlikely. No grassy woodland present.	Impacts unlikely.

Threatened fauna species known or predicted to occur in the locality

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
Birds								
<i>Rostratula australis</i>	Australian Painted Snipe	E	E	Species or species habitat likely to occur within locality (DotE 2015a)	Normally found in permanent or ephemeral shallow inland wetlands, either freshwater or brackish. Nests on the ground amongst tall reed-like vegetation near water. Feeds on mudflats and the water's edge taking insects, worm and seeds. Prefers fringes of swamps, dams and nearby marshy areas with cover of grasses, lignum, low scrub or open timber.	Unlikely. No suitable wetland habitat present.	Unlikely. No suitable wetland habitat present.	Impacts unlikely
<i>Botaurus poiciloptilus</i>	Australasian Bittern	E	E	1 record within 10km (OEH 2015a); Species or species habitat known to occur within locality (DotE 2015a)	Widespread but uncommon over most NSW except the northwest. Favours permanent freshwater wetlands with tall dense reedbeds particularly Typha spp. and Eleocharis spp., with adjacent shallow, open water for foraging. Roosts during the day amongst dense reeds or rushes and feeds mainly at night on frogs, fish, yabbies, spiders, insects and snails.	Unlikely. No suitable wetland habitat with emergent vegetation present.	Unlikely. No suitable wetland habitat with emergent vegetation present.	Impacts unlikely
<i>Ixobrychus flavicollis</i>	Black Bittern	V		1 record within 10km (OEH 2015a)	Occurs from southern NSW to Cape York and the Kimberley, and southwest WA. Inhabits terrestrial and estuarine wetlands, generally in areas of permanent water and dense vegetation. May occur in flooded grassland, forest, woodland, rainforest and mangroves as long as there is permanent water. Roosts by day in trees or within reeds on the ground. Nests in branches overhanging water and breeds from December to March.	Unlikely. No suitable wetland vegetation with emergent vegetation present in the proposal footprint.	Unlikely. No suitable wetland vegetation with emergent vegetation present in the proposal footprint.	Impacts unlikely
<i>Melithreptus gularis gularis</i>	Black-chinned Honeyeater (eastern subspecies)	V		4 records within 10km (OEH 2015a) Species recorded immediately east of the site by GHD (2011)	Widespread in NSW, but rarely recorded east of Great Dividing Range except in Richmond and Clarence River areas and scattered sites in the Hunter, Central Coast and Illawarra regions. Mostly in upper levels of drier open forests /woodlands dominated by box and ironbark eucalypts, or less commonly	Likely. May forage and breed in native vegetation in the study area.	Likely. May forage on occasion in the proposal footprint. Unlikely to breed in the proposal footprint due to disturbed nature of the vegetation.	Proposal would remove 13.03 ha of low quality foraging habitat.

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					smooth-barked gums, stringybarks and tea-trees. Forage over home range of >5 ha. Tend to occur within largest woodland patches in the landscape. They forage for insects, nectar and honeydew. The nest is hidden by foliage high in the crown of a tree.			
<i>Climacteris picumnus victoriae</i>	Brown Treecreeper (eastern subspecies)	V		1 record within 10km (OEH 2015a)	Most common on the inland slopes and plains. Inhabits eucalypt woodlands and dry open forest, usually dominated by stringybarks or rough-barked species with open grassy understorey. Fallen timber is important foraging habitat. Nests in hollows in standing trees or stumps.	Possible. Could forage and breed in the study area.	Possible. Could forage in the study area on occasion. Minimal potential breeding habitat present in the proposal footprint.	Proposal would remove 13.03 ha of low quality foraging habitat. A low number of hollow-bearing trees with small hollows would be removed.
<i>Dasyornis brachypterus</i>	Eastern Bristlebird	E	E	Species or species habitat likely to occur within locality (DotE 2015a)	Occurs in three disjunct areas of south-eastern Australia: southern Queensland/northern NSW, the Illawarra Region and in the vicinity of the NSW/Victorian border. Illawarra population comprises an estimated 1600 birds, mainly from Barren Grounds Nature Reserve, Budderoo National Park and the Jervis Bay area. Habitat characterised by dense, low vegetation including heath and open woodland with a heathy understorey. The fire history of habitat is important, and the Illawarra and southern populations reach maximum densities in habitat that have not been burnt for over 15 years.	Unlikely. Limited areas of dense heath present. No records from the Sydney Metro CMA.	Unlikely. Dense heath habitat not present in the proposal footprint.	Nil.
<i>Pandion cristatus</i>	Eastern Osprey	V		17 records within 10km (OEH 2015a)	Favours coastal areas, especially the mouths of large rivers, lagoons and lakes. They feed on fish over clear, open water. Breeding takes place from July to September in NSW, with nests being built high up in dead trees or in dead crowns of live trees, usually within one kilometre of the sea, though there are a handful of records from inland areas.	Nil. No suitable habitat present	Nil. No suitable habitat present	Nil
<i>Petroica phoenicea</i>	Flame Robin	V		2 record within 10km (OEH 2015a)	Breeds in upland moist eucalypt forests and woodlands, often on ridges and slopes, in areas of open understorey. Migrates in winter to more open lowland	Possible. May forage in the study area on occasion. Preferred breeding habitat not	Possible. May forage in the proposal footprint on occasion.	Proposal would remove 13.03 ha of potential foraging habitat.

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					habitats such as grassland with scattered trees and open woodland on the inland slopes and plains. Forages from low perches, feeding on invertebrates taken from the ground, tree trunks, logs and other coarse woody debris. Fallen logs and coarse woody debris are important habitat components. Open cup nest of plant fibres and cobweb is often built near the ground in a sheltered niche, ledge or shallow cavity in a tree, stump or bank.	present.	Preferred breeding habitat not present.	
<i>Callocephalon fimbriatum</i>	Gang-gang Cockatoo	V		7 records within 10km (OEH 2015a)	Restricted to the south-eastern coast and highlands, from the lower Hunter and northern Blue Mountains to the Southwestern Slopes, south to and contiguous with the Victorian population. Inhabits eucalypt open forests and woodlands with an acacia understorey. In summer it lives in moist highland forest types, and in winter it moves to more open types at lower elevations. The Gang-Gang Cockatoo nests in hollows in the trunks, limbs or dead spouts of tall living trees, especially eucalypts, often near water. The Gang-gang Cockatoo feeds on seeds obtained in trees and shrubs, mostly from eucalypts and wattles.	Possible. Could forage and breed in the study area.	Possible. Could forage in the study area on occasion. No breeding habitat present in the proposal footprint.	Proposal would remove 13.03 ha of low quality foraging habitat.
<i>Calyptrorhynchus lathamii</i>	Glossy Black-Cockatoo	V		1 record within 10km (OEH 2015a), last recorded 1990	Widespread but uncommon from coast to southern tablelands and central western plains. Feeds almost exclusively on the seeds of <i>Allocasuarina</i> species. Prefers woodland and open forests, rarely away from <i>Allocasuarina</i> . Roost in leafy canopy trees, preferably eucalypts, usually <1km from feeding site. Nests in large (approx. 20cm) hollows in trees, stumps or limbs, usually in Eucalypts (Higgins 1999).	Likely. Could forage and breed in the study area.	Likely. Native vegetation dominated by <i>Allocasuarina</i> species. No breeding habitat present in the proposal footprint. No evidence of chewed cones found during surveys.	Proposal would remove 13.03 ha of good quality foraging habitat.
<i>Glossopsitta pusilla</i>	Little Lorikeet	V		13 records within 10km (OEH 2015a)	Occurs from coast to western slopes of the Great Dividing Range. Inhabits dry, open eucalypt forests and woodlands.	Likely. Could forage and breed in the study area.	Possible. May occur on occasion, although previous	Proposal would remove 13.03 ha of low quality foraging

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					Occurrence is positively associated with patch size, and with components of habitat complexity including canopy cover, shrub cover, ground cover, logs, fallen branches and litter. Feed primarily on profusely-flowering eucalypts and a variety of other species including melaleucas and mistletoes. Mostly nests in small (opening approx. 3cm) hollows in living, smooth-barked eucalypts. Most breeding records are from the western slopes.		clearing may have impacted structural complexity required for this species. Limited potential breeding habitat present in the proposal footprint.	habitat.
<i>Hieraaetus morphnoides</i>	Little Eagle	V		9 records within 10km (OEH 2015a)	Occurs throughout NSW except most densely forested parts of the Dividing Range escarpment. Occupies habitats rich in prey within open eucalypt forest, woodland or open woodland. Sheoak or acacia woodlands and riparian woodlands of interior NSW are also used. For nest sites it requires a tall living tree within a remnant patch, where pairs build a large stick nest in winter and lay in early spring.	Possible. May forage and breed in the study area.	Possible. May forage on occasion in the proposal footprint. No preferred breeding habitat (tall trees) present.	Proposal would remove 13.03 ha of potential foraging habitat.
<i>Tyto novaehollandiae</i>	Masked Owl	V		3 records within 10km (OEH 2015a)	Occurs across NSW except NW corner. Most common on the coast. Inhabits dry eucalypt woodlands from sea level to 1100 m. Roosts and breeds in large (>40cm) hollows and sometime caves in moist eucalypt forested gullies. Hunts along the edges of forests and roadsides. Home range between 500 ha and 1000 ha. Prey mostly terrestrial mammals but arboreal species may also be taken.	Possible. May forage and breed in the study area.	Possible. May forage on occasion in the proposal footprint. No breeding habitat (large old hollow trees) present.	Proposal would remove 13.03 ha of potential foraging habitat.
<i>Neophema chrysogaster</i>	Orange-bellied Parrot	CE	CE	Species or species habitat may occur within locality (DotE 2015a)	Breeds in Tasmania and migrates in winter to SE South Australia and southern Victoria. There are occasional reports from NSW, including Shellharbour, Maroubra and the Shoalhaven. In winter, usually found within 3 km of the coast in saltmarsh and strandline/ foredune vegetation. May also occur on golf-courses and other grassy areas, including improved	Nil. No suitable habitat present.	Nil. No suitable habitat present.	Nil.

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					pasture.			
<i>Petroica rodinogaster</i>	Pink Robin	V		1 record within 10km (OEH 2015a), last recorded 1987	In NSW occurs mainly in the South Coast and Southern Tablelands regions. It is vagrant in the Sydney and Illawarra areas, with generally only individual birds recorded in these areas. It prefers a dense shrub layer in damp or wet forests or rainforests. It generally breeds in wet gullies. It forages for insects on the ground or in low undergrowth. It may be partly migratory or dispersive in autumn and winter. It is generally seen in pairs, occasionally small flocks.	Nil. No suitable habitat present.	Nil. No suitable habitat present.	Nil
<i>Ninox strenua</i>	Powerful Owl	V		962 records within 10km (OEH 2015a)	Occurs from the coast to the western slopes. Solitary and sedentary species. Inhabits a range of habitats from woodland and open sclerophyll forest to tall open wet forest and rainforest. Prefers large tracts of vegetation. Nests in large tree hollows (> 0.5 m deep), in large eucalypts (dbh 80-240 cm) that are at least 150 years old. Pairs have high fidelity to a small number of hollow-bearing nest trees and defend a large home range of 400 - 1,450 ha. Forages within open and closed woodlands as well as open areas.	Likely. May forage and breed in the study area.	Likely. May forage on occasion in the proposal footprint. No breeding habitat (large old hollow trees) present.	Proposal would remove 13.03 ha of potential foraging habitat.
<i>Anthochaera phrygia</i>	Regent Honeyeater	CE	E	1 record within 10km (OEH 2015a), last recorded 1983; Species or species habitat known to occur within locality (DotE 2015a)	In NSW confined to two known breeding areas: the Capertee Valley and Bundarra-Barraba region. Non-breeding flocks occasionally seen in coastal areas foraging in flowering Spotted Gum and Swamp Mahogany forests, presumably in response to drought.	Unlikely. No preferred feed trees present. Does not breed in this area.	Unlikely. No preferred feed trees present.	Impacts unlikely
<i>Ptilinopus regina</i>	Rose-crowned Fruit Dove	V		1 record within 10km (OEH 2015a)	Occurs from Newcastle north to Cape York, with vagrants occasionally as far south as Victoria. Occur mainly in sub-tropical and dry rainforest and occasionally in moist eucalypt forest and swamp forest, where fruit is plentiful. Thought to be locally nomadic in response to fruit availability.	Nil. No suitable habitat present.	Nil. No suitable habitat present.	Nil

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
<i>Petroica boodang</i>	Scarlet Robin	V		7 records within 10km (OEH 2015a) Species possibly recorded (call only) immediately east of the site by GHD (2011)	In NSW occurs from coast to inland slopes. Breeds in drier eucalypt forests and temperate woodlands, often on ridges and slopes, within open understorey of shrubs and grasses and sometimes in open areas. In autumn and winter it migrates to more open habitats such as grassy open woodland or paddocks with scattered trees. Abundant logs and coarse woody debris are important habitat components.	Possible. May forage in the study area on occasion. Preferred breeding habitat not present.	Possible. May forage in the proposal footprint on occasion. Preferred breeding habitat not present.	Proposal would remove 13.03 ha of potential foraging habitat.
<i>Tyto tenebricosa</i>	Sooty Owl	V		22 records within 10km (OEH 2015a)	Occurs in the coastal, escarpment and tablelands regions of NSW. More common in the north and absent from the western tablelands and further west. Inhabits tall, moist eucalypt forests and rainforests, and are strongly associated with sheltered gullies, particularly those with tall rainforest understorey. Roosts in tree hollows, amongst dense foliage in gullies or in caves, recesses or ledges of cliffs or banks. Nest in large (>40cm wide, 100cm deep) tree hollows in unlogged/unburnt gullies within 100m of streams or in caves.	Unlikely. Limited suitable habitat likely to be present.	Nil. No suitable habitat present.	Nil.
<i>Lophoictinia isura</i>	Square-tailed Kite	V		8 records within 10km (OEH 2015a)	Occurs across NSW, resident in North, northeast and along west-flowing rivers. Summer breeding migrant to southeast of state. Inhabits a variety of habitats including woodlands and open forests, with preference for timbered watercourses. Favours productive forests on the coastal plain, box-ironbark-gum woodlands on the inland slopes, and Coolibah/River Red Gum on the inland plains. In Sydney area nests in mature living trees within 100m of ephemeral/permanent watercourse. Large home range > 100 km2.	Possible. May forage and breed in the study area.	Possible. May forage on occasion in the proposal footprint. No preferred breeding habitat (tall trees) present.	Proposal would remove 13.03 ha of potential foraging habitat.
<i>Ptilinopus superbus</i>	Superb Fruit-Dove	V		1 record within 10km (OEH 2015a)	Occurs mainly north from NE NSW, much less common further south and largely confined to pockets of habitat south to Moruya. Vagrants occur south to VIC and TAS. Inhabits rainforest and	Nil. No suitable habitat present.	Nil. No suitable habitat present.	Nil

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					closed forests, may also forage in eucalypt or acacia woodland with fruit-bearing trees. Nests 5-30 m above ground in rainforest/rainforest edge tree and shrub species. Part of the population migratory/nomadic.			
<i>Lathamus discolor</i>	Swift Parrot	E	E	7 record within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a)	Migratory, travelling to the mainland from March to October. Breeds in Tasmania from September to January. On the mainland, it mostly occurs in the southeast foraging on winter flowering eucalypts and lerps, with records of the species between Adelaide and Brisbane. Principal over-winter habitat is box-ironbark communities on the inland slopes and plains. Eucalyptus robusta, Corymbia maculata and C. gummifera dominated coastal forests are also important habitat.	Possible. May forage on occasion in the study area. Does not breed on the Australian mainland.	Possible. <i>Corymbia gummifera</i> , a preferred forage tree in coastal areas, is the dominant eucalypt in the proposal footprint.	Proposal would remove 13.03 ha of low quality potential foraging habitat.
<i>Daphoenositta chrysoptera</i>	Varied Sittella	V		26 records within 10km (OEH 2015a)	Sedentary, occurs across NSW from the coast to the far west. Inhabits eucalypt forests and woodlands, especially rough-barked species and mature smooth-barked gums with dead branches, mallee and Acacia woodland. Sensitive to habitat isolation and loss of structural complexity, and adversely affected by dominance of Noisy Miners. Cleared agricultural land is potentially a barrier to movement. Builds a cup-shaped nest of plant fibres and cobwebs in an upright tree fork high in the living tree canopy, and often re-uses the same fork or tree in successive years.	Likely. May forage and breed in the study area.	Possible. May occur on occasion, although previous clearing may have impacted structural complexity required for this species.	Proposal would remove 13.03 ha of potential foraging habitat.
<i>Epthianura albifrons</i>	White-fronted Chat White-fronted Chat endangered population in the Sydney Metro CMA	V EP		4 records within 10km (OEH 2015a)	This species occurs from southern Queensland to Western Australia and down to Tasmania. There are two isolated sub-populations of White-fronted Chats currently known from the Sydney Metropolitan CMA: at Newington Nature Reserve and at Towra Point Nature Reserve. It is found in damp open habitats, particularly wetlands containing saltmarsh areas that are bordered by	Nil. No suitable habitat present.	Nil. No suitable habitat present.	Nil

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					open grasslands. Along the coast they are found in estuarine and marshy habitats with vegetation <1m tall, and in open grasslands and areas bordering wetlands.			
Mammals								
<i>Petrogale penicillata</i>	Brush-tailed Rock-wallaby	E	V	1 record within 10km (OEH 2015a); Species or species habitat known to occur within locality (DotE 2015a)	Occurs from the Shoalhaven north to the Queensland border. Now mostly extinct west of the Great Dividing Range, except in the Warrumbungles and Mt Kaputar. Occurs on rocky escarpments, outcrops and cliffs with a preference for complex structures with fissures, caves and ledges facing north. Diet consists of vegetation in adjacent to rocky areas eating grasses and forbs as well as the foliage and fruits of shrubs and trees.	Nil. No escarpment habitat present.	Nil. No escarpment habitat present.	Nil.
<i>Cercartetus nanus</i>	Eastern Pygmy-possum	V		25 records within 10km (OEH 2015a)	Occurs along the east coast of NSW, and inland to the Pillaga, Dubbo, Parkes and Wagga Wagga. Inhabits range of habitats from coastal heath and woodland through open and closed forests, subalpine heath and rainforest (Tulloch and Dickman 1995). Inhabits rainforest, sclerophyll forests and heath. Banksia spp. and myrtaceous shrubs and trees are favoured food sources and nesting subject sites in drier habitats. Diet mostly pollen and nectar from Banksia spp., Eucalyptus spp., Callistemon spp. and insects (Ward and Turner 2008). Nests in hollows in trees, under the bark of Eucalypts, forks of tea-trees, abandoned bird nests and Xanthorrhoea bases (Ward and Turner 2008, Tulloch and Dickman 2006).	Likely. Suitable foraging and nesting habitat present in native vegetation in the study area.	Likely. Suitable foraging and nesting habitat present in native vegetation in the proposal footprint.	Proposal would remove 13.03 ha of potential foraging and breeding habitat.
<i>Phascolarctos cinereus</i>	Koala	V	V	371 records within 10km (OEH 2015a); Species or species habitat known to occur within locality (DotE 2015a)	Occurs from coast to inland slopes and plains. Restricted to areas of preferred feed trees in eucalypt woodlands and forests. Home range varies depending on habitat quality, from < 2 to several hundred hectares.	Likely. Has been recorded previously in near the study area (OEH 2014a).	Possible. No primary feed trees present. Occasional secondary feed trees are present. May forage in the proposal footprint	Proposal would remove 13.03 ha of low quality potential foraging habitat.

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
							on occasion when moving between other areas of better quality habitat. Unlikely to breed in the proposal footprint.	
<i>Potorous tridactylus</i>	Long-nosed Potoroo,	V	V	Species or species habitat may occur within locality (DotE 2015a)	Restricted to east of the Great Dividing Range, with annual rainfall >760 mm. Inhabits coastal heath and dry and wet sclerophyll forests. Requires relatively thick ground cover and appears restricted to areas of light and sandy soil (Johnston 2008). Feeds on fungi, roots, tubers, insects and their larvae, and other soft-bodied animals in the soil.	Unlikely. Potentially suitable foraging and breeding habitat occurs in better quality vegetation in the study area. No populations known from the locality.	Unlikely. Potentially suitable foraging and breeding habitat occurs in better quality vegetation in the proposal footprint. Historical clearing in the study area likely to have substantially reduced habitat quality. No populations known from the locality.	Impacts unlikely
<i>Pseudomys novaehollandiae</i>	New Holland Mouse		V	4 record within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a)	Occurs in disjunct, coastal populations from Tasmania to Queensland. In NSW inhabits a variety of coastal habitats including heathland, woodland, dry sclerophyll forest with a dense shrub layer and vegetated sand dunes (Wilson and Bradtke 1999). Populations may recolonise/ increase in size in regenerating native vegetation after wildfire, clearing and sandmining. Presence strongly correlated with understorey vegetation density, and high floristic diversity in regenerating heath (Lock and Wilson 1999).	Unlikely. May occur in heath habitat, although not recorded during targeted trapping survey to the east of the proposal footprint (GHD 2011).	Unlikely. No suitable diverse heath habitat present in the proposal footprint.	Impacts unlikely
<i>Isodon obesulus obesulus</i>	Southern Brown Bandicoot (eastern)	E	E	Species or species habitat likely to occur within locality (DotE 2015a)	Occurs mainly in 2 areas: Ku-ring-gai Chase and Garigal National Parks N of Sydney, and far SE NSW including Ben Boyd National Park, East Boyd State Forest, Nadgee Nature Reserve, Nadgee State Forest, South East Forest and Yambulla State Forest but also occurs between these areas. Inhabits	Unlikely. Potentially suitable foraging and breeding habitat occurs in better quality vegetation in the study area. No populations known	Unlikely. Potentially suitable foraging and breeding habitat occurs in better quality vegetation in the proposal footprint. Historical	Impacts unlikely

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					scrubby vegetation, including heath, shrubland, and heathy forest and woodland. Often associated with well-drained soils and dry heathland communities, and prefers periodically burnt areas as this increases insect abundance.	from the locality.	clearing in the study area likely to have substantially reduced habitat quality. No populations known from the locality.	
<i>Dasyurus maculatus</i>	Spotted-tailed Quoll	V	E	4 records within 10km (OEH 2015a); Species or species habitat known to occur within locality (DotE 2015a)	Inhabits a range of environments including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline. Den sites are in hollow-bearing trees, fallen logs, small caves, rock crevices, boulder fields and rocky-cliff faces. Females occupy home ranges of up to 750 ha and males up to 3,500 ha, usually traversed along densely vegetated creek lines.	Possible. May forage and breed in the study area.	Possible. May utilise the proposal footprint for dispersal and foraging. Two small rock outcrops (which appear to be utilised by foxes) and fallen timber are present, representing potential foraging habitat. Tree hollows present are very small (~5cm diameter) and are not suitable denning habitat.	Proposal would remove 13.03 ha of potential foraging and breeding habitat.
<i>Petaurus norfolcensis</i>	Squirrel Glider	V		1 record within 10km (OEH 2015a)	Occurs along the drier inland slopes as well as coastal habitats. Inhabits woodland and open forest with a Eucalyptus, Corymbia or Angophora overstorey and a shrubby understorey of Acacia or Banksia. Key habitat components include reliable winter and early-spring flowering Eucalypts, Banksia or other nectar sources, and hollow-bearing trees for roost and nest sites (van der Ree and Suckling 2008, Quin et al 2004), with social groups moving between multiple hollows. Social groups include one or two adult males and females with offspring, and have home ranges of 5-10ha within NSW (van der Ree and Suckling 2008, Kavanagh 2004).	Possible. Could forage and breed in the study area.	Possible. Could forage on occasion in the proposal footprint. Limited suitable den habitat present.	Proposal would remove 13.03 ha of potential foraging and breeding habitat.

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
<i>Petaurus australis</i>	Yellow-bellied Glider	V		1 record within 10km (OEH 2015a)	Occurs along the east coast to the western slopes of the Great Dividing Range. Inhabits a variety of forest types but prefers tall mature eucalypt forest with high rainfall and rich soils. Relies on large hollow-bearing trees for shelter and nesting, with family groups of 2-6 typically denning together. In southern NSW its preferred habitat at low altitudes is moist gullies and creek flats in mature coastal forests. Mostly feeds on sap, nectar and honeydew.	Unlikely. No tall mature forest on rich soils present.	Unlikely. No tall mature forest on rich soils present.	Impacts unlikely.
<i>Pteropus poliocephalus</i>	Grey-headed Flying-fox	V	V	88 records within 10km (OEH 2015a); Foraging, feeding or related behaviour known to occur within locality (DotE 2015a) Species recorded immediately east of the site by GHD (2011)	Roosts in camps within 20 km of a regular food source, typically in gullies, close to water and in vegetation with a dense canopy. Forages in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths, swamps and street trees, particularly in eucalypts, melaleucas and banksias. Highly mobile with movements largely determined by food availability (Eby and Law 2008). Will also forage in urban gardens and cultivated fruit crops.	Present. Recorded in adjacent vegetation (GHD 2011). Would forage regularly in the area. No breeding habitat (camp site) present.	Likely. May forage in woodland habitat within the proposal footprint on occasion. No breeding habitat present.	Potential for direct impacts on foraging habitat
<i>Miniopterus schreibersii oceanensis</i>	Eastern Bentwing-Bat	V		24 records within 10km (OEH 2015a) Species recorded immediately east of the site by GHD (2011)	Generally occurs east of the Great Dividing Range along NSW coast (Churchill 2008). Inhabits various habitats from open grasslands to woodlands, wet and dry sclerophyll forests and rainforest. Essentially a cave bat but may also roost in road culverts, stormwater tunnels and other man-made structures. Only 4 known maternity caves in NSW, near Wee Jasper, Bungonia, Kempsey and Texas. Females may travel hundreds of kilometres to the nearest maternal colony (Churchill 2008).	Present. Could forage in native vegetation and cleared areas within the study area. No breeding habitat present.	Likely. Could forage in native vegetation and cleared areas within the proposal footprint. No breeding habitat present.	Proposal would alter 13.03 ha of potential foraging habitat. Species could continue to forage above ARRT and GO facility after construction.
<i>Falsistrellus tasmaniensis</i>	Eastern False Pipistrelle	V		7 records within 10km (OEH 2015a)	Occurs on southeast coast and ranges. Prefers tall (>20m) and wet forest with dense understorey. Absent from small remnants, preferring continuous forest but can move through cleared landscapes and may forage in open	Likely. May forage and breed in the study area.	Possible. May forage on occasion in the study area. Previous clearing may have impacted structural	Proposal would remove 13.03 ha of potential foraging habitat.

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					areas. Roosts in hollow trunks of Eucalypts, underneath bark or in buildings. Forages in gaps and spaces within forest, with large foraging range (12km foraging movements recorded) (Churchill 2008, Law et al 2008).		complexity preferred by this species. No suitable roosting habitat present.	
<i>Mormopterus norfolkensis</i>	Eastern Freetail-Bat	V		4 records within 10km (OEH 2015a)	Occurs in dry sclerophyll forest and woodland east of the Great Dividing Range. Forages in natural and artificial openings in vegetation, typically within a few kilometres of its roost. Roosts primarily in tree hollows but also recorded from man-made structures or under bark (Churchill 2008).	Likely. May forage and breed in the study area.	Likely. May forage in the proposal footprint. Small number of potential roost trees present. No evidence of guano.	Proposal would remove 13.03 ha of potential foraging habitat. Limited potential breeding habitat would be removed.
<i>Scoteanax rueppellii</i>	Greater Broad-nosed Bat	V		7 records within 10km (OEH 2015a)	Occurs on the east coast and Great Dividing Range. Inhabits a variety of habitats from woodland to wet and dry sclerophyll forests and rainforest, also remnant paddock trees and timber-lined creeks, typically below 500m asl. Forages in relatively uncluttered areas, using natural or man-made openings in denser habitats. Usually roosts in tree hollows or fissures but also under exfoliating bark or in the roofs of old buildings. Females congregate in maternal roosts in suitable hollow trees (Hoye and Richards 2008, Churchill 2008).	Likely. May forage and breed in the study area.	Possibly recorded. Could forage in native vegetation and cleared areas within the proposal footprint. Small number of potential roost trees present. No evidence of guano.	Proposal would remove 13.03 ha of potential foraging habitat. Limited potential breeding habitat would be removed.
<i>Chalinolobus dwyeri</i>	Large-eared Pied Bat	V	V	3 record within 10km (OEH 2015a); Species or species habitat may occur within locality (DotE 2015a)	Occurs from the coast to the western slopes of the divide. Largest numbers of records from sandstone escarpment country in the Sydney Basin and Hunter Valley (Hoye and Schulz 2008). Roosts in caves and mines and most commonly recorded from dry sclerophyll forests and woodlands. An insectivorous species that flies over the canopy or along creek beds (Churchill 2008). In southern Sydney appears to be largely restricted to the interface between sandstone escarpments and fertile valleys.	Possible. May forage on occasion in the study area. No breeding habitat present.	Possible. Limited suitable forested foraging habitat present. No breeding habitat present. No record of the species during any surveys in the study area.	Proposal would remove 13.03 ha of potential foraging habitat.
<i>Myotis macropus</i>	Large-footed Myotis	V		13 records within 10km (OEH 2015a)	Mainly coastal but may occur inland along large river systems. Usually	Likely. May forage and breed in the study	Likely. May forage above dams and	Proposal would remove 13.03 ha of

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					associated with permanent waterways at low elevations in flat/undulating country, usually in vegetated areas. Forages over streams and watercourses feeding on fish and insects from the water surface. Roosts in a variety of habitats including caves, mine shafts, hollow-bearing trees, stormwater channels, buildings, under bridges and in dense foliage, typically in close proximity to water (Campbell 2011). Breeds November or December (Churchill 2008)	area.	Mill Creek on occasion. Small number of potential roost trees present. No evidence of guano. Unlikely to breed in the proposal footprint.	potential foraging habitat.
<i>Miniopterus australis</i>	Little Bentwing-Bat	V		4 records within 10km (OEH 2015a)	Occurs from Cape York to Sydney. Inhabits rainforests, wet and dry sclerophyll forests, paperbark swamps and vine thickets. Only one maternity cave known in NSW, shared with Eastern Bentwing-bats at Willi Willi, near Kempsey. Outside breeding season roosts in caves, tunnels and mines and has been recorded in a tree hollow on one occasion. Forages for insects beneath the canopy of well-timbered habitats (Churchill 2008, Hoyer and Hall 2008).	Likely. May forage in the study area. No breeding habitat present.	Possible. May forage on occasion in the study area. Previous clearing may have impacted structural complexity preferred by this species. No breeding habitat present.	Proposal would remove 13.03 ha of low quality potential foraging habitat.
<i>Saccolaimus flaviventris</i>	Yellow-bellied Sheath-tail-bat	V		4 records within 10km (OEH 2015a)	Migrates from tropics to SE Aus in summer. Forages across a range of habitats including those with and without trees, from wet and dry sclerophyll forest, open woodland, Acacia shrubland, mallee, grasslands and desert. Roosts communally in large tree hollows and buildings (Churchill 2008).	Likely. Could forage in native vegetation and cleared areas within the proposal footprint. May roost/breed in hollow-bearing trees in the study area.	Likely. May forage in the proposal footprint. Small number of potential roost trees present. No evidence of guano.	Proposal would remove 13.03 ha of potential foraging habitat. Limited potential breeding habitat would be removed.
Reptiles								
<i>Hoplocephalus bungaroides</i>	Broad-headed Snake	E	V	15 records within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a)	Nocturnal, sheltering in rock crevices and under flat sandstone rocks on exposed cliff edges during autumn, winter, and spring, moving to shelters in hollows of large trees within 200m of escarpments in summer. Feeds mostly on geckos and small skinks, and occasionally on frogs and small mammals.	Nil. No suitable escarpment habitat present.	Nil. No suitable escarpment habitat present in the proposal footprint.	Nil.

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
<i>Varanus rosenbergi</i>	Rosenberg's Goanna	V		19 records within 10km (OEH 2015a)	In NSW mainly occurs on the mid coast region from Wollemi NP to Nowra; the ACT and Goulburn regions and the South-west Slopes. Inhabits coastal heathlands, wet and dry sclerophyll forests, woodlands and mallee communities. Termite mounds are an important habitat feature: eggs are laid in the mounds in summer and incubate till spring, when the young dig themselves out. Young may return to the mound as a refuge for some months, while adults shelter in burrows dug under rocks or logs, or in rock crevices, hollow logs or even rabbit burrows (Sass 2008).	Likely. Potential foraging and breeding habitat present.	Possible. Potential foraging and breeding habitat present in the proposal footprint. No evidence of species from camera surveys or previous trapping (GHD 2011).	Proposal would remove 13.03 ha of potential foraging and breeding habitat.
Frogs								
<i>Heleioporus australiacus</i>	Giant Burrowing Frog	V	V	26 records within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a)	Occurs along the coast and eastern slopes of the Great Dividing Range south from Wollemi National Park. Appears to exist as 2 populations with a 100km gap in records between Jervis Bay and Eden. Northern population occurs on sandy soils supporting heath, woodland or open forest. Breeds in ephemeral to intermittent streams with persistent pools. Only infrequently moves to breeding sites, most commonly found on ridges away from creeks, several hundred metres from water.	Likely. A previous record exists in the study area (OEH 2014). Likely to occur along drainage lines and in adjacent vegetation.	Likely. May shelter in woodland habitat and along riparian zone. Not recorded during targeted survey in appropriate conditions.	Proposal would remove 13.03 ha of potential foraging and shelter habitat. Realignment of Mill Creek may remove a small area of potential breeding habitat.
<i>Litoria aurea</i>	Green and Golden Bell Frog	E	V	12 records within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a)	Formerly occurred from Brunswick Heads to Victoria, but >80% populations now extinct. Inhabits marshes, natural and artificial freshwater to brackish wetlands, dams and in stream wetlands. Prefers sites containing cumbungi (<i>Typha</i> spp.) or spike rushes (<i>Eleocharis</i> spp.), which are unshaded and have a grassy area and/or rubble as shelter/refuge habitat nearby. Eastern Gambusia is a key threat as they feed on Green and Golden Bell Frog eggs and tadpoles.	Unlikely. No suitable habitat present in the study area..	Unlikely. No suitable habitat present in the proposal footprint. Some areas of <i>Typha</i> are present along Mill Creek in the study area. Was not recorded during targeted surveys in appropriate conditions.	Impacts unlikely

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
<i>Litoria littlejohni</i>	Littlejohn's Tree Frog	V	V	Species or species habitat may occur within locality (DotE 2015a)	Occurs on plateaus and eastern slopes of the Great Dividing Range south from Watagan State Forest. Occurs along permanent rocky streams with thick fringing vegetation associated with eucalypt woodlands and heaths among sandstone outcrops, hunting either in shrubs or on the ground.	Unlikely. Potential habitat unlikely to be present in the study area.	Nil. No suitable rocky stream habitat present.	Nil.
<i>Litoria raniformis</i>	Southern Bell Frog	E	V	Species or species habitat may occur within locality (DotE 2015a)	Currently, the species is known to exist only in isolated populations in the Coleambally Irrigation Area, the Lowbidgee floodplain and around Lake Victoria. Usually found in or around permanent or ephemeral Black Box/Lignum/Nitre Goosefoot swamps, Lignum/Typha swamps and River Red Gum swamps or billabongs along floodplains and river valleys. They are also found in irrigated rice crops, particularly where there is no available natural habitat (OEH 2013).	Nil. No records of the species in the Sydney Basin. No suitable habitat present.	Nil. No records of the species in the Sydney Basin. No suitable habitat present.	Nil
<i>Mixophyes balbus</i>	Stuttering Frog	E	V	Species or species habitat likely to occur within locality (DotE 2015a)	Occurs along the east coast of Australia. Has undergone a massive range reduction particularly in the south of its range: within the Sydney Basin. Inhabits rainforest and wet, tall, open forest. Shelter in deep leaf litter and thick understorey vegetation on the forest floor. Feeds on insects and smaller frogs, breeding in streams during summer after heavy rain. The species does not occur in areas where the riparian vegetation has been disturbed or where there have been significant upstream human impacts (Mahony et al 1997).	Nil. No suitable wet habitat present.	Nil. No suitable wet habitat present.	Nil
<i>Pseudophryne australis</i>	Red-crowned Toadlet	V		77 records within 10km (OEH 2015a)	Restricted to Sydney Basin, from Nowra to Pokolbin and west to Mt Victoria. Inhabits heathland and open woodland on Hawkesbury and Narrabeen Sandstones, within 100m of ridgelines. Breeds in ephemeral feeder creeks or flooded depressions, requiring unpolluted water between 5.5 and 6.5	Likely. May occur along ephemeral creeks and drainage lines within intact vegetation.	Unlikely. Few ephemeral creeks or drainage lines present. pH of Mill Creek recorded to be above 6.7 at all locations tested during surveys	Low.

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					pH. Shelters under rocks, amongst masses of dense vegetation or leaf litter. Populations restricted to immediate vicinity of breeding areas.		(average of pH 8 over five sites tested).	
Invertebrates								
<i>Meridolum corneovirens</i>	Cumberland Plain Land Snail	E		41 records within 10km (OEH 2015a)	Occurs within a small area of the Cumberland Plain, from Richmond and Windsor to Picton. Found primarily under litter of bark, leaves and logs, or in loose soil around grass clumps within Cumberland Plain Woodland. Has also been found under rubbish. Feeds on fungus. During periods of drought can burrow into the soil to escape the dry conditions.	Nil. No suitable habitat present in the study area.	Nil. No suitable habitat present in the proposal footprint.	Nil.
<i>Archaeophya adamsi</i>	Adam's Emerald Dragonfly	E (FM Act)		Known to occur in the Sydney Metro CMA (DPI 2014)	The species is only known from a few sites in the greater Sydney region (including northern Sydney, Blue Mountains and the Gosford area. Larvae have been found in small creeks with gravel or sandy bottoms, in narrow, shaded riffle zones with moss and rich riparian vegetation. Adult dragonflies generally fly away from the water to mature before returning to breed. Males congregate at breeding sites and often guard a territory. Females probably lay their eggs into the water.	Possible. May occur along creek lines in intact native vegetation.	Unlikely. Previous disturbance and realignment of the creek are likely to have made the habitat unsuitable for this species, if present in the locality.	Unlikely.
<i>Austrocordulia leonardi</i>	Sydney Hawk Dragonfly	E (FM Act)		Known to occur in the Sydney Metro CMA (DPI 2014)	The Sydney Hawk Dragonfly has a very restricted distribution. The known distribution of the species includes three locations in a small area south of Sydney, from Audley to Picton. The species is known from the Hawkesbury-Nepean, Georges River, Port Hacking and Karuah drainages. The Sydney Hawk Dragonfly has specific habitat requirements, and has only ever been collected from deep and shady riverine pools with cooler water. Larvae are found under rocks where they co-exist with <i>Austrocordulia refracta</i> .	Nil. No suitable habitat present in the study area.	Nil. No suitable habitat present in the proposal footprint.	Nil.

Migratory species known or predicted to occur in the locality

Scientific Name	Common Name	NSW Status	EPBC Status	Source	Habitat Description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
<i>Rostratula australis</i>	Australian Painted Snipe	E	E, M	Species or species habitat likely to occur within locality (DotE 2015a)	Normally found in permanent or ephemeral shallow inland wetlands, either freshwater or brackish. Nests on the ground amongst tall reed-like vegetation near water. Feeds on mudflats and the water's edge taking insects, worm and seeds. Prefers fringes of swamps, dams and nearby marshy areas with cover of grasses, lignum, low scrub or open timber.	Unlikely. No suitable wetland habitat present.	Unlikely. No suitable wetland habitat present.	Impacts unlikely
<i>Monarcha melanopsis</i>	Black-faced Monarch		M	16 records within 10km (OEH 2015a); Species or species habitat known to occur within locality (DotE 2015a)	Found along the coast of eastern Australia, becoming less common further south. Found in rainforests, eucalypt woodlands, coastal scrub and damp gullies. It may be found in more open woodland when migrating. Resident in the north of its range, but is a summer breeding migrant to coastal south-eastern Australia, arriving in September and returning northwards in March. It may also migrate to Papua New Guinea in autumn and winter.	Possible. May occur on occasion during migration.	Possible. May occur on occasion during migration.	Proposal would remove 13.03 ha of potential foraging habitat.
<i>Ardea ibis</i>	Cattle Egret		C,J	4 records within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a)	Occurs across NSW. Principal breeding sites are the central east coast from Newcastle to Bundaberg. Also breeds in major inland wetlands in north NSW (notably the Macquarie Marshes). Occurs in tropical and temperate grasslands, wooded lands and terrestrial wetlands. Uses predominately shallow, open and fresh wetlands with low emergent vegetation and abundant aquatic flora. Sometimes observed in swamps with tall emergent vegetation and commonly use areas of tall pasture in moist, low-lying areas. Occurs across NSW.	Possible. May forage on occasion in dams and waterways.	Possible. May forage on occasion in dams and waterways.	Proposal would have limited impact on the foraging habitat of this species.
<i>Ardea modesta</i>	Eastern Great Egret		C,J,K	20 records within 10km (OEH 2015a); Species or species habitat known to occur within locality (DotE 2015a)	Occurs across NSW. Within NSW there are breeding colonies within the Darling Riverine Plains and Riverina regions, and minor colonies across its range including the north and north-east of the state. Reported from a wide range of wetland habitats (for example inland and coastal, freshwater and saline, permanent and ephemeral, open and	Possible. May forage on occasion in dams and waterways.	Possible. May forage on occasion in dams and waterways.	Proposal would have limited impact on the foraging habitat of this species.











Scientific Name	Common Name	NSW Status	EPBC Status	Source	Habitat Description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					vegetated, large and small, natural and artificial).			
<i>Pandion cristatus</i>	Eastern Osprey	V	M	17 records within 10km (OEH 2015a)	Occur in littoral and coastal habitats and terrestrial wetlands of tropical and temperate Australia and offshore islands. Adult Eastern Ospreys are mostly resident or sedentary around breeding territories.	Nil. No suitable habitat present	Nil. No suitable habitat present	Nil
<i>Apus pacificus</i>	Fork-tailed Swift		C,J,K	2 records within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a)	Recorded in all regions of NSW. Non-breeding, and almost exclusively aerial while in Australia. Occurs over urban and rural areas as well as areas of native vegetation. Recorded in all regions of NSW. Non-breeding, and almost exclusively aerial while in Australia. Occurs over urban and rural areas as well as areas of native vegetation.	Possible. May occur on occasion above the study area.	Possible. May occur on occasion above the proposal footprint.	Impacts unlikely.
<i>Gallinago hardwickii</i>	Latham's Snipe		C,J,K	79 records within 10km (OEH 2015a); Species or species habitat may occur within locality (DotE 2015a)	Occurs along the coast and west of the great dividing range. Non breeding visitor to Australia. Inhabit permanent and ephemeral wetlands up to 2000 m asl. Typically in open, freshwater wetlands with low, dense vegetation (incl. swamps, flooded grasslands and heathlands). Can also occur in saline/brackish habitats and in modified or artificial habitats close to human activity. Occurs along the coast and west of the great dividing range. Non breeding visitor to Australia. Inhabit permanent and ephemeral wetlands up to 2000 m asl. Typically in open, freshwater wetlands with low, dense vegetation (incl. swamps, flooded grasslands and heathlands). Can also occur in saline/brackish habitats and in modified or artificial habitats close to human activity.	Unlikely. No suitable wetland habitat present.	Unlikely. No suitable wetland habitat present.	Impacts unlikely
<i>Merops ornatus</i>	Rainbow Bee-eater		J	Species or species habitat may occur within locality (DotE 2015a)	Distributed across much of mainland Australia, and several near-shore islands. Occurs mainly in open forests and woodlands, shrublands, and in various cleared or semi-cleared habitats, including farmland and areas of human habitation. It usually occurs in open, cleared or lightly-timbered areas that are often, but not always, located in close proximity to permanent water. It also occurs in inland and coastal sand dune systems, and in mangroves	Possible. May forage and breed in the study area.	Possible. May forage and breed in the proposal footprint.	Proposal would remove 13.03 ha of potential foraging and breeding habitat.

Scientific Name	Common Name	NSW Status	EPBC Status	Source	Habitat Description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					in northern Australia, and has been recorded in various other habitat types including heathland, sedgeland, vine forest and vine thicket, and on beaches.			
<i>Rhipidura rufifrons</i>	Rufous Fantail		M	74 records within 10km (OEH 2015a); Species or species habitat known to occur within locality (DotE 2015a)	Found along NSW coast and ranges. Inhabits rainforest, dense wet forests, swamp woodlands and mangroves. During migration, it may be found in more open habitats or urban areas (Birds Australia 2008).	Possible. May occur on occasion during migration.	Possible. May occur on occasion during migration.	Proposal would remove 13.03 ha of potential foraging habitat.
<i>Myiagra cyanoleuca</i>	Satin Flycatcher		M	1 record within 10km (OEH 2015a); Breeding known to occur within locality (DotE 2015a)	In NSW widespread on and east of the Great Divide, sparsely scattered on the western slopes, very occasional records on the western plains. Inhabit heavily vegetated gullies in eucalypt-dominated forests and taller woodlands, often near wetlands and watercourses. On migration, occur in coastal forests, woodlands, mangroves and drier woodlands and open forests. Generally not in rainforests.	Possible. May occur on occasion during migration.	Possible. May occur on occasion during migration.	Proposal would remove 13.03 ha of potential foraging habitat.
<i>Symposiachrus trivirgatus</i>	Spectacled Monarch		M	Species or species habitat may occur within locality (DotE 2015a)	The Spectacled Monarch is found in coastal north-eastern and eastern Australia, including coastal islands, from Cape York, Queensland to Port Stephens, New South Wales. It is much less common in the south. Prefers thick understorey in rainforest, wet gullies and waterside vegetation as well as mangroves.	Unlikely. Outside usual distribution.	Unlikely. Outside usual distribution.	Impacts unlikely.
<i>Haliaeetus leucogaster</i>	White-bellied Sea-Eagle		C	32 records within 10km (OEH 2015a); Species or species habitat known to occur within locality (DotE 2015a)	Primarily coastal but may extend inland over major river systems. Breeds close to water, mainly in tall open forest/woodland but also in dense forest, rainforest, closed scrub or remnant trees. Usually forages over large expanses of open water, but also over open terrestrial habitats (e.g. grasslands).; Primarily coastal but may extend inland over major river systems. Breeds close to water, mainly in tall open forest/woodland but also in dense forest, rainforest, closed scrub or remnant trees. Usually forages over large expanses of open water, but also over open terrestrial habitats (e.g. grasslands).	Nil. No suitable habitat present	Nil. No suitable habitat present	Nil
<i>Hirundapus</i>	White-throated		C,J,K	11 records within	Recorded along NSW coast to the western	Possible. May	Possible. May	Impacts

Scientific Name	Common Name	NSW Status	EPBC Status	Source	Habitat Description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
<i>caudacutus</i>	Needletail			10km (OEH 2015a); Species or species habitat known to occur within locality (DotE 2015a)	slopes and occasionally from the inland plains. Breeds in northern hemisphere. Almost exclusively aerial while in Australia. Occur above most habitat types, but are more frequently recorded above more densely vegetated habitats (rainforest, open forest and heathland) than over woodland or treeless areas.; Recorded along NSW coast to the western slopes and occasionally from the inland plains. Breeds in northern hemisphere. Almost exclusively aerial while in Australia. Occur above most habitat types, but are more frequently recorded above more densely vegetated habitats (rainforest, open forest and heathland) than over woodland or treeless areas.	occur on occasion above the study area.	occur on occasion above the proposal footprint.	unlikely.

Appendix C Framework for Biodiversity Assessment Data

Assessment of geographic / habitat features

Impact?	Common name	Scientific name	Feature
	Rosenberg's Goanna	<i>Varanus rosenbergi</i>	Land within 250 m of termite mounds or rock outcrops
	Red-crowned Toadlet	<i>Pseudophryne australis</i>	Heath or eucalypt forest on sandstone with a build-up of litter or other debris and containing, or within 40 m of, ephemeral or intermittent drainage lines
	Large-eared Pied Bat	<i>Chalinolobus dwyeri</i>	Land containing escarpments, cliffs, caves, deep crevices, old mine shafts or tunnels
	Giant Burrowing Frog	<i>Heleioporus australiacus</i>	Land within 40 m of heath, woodland or forest with sandy or friable soils
	Broad-headed Snake	<i>Hoplocephalus bungaroides</i>	Land within 50 m of sandstone escarpments with hollow-bearing trees, rock crevices or flat sandstone rocks on exposed cliff edges
	Hygrocybe anomala subsp. ianthinomarginata	<i>Hygrocybe anomala</i> subsp. <i>ianthinomarginata</i>	Land within Blue Mountains National Park in Wollemi CMA subregion
	Eastern Bristlebird	<i>Dasyornis brachypterus</i>	Dense (>80% projected cover) heath, unburnt for 3 or more years
	Green and Golden Bell Frog	<i>Litoria aurea</i>	Land within 100 m of emergent aquatic or riparian vegetation
	Littlejohn's Tree Frog	<i>Litoria littlejohni</i>	Land within 100 m of permanent rocky streams with thick fringing vegetation
	Black Cypress Pine, Woronora Plateau population	<i>Callitris endlicheri</i> , Woronora Plateau population	Confined to the Woronora Plateau in Wollongong LGA

Survey / time matrix

Scientific name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
FLORA												
<i>Acacia baueri</i> subsp. <i>aspera</i>	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
<i>Acacia bynoeana</i>	Y	Y	Y						Y	Y	Y	Y
<i>Acacia prominens</i> - endangered population	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
<i>Acacia pubescens</i>	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
<i>Astrotricha crassifolia</i>	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
<i>Caesia parviflora</i> subsp. <i>minor</i>	Y	Y							Y	Y	Y	Y
<i>Caladenia tessellata</i> **									Y	Y		
<i>Callistemon linearifolius</i>	Y	Y	Y						Y	Y	Y	Y
<i>Epacris purpurascens</i> subsp. <i>purpurascens</i>	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
<i>Eucalyptus camfieldii</i>	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
<i>Genoplesium baueri</i>		Y	Y									
<i>Grevillea parviflora</i> subsp. <i>parviflora</i>	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
<i>Hibbertia puberula</i>	Y	Y							Y	Y	Y	Y
<i>Hibbertia stricta</i> subsp. <i>furcatula</i>	Y	Y	Y						Y	Y	Y	Y
<i>Leucopogon exolasius</i>	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
<i>Melaleuca deanei</i>	Y	Y										Y
<i>Persoonia bargoensis</i>	Y	Y	Y	Y	Y							Y
<i>Persoonia hirsuta</i>	Y	Y	Y	Y	Y							Y
<i>Prostanthera densa</i>	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
<i>Pterostylis</i> sp. Botany Bay**								Y	Y			
<i>Pultenaea aristata</i>	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
FAUNA												
<i>Cercartetus nanus</i> ***												
<i>Heleioporus australiacus</i>	Y	Y	Y	Y	Y				Y	Y	Y	Y

Scientific name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<i>Isododon obesulus</i> subsp. <i>obesulus</i>	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
<i>Litoria aurea</i>	Y	Y	Y					Y	Y	Y	Y	Y
<i>Phascolarctos cinereus</i>	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
<i>Pseudophryne australis</i>	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
<i>Varanus rosenbergi</i>	Y	Y									Y	Y

* bold type indicates that GHD field surveys were conducted in these months.

** no suitable habitat and/or no local records are present for these species. No surveys were considered necessary (see section 7.2.2).

*** note that OEH has not identified a suitable survey time for this species in the credit calculator. This species was assumed to be present based on the presence of suitable habitat and local records (see section 7.2.2).

Appendix D Survey results

Plot/transect data

PCT ID	Condition	Plot ID	Native plant species richness	Native over-storey cover	Native mid-storey cover	Native ground cover (grasses)	Native ground cover (shrubs)	Native ground cover (other)	Exotic plant cover	Number of trees with hollows	Over storey regeneration	Total length of fallen logs
ME014		Benchmark	>39	17-27	75-85	1-10	7-11	13-17		>1	1	>30
	Mod-good (medium)	2	31	9	52	20	10	44	0	0	1	2
	Mod-good (medium)	5	49	52	13	4	8	46	0	3	1	0
ME014		Benchmark	>39	17-27	75-85	1-10	7-11	13-17		>1	1	>30
	Mod-good (poor)	3	33	1	28	6	8	36	0	0	1	0
	Mod-good (poor)	4	32	17	30	2	6	16	0	0	1	0
	Mod-good (poor)	6	21	27	21	2	12	14	0	0	1	1
ME015		Benchmark	29	19-24	20-30	23-31	0-5	12-20		1		5
	Mod-good	1	58	0	4	0	8	90	0	0	1	2
Exotic grassland		7	4	0	0	8	0	0	92	0	0	0

Flora species recorded in the proposal footprint

Family	Exotic	Scientific Name	Common Name	TSC Status	EPBC Status	Plot/transect							Opportunistic
						Q1	Q2	Q3	Q4	Q5	Q6	Q7	
Apiaceae		<i>Actinotus minor</i>	Lesser Flannel Flower			3	2	2		2	2		X
	*	<i>Foeniculum vulgare</i>	Fennel										X
		<i>Platysace linearifolia</i>											X
		<i>Xanthosia tridentata</i>	Rock Xanthosia										X
Apocynaceae	*	<i>Araujia sericifera</i>	Moth Vine										X
Asparagaceae	*	<i>Asparagus aethiopicus</i>	Asparagus Fern										X
Asteraceae	*	<i>Ageratina adenophora</i>	Crofton Weed										X
	*	<i>Ageratina riparia</i>	Mistflower										X
	*	<i>Bidens pilosa</i>	Cobbler's Pegs									2	X
	*	<i>Cirsium vulgare</i>	Spear Thistle									2	X
	*	<i>Conyza bonariensis</i>	Flaxleaf Fleabane									3	X
	*	<i>Conyza sumatrensis</i>	Tall fleabane									2	X
	*	<i>Lactuca serriola</i>	Prickly Lettuce										X
	*	<i>Hypochaeris radicata</i>	Catsear									2	X
		<i>Ozothamnus diosmifolius</i>	White Dogwood										X
		<i>Pseudognaphalium luteoalbum</i>	Jersey Cudweed									3	
	*	<i>Senecio madagascariensis</i>	Fireweed									2	
	*	<i>Sonchus oleraceus</i>	Common Sowthistle									2	X
	*	<i>Taraxacum officinale</i>	Dandelion									2	X
Basellaceae	*	<i>Anredera cordifolia</i>	Madeira Vine										X
Blechnaceae		<i>Blechnum indicum</i>	Swamp Water Fern			2							
Brassicaceae	*	<i>Capsella bursa-pastoris</i>	Shepherd's Purse										X
Brassicaceae	*	<i>Hirschfeldia incana</i>	Buchan Weed										X

Family	Exotic	Scientific Name	Common Name	TSC Status	EPBC Status	Plot/transect							Opportunistic
						Q1	Q2	Q3	Q4	Q5	Q6	Q7	
Caryophyllaceae	*	<i>Cerastium glomeratum</i>	Mouse-ear Chickweed										X
Casuarinaceae		<i>Allocasuarina diminuta</i> subsp. <i>mimica</i>		EP					2				X
		<i>Allocasuarina distyla</i>					4	3	2		3		X
		<i>Allocasuarina littoralis</i>	Black She-Oak			3	5	4	3	4	4	4	X
		<i>Allocasuarina torulosa</i>	Forest Oak										X
		<i>Casuarina cunninghamiana</i> subsp. <i>cunninghamiana</i>	River Oak										X
Centrolepidaceae		<i>Centrolepis fascicularis</i>				2							
Commelinaceae	*	<i>Tradescantia fluminensis</i>	Wandering Jew										X
Convolvulaceae		<i>Dichondra repens</i>	Kidney Weed										X
Cyperaceae		<i>Baumea acuta</i>				2							
		<i>Baumea rubiginosa</i>				3							
		<i>Baumea teretifolia</i>				4							
		<i>Caustis flexuosa</i>	Curly Wig			2	3	2	2				X
		<i>Caustis recurvata</i>					2			2			
		<i>Cyathochaeta diandra</i>				2	2			2	2		X
	*	<i>Cyperus eragrostis</i>	Umbrella Sedge										X
		<i>Cyperus polystachyos</i>				1							
		<i>Gahnia sieberiana</i>	Red-fruit Saw-sedge						2				
		<i>Gymnoschoenus sphaerocephalus</i>	Button Grass			2							
		<i>Lepidosperma concavum</i>											X
		<i>Lepidosperma laterale</i>	Variable Sword-sedge			2	2	2					
		<i>Lepidosperma limicola</i>				2							
		<i>Lepidosperma neesii</i>				2							
		<i>Ptilothrix deusta</i>				2	2	2		2			X
		<i>Schoenus brevifolius</i>				5							

Family	Exotic	Scientific Name	Common Name	TSC Status	EPBC Status	Plot/transect							Opportunistic
						Q1	Q2	Q3	Q4	Q5	Q6	Q7	
		<i>Schoenus ericetorum</i>				2							
		<i>Schoenus paludosus</i>				3							
Dennstaedtiaceae		<i>Pteridium esculentum</i>	Bracken										X
Dicksoniaceae		<i>Calochlaena dubia</i>	Rainbow Fern										X
Dilleniaceae		<i>Hibbertia aspera</i> subsp. <i>aspera</i>											X
Elaeocarpaceae		<i>Tetratheca neglecta</i>											X
Ericaceae		<i>Brachyloma daphnoides</i>	Daphne Heath						2	2			
		<i>Epacris microphylla</i> var. <i>microphylla</i>	Coral Heath			1	2			2	2		X
		<i>Epacris obtusifolia</i>	Blunt-leaf Heath					2		2	1		
		<i>Leucopogon esquamatus</i>								2			X
		<i>Leucopogon microphyllus</i> var. <i>microphyllus</i>						1		1			
		<i>Monotoca scoparia</i>					2	2		2	2		
Euphorbiaceae		<i>Micrantheum ericoides</i>								1	1		X
Fabaceae (Caesalpinioideae)	*	<i>Senna pendula</i> var. <i>glabrata</i>											X
Fabaceae (Faboideae)		<i>Bossiaea ensata</i>	Sword Bossiaea										X
		<i>Bossiaea heterophylla</i>	Variable Bossiaea				2	2	2				X
		<i>Bossiaea stephensonii</i>											X
		<i>Daviesia mimosoides</i>											X
		<i>Dillwynia floribunda</i>				2	1		2	2			
		<i>Glycine clandestina</i>	Twining glycine										X
		<i>Glycine tabacina</i>	Variable Glycine										X
		<i>Gompholobium glabratum</i>	Dainty Wedge Pea										X
		<i>Hardenbergia violacea</i>	False Sarsaparilla										X
		<i>Kennedia rubicunda</i>	Dusky Coral Pea										X
		<i>Phyllota phyllicoides</i>	Heath Phyllota							2			X

Family	Exotic	Scientific Name	Common Name	TSC Status	EPBC Status	Plot/transect							Opportunistic
						Q1	Q2	Q3	Q4	Q5	Q6	Q7	
		<i>Pultenaea divaricata</i>				1			2	2			
Fabaceae (Faboideae)		<i>Pultenaea tuberculata</i>											X
	*	<i>Trifolium dubium</i>	Yellow Suckling Clover									2	
	*	<i>Trifolium repens</i>	White Clover									2	
	*	<i>Trifolium subterraneum</i>	Subterranean Clover										X
Fabaceae (Mimosoideae)		<i>Acacia bynoeana</i>	Bynoe's Wattle	E	V								X
		<i>Acacia echinula</i>	Hedgehog Wattle						2				
		<i>Acacia irrorata</i> subsp. <i>irrorata</i>	Green Wattle										X
		<i>Acacia linifolia</i>	White Wattle			2	3	3	3		3		
		<i>Acacia longifolia</i> subsp. <i>longifolia</i>	Sydney Golden Wattle										X
		<i>Acacia myrtifolia</i>	Red-stemmed Wattle						1				X
		<i>Acacia obtusifolia</i>						3	3				
		<i>Acacia rubida</i>	Red-stemmed Wattle						2				
		<i>Acacia suaveolens</i>	Sweet Wattle					2	2	3			X
		<i>Acacia terminalis</i> subsp. <i>angustifolia</i>							2				X
		<i>Acacia ulicifolia</i>	Prickly Moses						1				X
Gentianaceae	*	<i>Centaurium erythraea</i>	Common Centaury									2	X
Goodeniaceae		<i>Dampiera stricta</i>				1		1					X
		<i>Goodenia heterophylla</i> subsp. <i>eglandulosa</i>											X
		<i>Goodenia stelligera</i>	Spiked Goodenia										X
Iridaceae		<i>Patersonia sericea</i>	Silky Purple-Flag				2				2		X
Juncaceae		<i>Juncus continuus</i>				2							X
		<i>Juncus subsecundus</i>	Finger Rush										X
		<i>Juncus usitatus</i>											X
Lauraceae		<i>Cassytha glabella</i>						3					X

Family	Exotic	Scientific Name	Common Name	TSC Status	EPBC Status	Plot/transect							Opportunistic
						Q1	Q2	Q3	Q4	Q5	Q6	Q7	
		<i>Cassytha pubescens</i>	Downy Dodder-laurel							2			
		<i>Cinnamomum camphora</i>	Camphor Laurel										X
Lindsaeaceae		<i>Lindsaea linearis</i>	Screw Fern			1				2			X
Lobeliaceae		<i>Lobelia dentata</i>				2							
		<i>Pratia purpurascens</i>	Whiteroot										X
Loganiaceae		<i>Mitrasacme polymorpha</i>				1							
Lomandraceae		<i>Lomandra brevis</i>											X
		<i>Lomandra filiformis subsp. coriacea</i>	Wattle Matt-rush										X
		<i>Lomandra obliqua</i>											X
Malvaceae	*	<i>Malva parviflora</i>	Small-flowered Mallow										X
	*	<i>Modiola caroliniana</i>	Red-flowered Mallow										X
	*	<i>Sida rhombifolia</i>	Paddy's Lucerne										X
Myrsinaceae	*	<i>Anagallis arvensis</i>	Scarlet Pimpernel										X
Myrtaceae		<i>Angophora costata</i>	Sydney Red Gum						3				X
		<i>Angophora hispida</i>	Dwarf Apple						2	3			X
		<i>Angophora hispida</i> x <i>Corymbia gummifera</i>											X
		<i>Baeckea brevifolia</i>				1		2					
		<i>Baeckea imbricata</i>						2					
		<i>Callistemon citrinus</i>	Crimson Bottlebrush			3			3				X
		<i>Callistemon linearis</i>	Narrow-leaved Bottlebrush										X
		<i>Calytrix tetragona</i>	Common Fringe-myrtle										X
		<i>Corymbia gummifera</i>	Red Bloodwood			1	3	3	2	3			X
		<i>Eucalyptus capitellata</i>	Brown Stringybark										X
		<i>Eucalyptus haemastoma</i>	Broad-leaved Scribbly Gum							1			X
		<i>Eucalyptus luehmanniana</i>	Yellow Top Mallee Ash										X

Family	Exotic	Scientific Name	Common Name	TSC Status	EPBC Status	Plot/transect							Opportunistic
						Q1	Q2	Q3	Q4	Q5	Q6	Q7	
		<i>Eucalyptus oblonga</i>				2				4			X
		<i>Eucalyptus piperita</i>	Sydney Peppermint						3				X
		<i>Eucalyptus punctata</i>	Grey Gum						4				X
		<i>Eucalyptus racemosa</i> subsp. <i>racemosa</i>	Narrow-leaved Scribbly Gum				2	2	3	6			X
		<i>Eucalyptus saligna</i> / <i>E. botryoides</i> hybrid											X
		<i>Eucalyptus squamosa</i>	Scaly Bark										X
		<i>Euryomyrtus ramosissima</i>	Rosy Baeckea										X
		<i>Kunzea ambigua</i>	Tick Bush			3	5	4	4	1	3		X
		<i>Kunzea capitata</i>							2				X
		<i>Leptospermum arachnoides</i>				2	2						X
		<i>Leptospermum continentale</i>	Prickly Teatree						2				
		<i>Leptospermum juniperinum</i>	Prickly Tea-tree				2	2		3			
		<i>Leptospermum parvifolium</i>				2		2			1		
		<i>Leptospermum polygalifolium</i>	Tantoon			2							X
		<i>Leptospermum rotundifolium</i>								1			
		<i>Leptospermum squarrosum</i>				1							
		<i>Leptospermum trinervium</i>	Slender Tea-tree							3			X
		<i>Micromyrtus ciliata</i>	Fringed Heath-myrtle			2				1			
Olacaceae		<i>Olax stricta</i>				1							
Onagraceae	*	<i>Ludwigia peruviana</i>											X
Orchidaceae		<i>Microtis unifolia</i>	Common Onion Orchid				1						
Oxalidaceae		<i>Oxalis perennans</i>											X
Phormiaceae		<i>Dianella caerulea</i> var. <i>producta</i>											X
		<i>Dianella revoluta</i> var. <i>revoluta</i>	A Blue Flax Lily										X
Phyllanthaceae		<i>Phyllanthus hirtellus</i>	Thyme Spurge				1						X

Family	Exotic	Scientific Name	Common Name	TSC Status	EPBC Status	Plot/transect							Opportunistic
						Q1	Q2	Q3	Q4	Q5	Q6	Q7	
Pittosporaceae		<i>Billardiera scandens</i>	Hairy Apple Berry										X
Plantaginaceae	*	<i>Plantago lanceolata</i>	Lamb's Tongues									2	X
		<i>Veronica plebeia</i>	Trailing Speedwell										X
Poaceae		<i>Amphibromus nervosus</i>	Swamp Wallaby Grass						2	2			
	*	<i>Andropogon virginicus</i>	Whisky Grass										X
		<i>Anisopogon avenaceus</i> var. <i>avenaceus</i>	Oat Speargrass			2				2			X
		<i>Aristida vagans</i>	Threeawn Speargrass										X
		<i>Austrodanthonia tenuior</i>	A Wallaby Grass										X
		<i>Austrostipa pubescens</i>											X
		<i>Bothriochloa macra</i>	Red Grass										X
	*	<i>Briza minor</i>	Shivery Grass										X
	*	<i>Bromus catharticus</i>	Praire Grass										X
	*	<i>Chloris gayana</i>	Rhodes Grass										X
	*	<i>Cortaderia selloana</i>	Pampas Grass			1							X
		<i>Cynodon dactylon</i>	Common Couch									3	X
		<i>Echinopogon caespitosus</i> var. <i>caespitosus</i>	Tufted Hedgehog Grass										X
	*	<i>Ehrharta erecta</i>	Panic Veldtgrass									3	
		<i>Entolasia stricta</i>	Wiry Panic			1							X
	*	<i>Eragrostis curvula</i>	African Lovegrass									2	X
		<i>Eragrostis leptostachya</i>	Paddock Lovegrass										X
	*	<i>Hyparrhenia hirta</i>	Coolatai Grass										X
		<i>Imperata cylindrica</i>	Blady Grass										X
		<i>Microlaena stipoides</i> var. <i>stipoides</i>	Weeping Grass										X
		<i>Oplismenus imbecillis</i>											X
		<i>Panicum simile</i>	Two-colour Panic										X

Family	Exotic	Scientific Name	Common Name	TSC Status	EPBC Status	Plot/transect							Opportunistic
						Q1	Q2	Q3	Q4	Q5	Q6	Q7	
	*	<i>Paspalum dilatatum</i>	Paspalum									4	X
	*	<i>Paspalum urvillei</i>	Vasey Grass									6	X
	*	<i>Pennisetum clandestinum</i>	Kikuyu Grass										X
		<i>Poa affinis</i>								2			
	*	<i>Poa pratensis</i>	Kentucky Bluegrass									3	
		<i>Poa sieberiana</i>	Snowgrass										X
		<i>Setaria gracilis</i>				1						3	X
	*	<i>Sporobolus africanus</i>	Parramatta Grass									2	
		<i>Themeda australis</i>	Kangaroo Grass										X
Polygonaceae	*	<i>Acetosa sagittata</i>	Rambling Dock										X
	*	<i>Rumex crispus</i>	Curled Dock										X
Proteaceae		<i>Banksia ericifolia</i> subsp. <i>ericifolia</i>				2	2	4	3		4		X
		<i>Banksia marginata</i>	Silver Banksia			2	2	2		2			X
		<i>Banksia oblongifolia</i>	Fern-leaved Banksia					2		3			X
		<i>Banksia paludosa</i>				2							
		<i>Banksia robur</i>	Swamp Banksia			1				1			
		<i>Banksia serrata</i>	Old-man Banksia						2	2			X
		<i>Banksia spinulosa</i> var. <i>spinulosa</i>				2							X
		<i>Conospermum longifolium</i> subsp. <i>angustifolium</i>					2	2			2		
		<i>Grevillea diffusa</i> subsp. <i>diffusa</i>						2		1			
		<i>Grevillea oleoides</i>	Red Spider Flower										X
		<i>Grevillea phylicoides</i>	Grey Spider Flower										X
		<i>Grevillea sericea</i> subsp. <i>sericea</i>				2		2	2	2	2		X
		<i>Grevillea sphacelata</i>	Grey Spider Flower				3		2	2	3		X
		<i>Hakea dactyloides</i>	Finger Hakea			2			2	3			X

Family	Exotic	Scientific Name	Common Name	TSC Status	EPBC Status	Plot/transect							Opportunistic
						Q1	Q2	Q3	Q4	Q5	Q6	Q7	
		<i>Hakea gibbosa</i>				3	3						X
		<i>Hakea sericea</i>	Needlebush					2					X
		<i>Hakea teretifolia</i>	Needlebush								3		X
		<i>Isopogon anemonifolius</i>	Broad-leaf Drumsticks							2			X
		<i>Isopogon anethifolius</i>	Narrow-leaf Drumsticks							2			
		<i>Lambertia formosa</i>	Mountain Devil				3	3					X
		<i>Lomatia silaifolia</i>	Crinkle Bush							1			X
		<i>Persoonia lanceolata</i>	Lance Leaf Geebung										X
		<i>Persoonia levis</i>	Broad-leaved Geebung							2	3		
		<i>Persoonia linearis</i>	Narrow-leaved Geebung				4	3	2	2	3		X
		<i>Petrophile pulchella</i>	Conesticks										X
		<i>Petrophile sessilis</i>					3			2	3		
		<i>Symphionema paludosum</i>				1							
Rosaceae	*	<i>Rubus fruticosus</i> sp. agg.	Blackberry complex										X
Restionaceae		<i>Chordifex dimorphus</i>				2							
		<i>Chordifex fastigiatus</i>											
		<i>Empodisma minus</i>				3		2					
		<i>Eurychorda complanata</i>				2							
		<i>Hypolaena fastigiata</i>											X
		<i>Leptocarpus tenax</i>				4							X
		<i>Lepyrodia scariosa</i>				2	2	2		2	2		X
Rhamnaceae		<i>Cryptandra amara</i>	Bitter Cryptandra										X
Rutaceae		<i>Boronia parviflora</i>	Swamp Boronia			1							
		<i>Crowea saligna</i>					1						
		<i>Eriostemon australasius</i>								1			X

Family	Exotic	Scientific Name	Common Name	TSC Status	EPBC Status	Plot/transect							Opportunistic
						Q1	Q2	Q3	Q4	Q5	Q6	Q7	
Sapindaceae		<i>Dodonaea triquetra</i>	Large-leaf Hop-bush						2	2			
Schizaeaceae		<i>Schizaea bifida</i>	Forked Comb Fern										X
Scrophulariaceae	*	<i>Verbascum thapsus subsp. thapsus</i>	Great Mullein										X
Stackhousiaceae		<i>Stackhousia nuda</i>				1							
Sterculiaceae		<i>Rulingia hermanniifolia</i>											X
		<i>Lasiopetalum rufum</i>											X
Stylidiaceae		<i>Stylidium graminifolium</i>	Grass Triggerplant			2							
		<i>Stylidium productum</i>											X
Verbenaceae	*	<i>Lantana camara</i>	Lantana										X
	*	<i>Verbena bonariensis</i>	Purpletop									2	X
	*	<i>Verbena rigida var. rigida</i>	Veined Verbena										X
Violaceae		<i>Hybanthus monopetalus</i>	Slender Violet-bush						2				
Xanthorrhoeaceae		<i>Xanthorrhoea resinifera</i>				3				4			

Key: * introduced, E – endangered, EP – endangered population, V – vulnerabl, X – opportunistic record, relative abundance not recorded.

Cover abundance rankings within each plot/transect:

- 1 Foliage sparsely or very sparsely present, cover less than 5%;
- 2 1-5% Plentiful, foliage cover 1-5 %;
- 3 5-25% foliage cover;
- 4 26-50% foliage cover;
- 5 51-75% foliage cover;
- 6 76-100% foliage cover;

Fauna species recorded

Scientific Name	Common Name	TSC Status	EPBC Status	GHD 2014/2015 surveys				GHD 2010 surveys
				Landfill	Dams	Swamp	Woodland	
BIRDS								
<i>Cracticus tibicen</i>	Australian Magpie			O				O
<i>Aegotheles cristatus</i>	Australian Owlet-nightjar						O	
<i>Pelecanus conspicillatus</i>	Australian Pelican							O
<i>Anthus novaeseelandiae</i>	Australian Pipit			O				
<i>Corvus coronoides</i>	Australian Raven			O			OC	O
<i>Threskiornis molucca</i>	Australian White Ibis			O			K	O
<i>Melithreptus gularis gularis</i>	Black-chinned Honeyeater (eastern subspecies)	V						O
<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike							W
<i>Elanus axillaris</i>	Black-shouldered Kite			O				
<i>Gerygone mouki</i>	Brown Gerygone						W	O
<i>Accipiter fasciatus</i>	Brown Goshawk					O	O	O
<i>Coturnix ypsilophora</i>	Brown Quail			O				
<i>Acanthiza pusilla</i>	Brown Thornbill						W	O
<i>Melithreptus brevirostris</i>	Brown-headed Honeyeater							O
<i>Acanthiza reguloides</i>	Buff-rumped Thornbill						W	
<i>Scythrops novaehollandiae</i>	Channel-billed Cuckoo							W
<i>Anas castanea</i>	Chestnut Teal				O			
<i>Phaps chalcoptera</i>	Common Bronzewing							O
<i>Ocyphaps lophotes</i>	Crested Pigeon						O	
<i>Platycercus elegans</i>	Crimson Rosella							O
<i>Taeniopygia bichenovii</i>	Double-barred Finch						O	O

Scientific Name	Common Name	TSC Status	EPBC Status	GHD 2014/2015 surveys				GHD 2010 surveys
				Landfill	Dams	Swamp	Woodland	
<i>Gallinula tenebrosa</i>	Dusky Moorhen				O			
<i>Eudynamys orientalis</i>	Eastern Koel							W
<i>Acanthorhynchus tenuirostris</i>	Eastern Spinebill						O	W
<i>Eopsaltria australis</i>	Eastern Yellow Robin							W
<i>Cacomantis flabelliformis</i>	Fan-tailed Cuckoo							W
<i>Pachycephala pectoralis</i>	Golden Whistler							W
<i>Cracticus torquatus</i>	Grey Butcherbird							W
<i>Rhipidura albiscapa</i>	Grey Fantail							O
<i>Colluricincla harmonica</i>	Grey Shrike-thrush						W	O
<i>Dacelo novaeguineae</i>	Laughing Kookaburra							O
<i>Meliphaga lewinii</i>	Lewin's Honeyeater						W	
<i>Meliphaga lewinii</i>	Lewin's Honeyeater							W
<i>Corvus mellori</i>	Little Raven							W
<i>Anthochaera chrysoptera</i>	Little Wattlebird						O	O
<i>Grallina cyanoleuca</i>	Magpie-lark			O				O
<i>Vanellus miles</i>	Masked Lapwing			O				W
<i>Phylidonyris novaehollandiae</i>	New Holland Honeyeater			O		O	O	O
<i>Philemon corniculatus</i>	Noisy Friarbird					W	W	O
<i>Manorina melanocephala</i>	Noisy Miner							O
<i>Anas superciliosa</i>	Pacific Black Duck				O			
<i>Strepera graculina</i>	Pied Currawong							W
<i>Trichoglossus haematodus</i>	Rainbow Lorikeet							O
<i>Anthochaera carunculata</i>	Red Wattlebird							O
<i>Neochmia temporalis</i>	Red-browed Finch						O	W
<i>Todiramphus sanctus</i>	Sacred Kingfisher							W
<i>Petroica boodang</i>	Scarlet Robin	V						W

Scientific Name	Common Name	TSC Status	EPBC Status	GHD 2014/2015 surveys				GHD 2010 surveys
				Landfill	Dams	Swamp	Woodland	
<i>Chalcites lucidus</i>	Shining Bronze-cuckoo							W
<i>Zosterops lateralis</i>	Silvereye							W
<i>Ninox novaeseelandiae</i>	Southern Boobook						W	
<i>Ninox novaeseelandiae</i>	Southern Boobook							W
<i>Pardalotus punctatus</i>	Spotted Pardalote							W
<i>Acanthiza lineata</i>	Striated Thornbill							O
<i>Cacatua galerita</i>	Sulphur-crested Cockatoo						O	O
<i>Malurus cyaneus</i>	Superb Fairy-wren			O			O	O
<i>Podargus strigoides</i>	Tawny Frogmouth							O
<i>Malurus lamberti</i>	Variegated Fairy-wren							O
<i>Hirundo neoxena</i>	Welcome Swallow			O				O
<i>Sericornis frontalis</i>	White-browed Scrubwren							W
<i>Phylidonyris niger</i>	White-cheeked Honeyeater							O
<i>Lichenostomus leucotis</i>	White-eared Honeyeater							O
<i>Ardea pacifica</i>	White-necked Heron			O				
<i>Cormobates leucophaea</i>	White-throated Treecreeper							W
<i>Rhipidura leucophrys</i>	Willie Wagtail			O				
<i>Acanthiza nana</i>	Yellow Thornbill							W
<i>Lichenostomus chrysops</i>	Yellow-faced Honeyeater						W	O
<i>Calyptorhynchus funereus</i>	Yellow-tailed Black-cockatoo							O
MAMMALS								
<i>Rattus fuscipes</i>	Bush Rat							O
<i>Chalinolobus morio</i>	Chocolate Wattled Bat						Po	
<i>Trichosurus vulpecula</i>	Common Brushtail Possum							O
<i>Pseudocheirus peregrinus</i>	Common Ringtail Possum						OK	O
<i>Miniopterus schreibersii oceanensis</i>	Eastern Bentwing-bat	V						AD

Scientific Name	Common Name	TSC Status	EPBC Status	GHD 2014/2015 surveys				GHD 2010 surveys
				Landfill	Dams	Swamp	Woodland	
<i>Vespadelus pumilus</i>	Eastern Forest Bat				Po		Po	
<i>Macropus giganteus</i>	Eastern Grey Kangaroo			O			K	
<i>Vulpes vulpes</i>	Fox						KF	
<i>Chalinolobus gouldii</i>	Gould's Wattled Bat				AD		AD	AD
<i>Scoteanax rueppellii</i>	Greater Broad-nosed Bat	V			Po		Po	
<i>Pteropus poliocephalus</i>	Grey-headed Flying-fox	V	V					O
<i>Mus musculus</i>	House Mouse			O				
<i>Vespadelus vulturnus</i>	Little Forest Bat							AD
<i>Nyctophilus sp.</i>	long-eared bat						AD	
<i>Perameles nasuta</i>	Long-nosed Bandicoot						CKF	W
<i>Oryctolagus cuniculus</i>	Rabbit						CK	
<i>Rattus sp.</i>	Rat						K	
<i>Petaurus breviceps</i>	Sugar Glider							O
<i>Wallabia bicolor</i>	Swamp Wallaby			O			O	O
<i>Mormopterus "Species 2"</i>	Undescribed Freetail Bat				Po		Po	
<i>Tadarida australis</i>	White-striped Freetail-Bat							AD
REPTILES								
<i>Vermicella annulata</i>	Bandy-Bandy						O	
<i>Ctenotus taeniolatus</i>	Copper-tailed Skink						O	
<i>Lampropholis delicata</i>	Dark-flecked Garden Sunskink						O	O
<i>Tiliqua scincoides</i>	Eastern Blue-tongue							O
<i>Physignathus lesueurii</i>	Eastern Water Dragon				O			
<i>Eulamprus quoyii</i>	Eastern Water-Skink						O	
<i>Amphibolurus muricatus</i>	Jacky Lizard							O
<i>Varanus varius</i>	Lace Monitor						C	
<i>Oedura lesueurii</i>	Lesueur's Velvet Gecko							O

Scientific Name	Common Name	TSC Status	EPBC Status	GHD 2014/2015 surveys				GHD 2010 surveys
				Landfill	Dams	Swamp	Woodland	
<i>Rankinia diemensis</i>	Mountain Dragon						O	
FROGS								
<i>Litoria latopalmata</i>	Broad-palmed Frog				O			
<i>Limnodynastes peronii</i>	Brown-striped Frog					W	W	W
<i>Crinia signifera</i>	Common Eastern Froglet						W	W
<i>Uperoleia fusca</i>	Dusky Toadlet							O
<i>Limnodynastes dumerilii</i>	Eastern Banjo Frog							W
<i>Litoria fallax</i>	Eastern Dwarf Tree Frog				OW			O
<i>Litoria peronii</i>	Peron's Tree Frog				W			
<i>Uperoleia laevisgata</i>	Smooth Toadlet				W			W
<i>Uperoleia tyleri</i>	Tyler's Toadlet							W

Key: * - introduced; V – vulnerable; AD – anabat (definite); Po – anabat (possible); F – tracks; K – dead; O – observed; W – heard.

Appendix E Aquatic Ecosystem Investigation



SITA Australia Pty Ltd
Lucas Heights Resource Recovery Park
Aquatic Ecosystem Investigation

July 2015

Executive summary

GHD Pty Ltd (GHD) was commissioned to conduct one round of aquatic ecosystem monitoring within Mill Creek, adjacent to and downstream of the SITA Australia Pty Ltd (SITA) Lucas Heights Resource Recovery Park (LHRRP). The principal aims of this project were to establish:

- The presence and condition of aquatic and riparian¹ habitat currently existing within Mill Creek
- The presence and condition of aquatic macroinvertebrate² communities currently existing within Mill Creek

This report presents the monitoring data collected and assessed during this project and provides commentary on its implications. This report is subject to, and must be read in conjunction with, the limitations, assumptions and qualifications contained throughout the report.

This project consisted of the selection and subsequent field sampling / assessment of five monitoring locations present along Mill Creek (one upstream (MCUP, four downstream of the LHRRP – MC1, MC2, MC3 and MC4) for:

- Basic water quality parameters
- Aquatic macroinvertebrates
- Aquatic and riparian habitat condition

Following the completion of these fieldworks, the aquatic macroinvertebrate samples obtained during the fieldwork were identified in a laboratory using a microscope. Following identification of macroinvertebrates, a variety of data analyses were carried out. These analyses provide indices allowing for a broad assessment of the condition or “health” of sites and allow comparison between sites based upon community structure and defined habitat characteristics.

All sites downstream of the LHRRP assessed for the aquatic ecosystem investigation had a mostly natural and continuous riparian vegetation zone with the community almost completely dominated by native species. A healthy mix of ground cover, shrub layer and over story trees was present at all sites. The geomorphic nature of the sites was generally similar and characteristic of a small coastal lowland (below 150 m altitude) catchment. Habitat condition was generally good, although disturbance to the ground surface associated with recreational vehicle activities was observed at MC3, leading to increased levels of sediment deposition near this site.

A relatively high number of macroinvertebrate taxa were identified across the monitored locations suggesting that physical conditions are sufficient to support diverse macroinvertebrate life. Assessment of the pollution tolerances of taxa present found most monitoring locations had communities dominated by pollution tolerant taxa, although some sensitive taxa were present.

Based on the results of the field survey and data analysis, the following conclusions are made:

- Results of the *in situ* water quality monitoring suggested that dissolved oxygen was slightly below the ANZECC assessment criteria at the majority of the monitoring locations. Electrical conductivity and pH were within the recommended ranges. The LHRRP and off-site recreational vehicle users may be having some minor impacts on Mill Creek in

¹ Riparian refers to the narrow strips of land that immediately border creeks, rivers or other watercourses.

² Macroinvertebrates are organisms that are large (macro) enough to be seen with the naked eye and lack a backbone (invertebrate).

relation to turbidity values, although turbidity may have been affected by a recent rainfall event.

- Habitat was found to be generally in good condition. The LHRRP may be having some minor impacts on Mill Creek in relatively close proximity to the LHRRP (MC1), as condition here is lower than at the upstream site. Habitat condition improves at MC2. A decline at MC3 is likely to be the result of disturbance caused by recreational vehicle users. Aquatic and riparian habitat at MC 4 (located furthest from the LHRRP) was in a reasonably pristine condition. The recovery of habitat condition at this monitoring location suggests that any impacts of the LHRRP are spatially limited and that the natural condition of the surrounding catchment downstream will ensure minimal impacts to the Georges River receiving environment.
- Macroinvertebrate communities present at the monitoring locations were generally in a healthy condition. Communities were dominated by pollution tolerant taxa, although some sensitive taxa were present. Recent studies of urban streams in the Georges River catchment found few or no pollution-sensitive taxa, suggesting that Mill Creek is one of the better condition streams in the area. Key drivers of losses in taxonomic diversity in Mill Creek are currently unclear and are spatially limited and which may be linked to off-site activities in certain locations (such as recreational vehicle use).
- The proposal should result in a lower potential for impacts on the Mill Creek aquatic environment due to the proposed reprofiling of the site, increasing over time the capped and revegetated areas and via a number of best practice operational controls documented in the OEMPs.
- Further investigation of the habitat condition and macroinvertebrate populations is recommended to confirm the preliminary findings contained within this report. It is recommended that this work be undertaken every three years commencing soon after reprofiling works commence in Area E.

It is noted that River Health Monitoring Program monitors three important ecological indicators to provide an assessment of catchment health; water quality, vegetation and macroinvertebrates (refer Section 6.6) and that their findings reinforce the conclusions of this report. That is, any impacts of the LHRRP on Mill Creek are spatially limited as further downstream the health of Mill Creek was found to be in an excellent condition.

Glossary

Term	Definition
ANSTO	Australian Nuclear Science and Technology Organisation
AHD	Australian Height Datum; A geodetic datum for altitude measurement in Australia
ARRT facility	Advanced Resource Recovery Technology facility
Assessment criteria	Defined criteria against which physical and biological features of the aquatic ecosystem can be assessed
AUSRIVAS	(Australian River Assessment System) A rapid biological assessment system for streams and rivers that generates region-specific predictions of the invertebrate fauna expected to be present in the absence of environmental stress. Predicted or expected fauna are obtained from modelling data collected from a number of reference sites. The predicted fauna are then compared to the observed fauna lists and the resulting ratio is used to indicate the extent of the anthropogenic impact.
Bankfull width	The width of the channel at the top of the stream banks where subsequent increase in flow results in overflow onto a floodplain
Canopy	The upper layer or habitat zone of a vegetation community, predominantly formed by mature tree crowns but may include other biological organisms.
Class	A taxonomic rank in biological classification, class (Latin: classis). Other well-known ranks are life, domain, kingdom, phylum, order, family, genus, and species, with class fitting between phylum and order. As for the other well-known ranks, there is the option of an immediately lower rank, indicated by the prefix sub-: subclass (Latin: subclassis).
EIS	Environmental Impact Statement
EPA	New South Wales Environment Protection Authority and any successor body
Family	In biological classification, a family (Latin: familia, plural familiae) is a taxonomic rank between order and genus. A family may be divided into one or more subfamilies, intermediate ranks above the rank of genus.
Fauna	Animals especially the animals of a particular country region or time considered as a group or community
Geomorphology	Geomorphology is the scientific study of landscape features created by physical or chemical processes operating at or near the earth's surface. In a riverine setting geomorphology is focused on the shape and structure of the active river channel.
GHD	Gutteridge, Haskins and Davey. Gordon Gutteridge founded the company in 1928 and Gerald Haskins and Geoffrey Davey joined the partnership in 1939.
GO facility	The Garden Organics facility at LHRRP, that undertakes composting of waste including green and garden waste, but excluding waste types such as food waste and biosolids
In situ	A Latin phrase that translates literally to "on site" or "in position". It means "locally", "on site", "on the premises" or "in place" to describe an event where it takes place.
LHRRP	Lucas Heights Resource Recovery Park
Littoral zone	Shallow shoreline area of a body of water; often considered the portion of benthos from zero depth to the deepest extent of rooted plants
Macroinvertebrate	Larger invertebrates (i.e. without backbones) functionally defined as those retained on a 250 µm sieve; their body usually exceeds 1 mm and they are generally observable with the naked eye; includes insects arachnids crustaceans molluscs and annelids.

Term	Definition
Macrophyte	An aquatic plant that is visible to the naked eye but not including filamentous algae mosses or liverworts
Morphology	From the Greek and meaning "study of shape".
Order	In biological classification, the order (Latin: ordo) is a taxonomic rank used in the classification of organisms and recognized by the nomenclature codes. Other well-known ranks are life, domain, kingdom, phylum, class, family, genus, and species, with order fitting in between class and family. An immediately higher rank, superorder, may be added directly above order, while suborder would be a lower rank.
Reach	An expanse of stream or river under study; for standard Victorian rapid bioassessment purposes reach is defined as ten times the average stream width from a minimum of 50 m to a maximum of 150 m however reaches under other programs such the Sustainable Rivers Audit (SRA) and Victorian Environmental Flow Monitoring and Assessment Program (VEFMAP) may be defined as much longer than this
Riffle	A rapidly flowing portion of a river or stream where the influence of the bottom can be seen at the surface; a stretch of choppy water in a stream or river caused by shallow fast flows over rocks a shoal or a sandbar; a rapid
Riparian	Relating to or located on the banks of a river or stream; especially in terms of vegetation interacting with the stream
SITA	SembSITA Australia Pty Ltd (SembSITA) is the holding company for the SITA Australia (SITA) group of companies in Australia. SembSITA is the parent company of both SITA and WSN Environmental Solutions Pty Ltd (WSN). WSN owns part of the land on which the LHRRP is situated, and leases the remainder from ANSTO. SITA holds the environmental protection licence (EPL), and so is the operator of the facilities at LHRRP. For simplicity, the term 'SITA' is used to refer to all of these organisations in this report.
Subfamily	In biological classification, a subfamily (Latin: subfamilia, plural subfamiliae) is an auxiliary (intermediate) taxonomic rank, next below family but more inclusive than genus. Standard nomenclature rules end subfamily botanical names with "-oideae", and zoological names with "-inae".
Taxa	Plural of taxon
Taxon	A taxonomic category or group such as a phylum order family genus or species (plural is taxa); the named classification unit to which individuals or sets of species are assigned
Taxonomic	Pertaining to or involving taxonomy or the laws and principles of arranging species or groups into a system exhibiting their relationship to each other and their places in a natural classification

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Appendices

Appendix A – GHD Aquatic Ecosystem Database Field Data Report

Appendix B - Macroinvertebrate Data

Appendix C - AUSRIVAS Macroinvertebrate Taxa Expected to occur but not Observed

1. Introduction

1.1 Overview

SITA Australia (SITA)³ is proposing a number of activities at the Lucas Heights Resource Recovery Park (LHRRP) in Lucas Heights. SITA engaged GHD Pty Ltd (GHD) to prepare an Environmental Impact Statement (EIS) for a proposed expansion to current waste management operations at the LHRRP.

As part of the preparation of the EIS, GHD was retained to undertake a number of specialist studies, including a surface water impact assessment (assessment). To support this assessment, GHD was also retained to undertake one round of aquatic ecosystem monitoring within Mill Creek (a watercourse which rises within and runs through the LHRRP). The principal aims of this investigation were to establish:

- The presence and condition of aquatic and riparian habitat currently existing within Mill Creek
- The presence and condition of aquatic macroinvertebrate communities currently existing within Mill Creek

This report summarises the works completed during this investigation.

1.2 Purpose of this report

The purpose of this report is to document:

- Relevant site information
- The field and laboratory works completed and the monitoring data obtained
- The assessment of the monitoring data
- The conclusions made in relation to the works completed

1.3 Scope of works

GHD undertook the following scope of works:

- Selection and subsequent field sampling and assessment of five monitoring locations along Mill Creek for:
 - Basic water quality parameters
 - Habitat condition
 - Aquatic macroinvertebrate communities
- Identification of aquatic macroinvertebrate samples taken in the field at GHD's laboratory using a microscope
- Selection of appropriate assessment criteria and subsequent assessment of gathered data against these criteria (as relevant, habitat condition assessments generally performed in the field but also referenced against site photographs)

³ SembSITA Australia Pty Ltd (SembSITA) is the holding company for the SITA Australia (SITA) group of companies in Australia. SembSITA is the parent company of both SITA and WSN Environmental Solutions Pty Ltd (WSN). WSN owns part of the land on which the LHRRP is situated, and leases the remainder from ANSTO. SITA holds the environmental protection licence (EPL), and so is the operator of the facilities at LHRRP. For simplicity, the term 'SITA' is used to refer to all of these organisations in this report.

- Documentation of the works undertaken, the monitoring data obtained and GHD's conclusions and recommendations in a report (i.e. this report)

1.4 Assumptions

During preparation of this report, GHD has made a number of assumptions as identified through the text of this report. These assumptions include (but are not limited to) the following:

- SITA understands that water quality, habitat condition and macroinvertebrate populations are influenced by a number of factors and can vary significantly with both time and space
- SITA understands that this report presents the data and findings from one discrete monitoring round, the results of which may have been influenced by a number of factors including:
 - A significant rainfall event that occurred in the 24 hours prior to the fieldworks commencing
 - The time at which the fieldworks were undertaken⁴
 - The monitoring locations selected
- SITA understands that further works are required to confirm the ongoing ecological conditions within Mill Creek.

1.5 Reliance

The following documents were relied upon in the development of this report:

- ANZECC (2000), Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australia and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra (ANZECC (2000))
- Brycroft B.M., Coller B.A.W., Deacon G.B., Coleman D.J. and Lake P.S., (1982), Mercury contamination of the Lerderderg River, Victoria, Australia, from abandoned gold field, Environmental Pollution Series A, 28, 135-147
- Chessman B. (1995) Rapid assessment of rivers using macroinvertebrates: A procedure based on habitat-specific sampling, family level identification and a biotic index, Australian Journal of Ecology 20:122–129
- Chessman B., Growns J.E. and Kotlash A.R. (1997). Objective derivation of macroinvertebrate family sensitivity grade numbers for the SIGNAL biotic index: application to the Hunter River system, NSW. Marine and Freshwater Research. 48:159-172
- Chessman B. (2003) New sensitivity grades for Australian river macroinvertebrates. Marine and Freshwater Research, 54: 95-104.
- Chessman B., Williams S. and Besley C. (2007) Bioassessment of streams with macroinvertebrates: effect of sampled habitat and taxonomic resolution. Journal of The North American Benthological Society, 26(3):546–565
- Department of Natural Resources Queensland (2001) Queensland Australian River Assessment System (AUSRIVAS), Sampling and Processing Manual, August 2001. The State of Queensland, Department of Natural Resources 2001 (DNR 2001)

⁴ The macroinvertebrate sampling exercise occurred within two weeks of (but still outside) the recommended autumn (March 15 to June 15) or spring (September 15 to December 15) sampling periods as per the AUSRIVAS macroinvertebrate sampling methodology for NSW (Turak et al., 2004)

- Dudka S. and Adriano D.C. (1997) Environmental impacts of metal ore mining and processing: a review. *Journal of Environmental Quality*, 26, 590-602.
- Faith D.P., Dostine P.L., and Humphrey D.P. (1995) Detection of mining impacts on aquatic macroinvertebrate communities: results of a disturbance experiment and the design of a multivariate BACIP monitoring programme at Coronation Hill, Northern Territory. *Australian Journal of Ecology*, 20, pp 167-180.
- García-Criado F., Tomé A., Vega F.J. and Antolín C. (1999) Performance of some diversity and biotic indices in rivers affected by coal mining in northwestern Spain. *Hydrobiologia*, 394, pp 209-217.
- ISO (1983). *Water Quality: Methods of Biological Sampling - Handnet Sampling of Aquatic Benthic Macroinvertebrates*. Draft ISO International Standard.
- Norris R.H., Lake P.S. and Swain R. (1982) Ecological effects of mine effluents on the South Esk River, north-eastern Tasmania. III. Benthic macroinvertebrates, *Australian Journal of Marine and Freshwater Research*, 32, 165-173.
- Petersen, R. C. (1992). The RCE: a Riparian, Channel, and Environmental Inventory for small streams in the agricultural landscape. *Freshwater Biology*, 27, 295-306.
- Queensland Government Department of Science, Information Technology, Innovation and the Arts (DSITIA) and Bureau of Meteorology (BOM) (2014), SILO weather data (<http://www.longpaddock.qld.gov.au/silo>) accessed 10 June 2014.
- Tippler C., Hanlon A. and Birtles P. (2014) 2013 – 2014 River Health: Georges River Report Card. Georges River Combined Councils Committee Inc.
- Turak E., Waddell N. and Johnstone G. (2004) New South Wales (NSW) Australian River Assessment System (AUSRIVAS) Sampling and Processing Manual 2004. <http://ausrivas.ewater.com.au/ausrivas/index.php/manuals-a-datasheets?id=55>

1.6 Limitations

This report has been prepared by GHD for SITA Australia Pty Ltd and may only be used and relied on by SITA Australia Pty Ltd for the purpose agreed between GHD and SITA Australia Pty Ltd as set out in Section 1.2 of this report

GHD otherwise disclaims responsibility to any person other than SITA Australia Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

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

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at, or in connection with, specific sample points, and on conditions encountered and information reviewed at the date of preparation of the report. Conditions at or adjacent to other parts of the LHRP may be different from the conditions encountered at the specific sample points. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that this report was prepared.

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

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

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

2. Background information

2.1 LHRPP and Mill Creek locations

The LHRPP is located to the north of the intersection of New Illawarra Road and Heathcote Road in Lucas Height, New South Wales. Mill Creek rises in the south-western corner of the LHRPP, runs along the western boundary of the LHRPP and ultimately discharges into the Georges River.

The locations of the LHRPP and Mill Creek are shown on Figure 2.1 below.



Figure 2.1 Locations of the LHRPP and Mill Creek

2.2 Hydrology

Clean stormwater run-off from the revegetated areas of the LHRRP is shed via sheet flow across the LHRRP's surface towards the perimeter of the LHRRP. Surface water in contact with daily and intermediate cover is diverted to sediment and erosion control measures before this water is released from the site. From there, this water drains off-site into northerly flowing local surface watercourses to the west and east of the LHRRP (including Mill Creek and Bardens Creek). All of these off-site watercourses ultimately drain northwards into the Georges River.

Stormwater run-off that may contain sediment is collected via a series of drains, swales and ponds and directed to the main sediment dam located in the northwestern part of the LHRRP. This dam is designed to allow for settlement of suspended solids before discharging offsite following large rainfall events when stormwater dam has reached its design capacity or via the stormwater treatment plant (following its treatment). These discharged waters flow into Mill Creek.

As shown on Figure 1, Mill Creek originates within the LHRRP and flows northwards along the western boundary of the LHRRP towards the Georges River. Mill Creek drains the majority of stormwater run-off from the LHRRP.

Mill Creek is a perennial water courses. As such, typically it would be expected that base flow for this watercourse would be derived from local groundwater. However, existing groundwater level data for the LHRRP suggests that Mill Creek is only partially recharged by groundwater in the vicinity of the LHRRP with the majority of its flow "fed" by surface water run-off.

2.3 Local climate / meteorology

Review of data from Bureau of Meteorology (BOM, 2014) and data from the Queensland Government Department of Science, Information Technology, Innovation and the Arts (DSITIA, 2014) suggests that a warm temperate climate with strong maritime influence is experienced in the Lucas Heights area. Mean daily temperatures range from 26.0 °C to 17.0 °C in February and from 15.8 °C to 6.6 °C in July. Frost is not experienced in this area.

Seasonal variations occur in rainfall with a greater proportion being received during summer months. A generally even rainfall distribution is experienced over the region with a mean annual rainfall of 1015 millimetres (mm).

Recent climatic / meteorological conditions are a key consideration in relation to the data obtained during aquatic ecological monitoring as they have the potential to significantly affect:

- The water quality encountered within watercourses
- The presence and condition of aquatic macroinvertebrate communities encountered within watercourses
- The presence and condition of aquatic habitat encountered within watercourses

Section 3 provides information on the sampling and analysis program developed and applied during this project.

3. Sampling and analysis program

3.1 Overview

The sampling and analysis program adopted during this monitoring round consisted of undertaking environmental monitoring at five selected monitoring locations along Mill Creek on 2 March 2015. These works included both fieldworks and subsequent laboratory based works.

The environmental monitoring undertaken at the five monitoring locations consisted of the following:

- Monitoring basic water quality parameters with portable instrumentation
- Visual assessment of habitat condition
- Sampling (and subsequent laboratory identification) of aquatic macroinvertebrate populations

Additional information on the selected monitoring locations and associated monitoring parameters are contained in the following sections.

3.1.1 Environmental monitoring locations

The monitoring locations selected for environmental monitoring are shown on Figure 3.1.

Further details on these monitoring locations are provided in Table 3.1 below.

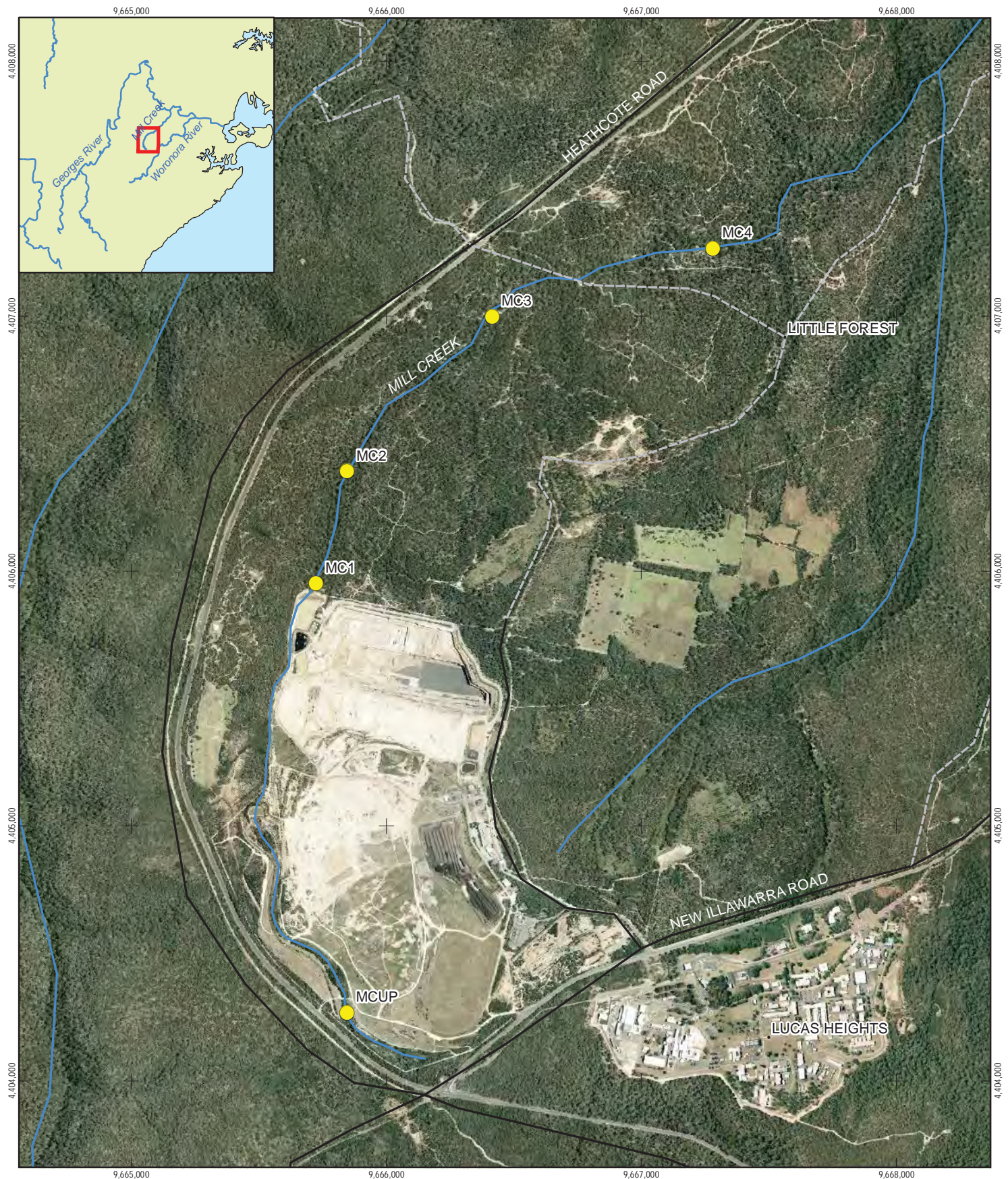
Table 3.1 Location details of environmental monitoring locations

Site code	Site name and location	Latitude	Longitude	Altitude (m AHD)
MCUP	Mill Creek Upstream of Duck Pond	-34.05119	150.96673	175
MC1	Mill Creek Immediately downstream of SITA Lucas Heights	-34.03606	150.96473	105
MC2	Mill Creek Adjacent to MTB track	-34.03205	150.96586	100
MC3	Mill Creek End of Little Forest Rd access track	-34.02638	150.97178	100
MC4	Mill Creek Downstream	-34.02367	150.98104	80

The monitoring locations shown on Figure 3.1 and in Table 3.1 were selected during a field inspection undertaken on 22 January 2015. These locations were selected by GHD with consideration of the need to have an adequate spatial distribution along Mill Creek, the need to have both upstream and downstream monitoring locations (of the LHRRP) and access limitations.

3.2 Environmental monitoring parameters

The environmental monitoring undertaken consisted of monitoring appropriate physical, chemical and biological parameters within Mill Creek at the identified monitoring locations. Further details on the precise parameters monitored are provided in the Section 4.



LEGEND

- Aquatic Ecosystem Sampling Site
- Waterway
- Road
- Track

Paper Size A4
 0 100 200 300 400 500
 Meters
 Map Projection: Transverse Mercator
 Horizontal Datum: GDA 1994
 Grid: GDA 1994 MGA Zone 55



SITA Support Services
 Lucas Heights Landfill

Job Number | 2120508
 Revision | A
 Date | 09 Mar 2015

Aquatic Ecosystem Sampling Sites

Figure 3.1

4. Environmental monitoring

4.1 Overview

GHD undertook the environmental monitoring work in accordance with the sampling and analysis program developed for this project. This consisted of:

- Fieldworks to inspect the monitoring locations, undertake in situ water quality monitoring, identify the condition and presence of aquatic and riparian habitat and to sample aquatic macroinvertebrates for subsequent visual identification at GHD's laboratory
- Laboratory works to visually identify macroinvertebrates contained within the samples taken in the field

These works were completed by a professionally qualified and experienced aquatic biologist (Mr. Adrian Dickson of GHD).

The following sections present further information on the fieldwork and laboratory works undertaken as part of this project.

4.2 Fieldworks

4.2.1 Overview

The fieldwork aspects of the investigation were undertaken on 2 March 2015. The fieldworks included:

- Monitoring basic water quality parameters with portable instrumentation
- Visual assessment of habitat condition
- Sampling of macroinvertebrates

Monitoring data obtained during these fieldworks was captured electronically in the field into a Microsoft Access database. The data fields recorded in the specialised database were created with consideration and guidance of field data sheets used for the First National Assessment of River Health (FNARH) and the NSW, QLD and ACT AUSRIVAS Manuals (Turak *et al.*, 2004; DNRM, 2001; Nicholls *et al.*, 2000). These documents are widely used by ecological practitioners in NSW in relation to the assessment of aquatic ecosystems.

4.2.2 In situ water quality

The following in situ water quality parameters were measured just below the water surface adjacent to the stream bank at each of the monitoring locations;

- Temperature (°C)
- pH
- Electrical Conductivity (µS/cm)
- Dissolved Oxygen (mg/L and % saturation)
- Turbidity (NTU)
- Alkalinity (mg/L CaCO₃)

Temperature, pH, electrical conductivity, and dissolved oxygen were measured using a YSI 600QS multi-parameter water quality meter. Turbidity was measured in the field using a Hach 2100 Turbidimeter. Both meters were calibrated in accordance with GHD's Quality System requirements and the manufacturer's specifications prior to its use in the field. Alkalinity was

measured in the field using a Hach Digital Alkalinity Titration kit. This is a hand held titration kit that is factory set and does not require calibration.

4.2.3 Habitat condition

Assessment of habitat condition is performed in association with water quality and macroinvertebrate sampling as it provides supporting evidence of the site condition and aids in the interpretation of water quality and macroinvertebrate community data.

Visual assessment of the habitat condition at each of the monitoring locations was undertaken. This included recording certain data and completing in-field assessments of habitat condition using several assessment techniques widely used by ecological practitioners in NSW in relation to the assessment of aquatic ecosystem condition. The habitat condition works included recording and assessment of the following:

- Site location information and photographs
- Visual assessment of geomorphology and Riparian⁵ vegetation
- Assessment of disturbances related to human activities (as per NSW AUSRIVAS; Turak *et al.*, 2004)
- Assessment of Modified RCE; Riparian, Channel and Environmental inventory (as per Chessman *et al.*, 1997)
- Assessment against reference condition selection criteria (as per DNR, 2001)

Further information on the four assessment techniques identified above is provided in Section 5.

4.2.4 Macroinvertebrate sampling

Field sampling of macroinvertebrates was undertaken at each of the monitoring locations using Rapid Bioassessment (RBA) protocols in accordance with the NSW AUSRIVAS⁶ Sampling and Processing Manual (Turak *et al.*, 2004).

RBA sampling was conducted using a standard ISO 7828 (1983) design sweep-net with 250 µm mesh. This net was washed thoroughly between sampling events to remove any material retained on it.

At each monitoring location, the littoral or edge habitat was sampled by sweeping the sweep-net along the edge of Mill Creek in areas of little or no current. The net was swept around overhanging terrestrial vegetation, against snags if present, in backwaters, and through beds of macrophytes⁷ if present. This process was continued, working upstream against the flow, with the sample covering approximately 10 m of edge. Sampling considered both banks where possible and the quantity of habitat types sampled was approximately proportional, and representative of the quantity of habitat types present at the site.

For each RBA sample taken (one per monitoring location), the collected material was placed into a sorting tray and macroinvertebrates were picked for a minimum of 40 minutes using forceps and pipettes. If new taxa⁸ were visually identified between 30 and 40 minutes of sorting, sorting continued for a further 10 minutes. The processing cycle was continued up to a total maximum sorting time of 1 hour.

⁵ Riparian refers to the narrow strips of land that immediately border creeks, rivers or other watercourses.

⁶ The AUSRIVAS program is a nationally recognised, standardised sampling protocol used to assess the health of Australian Rivers and developed for Australia's National River Health Program (NRHP)

⁷ A macrophyte is an aquatic plant that grows in or near water and is either emergent, submergent, or floating

⁸ Taxa (plural) refers to a group of one or more populations of an organism or organisms seen by taxonomists to form a unit.

The objective of the RBA sorting protocol is to obtain a sample containing as diverse a fauna as possible (and hence provide a useful measure of taxa richness). Attempts were made by GHD to avoid bias towards abundant taxa and to collect all taxa present in the sample, including rare or cryptic animals. Samples were preserved in 70% ethanol and clearly labelled with information including site, habitat, sampling method, date and sampler.

These samples were transported back to GHD's laboratory in Canberra for subsequent macroinvertebrate identification (see following section).

4.3 Laboratory works

Macroinvertebrates contained within the samples were examined using a microscope with a zoom capability between 6 and 50x. Macroinvertebrates present were identified using published taxonomic keys, unpublished working keys and an extensive specimen reference collection maintained by GHD following protocols identified in Hawking (2000).

Most macroinvertebrates present within the samples were identified to Family level⁹ with the following exceptions:

- The larvae of flies of the non-biting midges (Chironomidae - Diptera) were identified to sub-family (e.g. Orthoclaadiinae, Chironominae, and Tanypodinae)
- Groups such as round worms (Nematoda), segmented worms (Oligochaeta) and mites (Acarina) were identified to class or order level
- The Microcrustaceans including seed shrimp (Ostracoda), water fleas (Cladocera) and copepods (Copepoda) were identified to the Order level.

Upon completion of identification, all samples were returned to 100% ethanol for long-term archiving. This process allows samples to be re-examined at a later date if required.

Following completion of the laboratory works, GHD developed a basis for the assessment of certain relevant monitoring data that had not already been assessed during the fieldworks. Further detail on the basis for assessment developed for all relevant monitoring data is provided in the Section 5.

⁹ Following standard conventions of the NSW AUSRIVAS sampling and processing manual (Turak *et al.*, 2004).

5. Basis for data assessment

5.1 Overview

In order to adequately assess environmental monitoring data, appropriate assessment criteria must be selected and applied. These assessment criteria must be selected with consideration of potential receptors and their associated sensitivities.

Further information on the assessment criteria that have been selected for the purposes of assessing the monitoring data obtained during this project is provided in the following sections.

5.2 Potential receptors

The following receptors were identified for waterborne contamination potentially entering Mill Creek:

- Local surface water quality within Mill Creek
- Macroinvertebrates living within Mill Creek
- Habitat / plants within Mill Creek

5.3 Nominated assessment criteria

GHD identified and selected a number of relevant reference documents containing appropriate assessment criteria for application against the environmental monitoring data obtained during this project. Further details on these reference documents and associated assessment criteria are contained in the following sections.

5.3.1 Water quality

The ANZECC (2000) assessment criteria for slightly disturbed aquatic ecosystems of south-east Australia has been selected for application in the assessment of the water quality data obtained. In accordance with ANZECC (2000):

- Monitoring locations MC1 to MC4 (which are all below an altitude of 150 metres) have been assessed against the assessment criteria for a lowland river
- Monitoring location MCUP (which is above 150 metres in altitude but less than 1500 metres) has been assessed against the assessment criteria for an upland river

Table 5.1 below identifies the relevant assessment criteria applied to the data obtained during this investigation.

Table 5.1 ANZECC (2000) assessment criteria applied

Eco-type	Temp. (°C)	EC (µS/cm)	pH	DO (%sat)	DO (mg/L)	Turbidity (NTU)	Alkalinity (mg/L)
Upland river	N/A	30-350	6.5-8.0	90-110	N/A	2 - 25	N/A
Lowland river	N/A	125-2200	6.5-8.0	85-110	N/A	6 - 50	N/A

Notes: N/A = not applicable

5.3.2 Habitat condition

Habitat condition was assessed in-field using several assessment techniques widely used by ecological practitioners in NSW in relation to the assessment of aquatic ecosystem condition. These assessment techniques were as follows:

- Visual assessment
- NSW AUSRIVAS Visual Assessment of Disturbance Related to Human Activities
- Modified Riparian, Channel and Environmental (RCE) inventory
- Reference condition selection criteria

Descriptions of these assessment techniques applied in-field are provided below.

Visual assessment

Descriptions of aquatic habitat were based on visual estimates of characteristics such as streambed composition (percentage of total composition for each substrate category), aquatic and riparian vegetation cover, amount of in stream organic material, and area of aquatic habitat and canopy cover. Estimates of channel morphology characteristics were made including stream width (wetted width in meters), bank full width (mean width between top of banks), and estimated depth.

Stream reach geomorphology and habitat descriptions were documented as per the NSW AUSRIVAS Sampling and Processing Manual (Turak *et al*, 2004), and include a whole of reach (at least 100 m section of the waterway) assessment, the presence of different instream habitat types, and the structure and condition of riparian vegetation. The information recorded was used to describe the nature of aquatic habitats present within Mill Creek, and identify any areas of potential habitat for threatened aquatic macroinvertebrates.

NSW AUSRIVAS Visual Assessment of Disturbance Related to Human Activities

This assessment is aimed at summarising evidence available at the site of alteration caused by human activities to different components of the stream ecosystem. Some evidence is objective, easy to identify and valid for all stream types. Other evidence, however, may be specific to the type of river in question and harder to identify. The assessor is required to use knowledge of streams in the nearby area and decide how much this site has changed as a result of human activities.

There are four assessment categories including water quality, instream, riparian zone and catchment. Examples of the types of impacts that should be considered when assessing this are provided below;

- Water Quality - odour, water clarity, disruption of the natural hydrology, presence of foam from detergents, oil
- Instream - change in substrate e.g. rock piles or sedimentation from road construction or other development pipes, rubbish, filamentous algae, alien fish species, invasion by exotic aquatic plants
- Riparian Zone - revegetation, exotic plant invasion, bank degradation, point sources.
- Catchment Assessment - mine, sewage treatment plant, landfill, dam, industry, logging, agriculture, clearing, salinity, grazing, urban development

A ranking is given for each category which has an associated description as provided in

Table 5.2 below.

Table 5.2 NSW AUSRIVAS visual assessment ranking categories

Ranking	Description	Total Visual Assessment Score
0	No evidence of disturbance	0-2
1	Little disturbance	3-5
2	Moderate disturbance	6-8
3	High disturbance	8-11
4	Extreme disturbance	12-16

Using the system outlined in

Table 5.2, a higher score indicates a higher level of anthropogenic impact and a lower score a lower level of impact. By summing these rankings for each site, an overall assessment of anthropogenic impacts can be made with the total possible site score ranging from 0 to 16. By assigning a range for the total score to each descriptive category, an assessment of anthropogenic impacts at the site can be made, allowing for easy comparisons between sites. Following the precautionary principle, a ranking of 4 is given to categories indicating high levels of anthropogenic disturbance.

Modified Riparian, Channel and Environmental (RCE) inventory

The modified Riparian, Channel and Environmental (RCE) inventory was established by Chessman *et al.* (1997) whom modified the RCE (Petersen, 1992) to suit Australian conditions. The modified RCE assesses aquatic and riparian habitats against thirteen categories providing a score ranging from 0 to 4 for each category.

Each score, in each category has a description of habitat condition which provides a consistent basis to descriptively assess and compare individual sites. Higher scores indicate better quality, less disturbed habitats and the total score provides an overall assessment of habitat conditions. This also allows for assessment against categories of recommended actions to address aquatic habitat condition as identified in Table 5.3.

Table 5.3 Modified RCE Total score, status, class and recommended actions

RCE Total Score	RCE Status	RCE Class	Recommended Action
0-11	Poor	V	Complete structural reorganization
12-21	Fair	IV	Major alterations required
22-31	Good	III	Minor alterations needed
32-41	Very Good	II	Selected alterations and monitoring for changes
42-52	Excellent	I	Bio-monitoring and protection of the existing status

Although the RCE scoring system is designed for use in agricultural landscapes, it can provide an indication of the quality of riparian and instream habitat of surveyed sites. Precautions should be taken to ensure results are not used in isolation, but rather in a 'multiple lines of evidence approach'.

Reference condition selection criteria

An assessment of habitat condition conducted following the reference condition selection criteria (DNR, 2001) rates the level of impact for ten possible impact categories on a scale from extreme impact (1) to no impact (5). These scores are added together to indicate the level of possible anthropogenic impacts at the monitored site. Assessing the resultant score against a range of possible scores provides a means of assessing the condition of the monitored site and its suitability for selection as a reference site. Table 5.4 below provides the range of possible scores and the associated reference site suitability.

Table 5.4 Reference condition selection criteria total scores and reference site suitability

Reference Site Selection Criteria Total Score	Reference Site Suitability
10-23	Poor
24-33	Marginal
34-44	Sub-optimal
44-50	Optimal

5.3.3 Macroinvertebrates

A number of assessment techniques widely used by ecological practitioners in NSW in relation to the assessment of aquatic ecosystem condition were selected for application in the assessment of the macroinvertebrate data obtained. These were as follows:

- Taxa Richness Index
- EPT¹⁰ Taxa Index
- SIGNAL 2 Taxa Richness Index?
- SIGNAL 2 Biotic Index (Chessman, 2003)
- SIGNAL-SF (Sydney Families)
- NSW AUSRIVAS – Autumn Edge Model

Brief descriptions of these analysis techniques are provided in the following text.

Taxa Richness Index

Richness refers to the number of different taxa contained in a sample. Generally speaking higher richness scores indicate better ecological health, although some exceptions do apply to this general rule.

EPT Taxa Richness Index

The EPT taxa index refers to the proportional representation of key macroinvertebrate taxa belonging to the Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) groups. These groups are generally recognised to be among the more pollution-sensitive macroinvertebrate taxa. EPT richness refers to the number of EPT families present within a given sample.

SIGNAL 2 (Stream Invertebrate Grade Number – Average Level) – Taxa richness Index and biotic index

SIGNAL 2 is a biotic index based on pollution sensitivity values assigned to aquatic macroinvertebrate families that have been derived from published and unpublished information on their tolerance to pollutants (Chessman, 1995). Each family in a sample is assigned a grade between 1 (most tolerant) and 10 (most sensitive). Recently these grades have been revised in Chessman (2003) with the new version called SIGNAL 2.

Not all macroinvertebrate taxa have been assigned a SIGNAL 2 grade and those without grades are removed from the SIGNAL 2 biotic index calculation. This provides a richness index of taxa with assigned SIGNAL 2 grades further referred to as the SIGNAL 2 taxa richness index.

The SIGNAL 2 biotic index and its associated standard error are calculated as the average for all families present in the sample. The resulting biotic index score can then be interpreted by comparison with reference and/or control sites. The calculation of the SIGNAL 2 biotic index has not been weighted in regards to the abundance of organisms. For easier interpretation, SIGNAL 2 biotic index scores and SIGNAL 2 taxa richness index have been graphed using a quadrant diagram that divides results into four general settings as shown in Figure 5.1 (refer following section).

The boundaries between the four quadrants differ between geographic regions of Australia because of natural variation in macroinvertebrate communities. They also vary according to sampling effort and the types of habitats sampled (Chessman, 2003). After consideration of

¹⁰ In this context, EPT stands for **E**phemeroptera (mayflies), **P**lecoptera (stoneflies) and **T**richoptera (caddisflies).

suggested NSW interim boundaries, the quadrant boundaries applied to the monitoring data obtained during this project have been set at a SIGNAL 2 biotic index score of 4.00 and a SIGNAL 2 taxa richness index of 15.5.

SIGNAL-SF (Sydney Families)

The SIGNAL-SF was derived by Chessman *et al.* (2007) and although based on SIGNAL 2 biotic index (Chessman, 2003), SIGNAL-SF grades for macroinvertebrate families were derived specifically for the Sydney region. These grades also range from 1 to 10, with higher scores indicative of lower environmental stress (Chessman *et al.*, 2007).

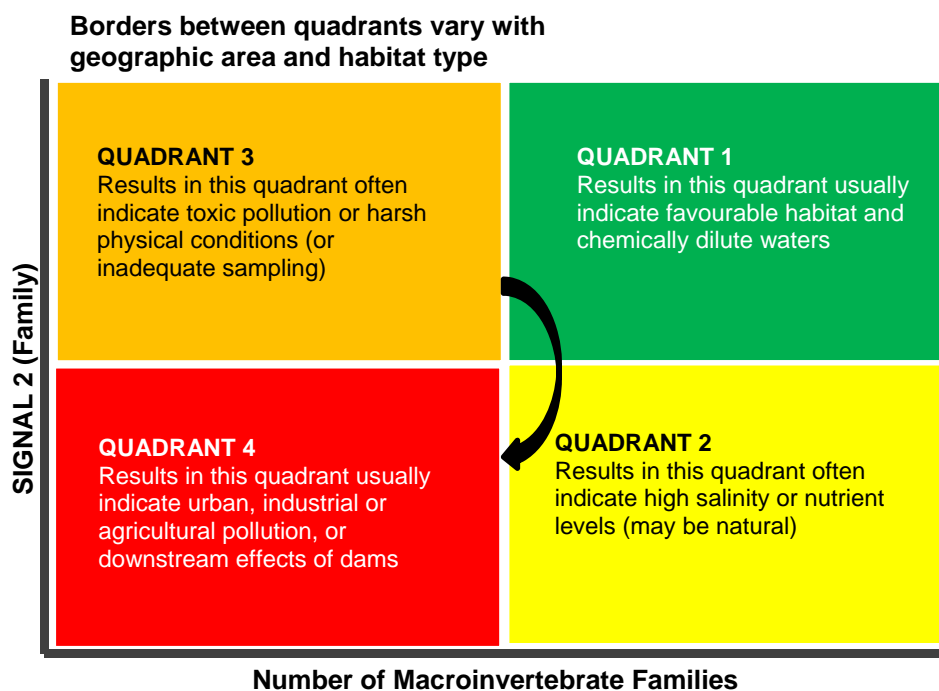


Figure 5.1 An example of the quadrant diagram for interpretation of the SIGNAL 2 and SIGNAL-SF biotic indices

NSW AUSRIVAS – Autumn Edge Model

The NSW AUSRIVAS – Autumn Edge Model generates site-specific predictions of the macroinvertebrate fauna expected to be present in the absence of environmental stress.

Using this model, the expected fauna from reference sites with a similar set of physical and chemical characteristics to those monitored during an individual project are compared with the observed fauna and an expected fauna to observed fauna ratio derived (O/E ratio). This ratio is used to indicate the extent of potential environmental impact. This ratio ranges from zero (0), when none of the expected fauna are found at a site, to approximately one (1), when all of the expected fauna are present. The value can also be greater than one (1) when more families are found at the site than predicted by the model. The ratio scores are then placed into the bands outlined in in Table 5.5 below.

Table 5.5 Key to AUSRIVAS O/E bands for the NSW autumn edge model

Band Label	Upper Limit	Band Name	Band Description
X	Infinity	More biologically diverse than reference sites	More taxa found than expected. Potential biodiversity hot-spot. Possible mild organic enrichment.
A	1.17	Reference condition	Most/all of the expected families found. Water quality and/or habitat condition roughly equivalent to reference sites. Impact on water quality and habitat condition does not result in a loss of macroinvertebrate diversity.
B	0.81	Significantly impaired	Fewer families than expected. Potential impact either on water quality or habitat quality or both, resulting in loss of taxa.
C	0.46	Severely impaired	Many fewer families than expected. Loss of macroinvertebrate biodiversity due to substantial impacts on water and/or habitat quality.
D	0.11	Extremely impaired	Few of the expected families remain. Extremely poor water and/or habitat quality. Highly degraded.

The Band Names and descriptions within Table 5.5 provide a means to describe the scores derived by the AUSRIVAS models and indicate aquatic ecosystem condition. The NSW AUSRIVAS – Autumn Edge model also generates a list of missing taxa from individual sampling sites by comparing observed taxa against expected taxa.

Section 6 presents the monitoring data obtained and assessed during this project.

6. Monitoring data and assessment

6.1 Overview

The environmental monitoring data obtained at each monitoring location investigated during this project is provided in Appendix A. It is noted that the environmental monitoring data presented and assessed in this section represents data from five discrete monitoring locations obtained on one occasion. This data may have been influenced by a number of factors including:

- An elevated rainfall event that occurred in the 24 hours prior to the fieldworks commencing (further information provided in Section 6.2)
- The time at which the fieldworks were undertaken¹¹
- The monitoring locations selected

Furthermore, it is noted that no riffle¹² habitat suitable for sampling following the AUSRIVAS protocols was observed during the fieldworks. As such all macroinvertebrate data presented and assessed within this report relates to edge samples only.

The data presented and assessed in the following sections (and associated conclusions and recommendations) should be considered with respect of these facts.

6.2 Rainfall data

In the 24 hours prior to the fieldworks commencing on 2 March 2015, an elevated rainfall event (13.2 mm¹³) occurred in the general vicinity of the LHRP. This suggests that high stream flows may have occurred in Mill Creek immediately prior to the fieldworks commencing. These high stream flows may have influenced the environmental conditions within Mill Creek and therefore the monitoring data obtained during GHD's fieldworks. This said, the potential significance of this issue on the collected data is considered to be relatively minor by GHD (refer below).

Figure 6.1 presents the mean monthly rainfall¹⁴ for 2010 to 2015 compared to all data (1969 to 2015).

From the data in Figure 6.1, it can be seen that the mean monthly rainfall in the two months preceding the GHD fieldworks:

- Was above the all data figure in January 2015
- Was below the all data figure in February 2015

The February 2015 data suggests that in the period prior to GHD's fieldworks commencing, rainfall and stream flow conditions are likely to have been relatively low and consistent¹⁵. This would have likely resulted in relatively stable environmental conditions prevailing within Mill Creek prior to the fieldworks commencing (assuming no other influences).

¹¹ The macroinvertebrate sampling exercise occurred within two weeks of (but still outside) the recommended autumn (March 15 to June 15) or spring (September 15 to December 15) sampling periods as per the AUSRIVAS macroinvertebrate sampling methodology for NSW (Turak et al., 2004)

¹² A riffle is a short, relatively shallow and coarse-bedded length of stream over which the stream flows at slower velocity but a higher turbulence than it normally does in comparison to a pool

¹³ Data from Lucas Heights (ANSTO) Bureau of Meteorology Weather Station, Weather Station Number 066078 at 9 a.m. local clock time on 2 March 2015 (rainfall data is the total rainfall for the preceding 24 hours)

¹⁴ As recorded at Lucas Heights (ANSTO) Bureau of Meteorology Weather Station, Weather Station Number 066078

¹⁵ With the exception of the significant rainfall event observed in the 24 hours immediately prior to the fieldworks commencing

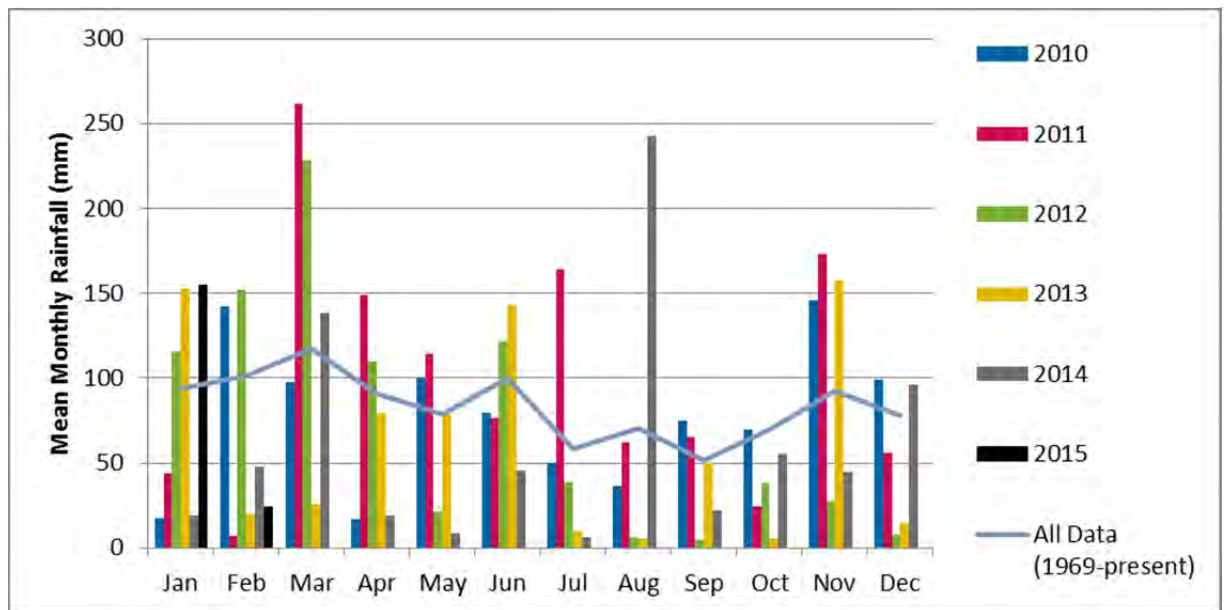


Figure 6.1 Mean monthly rainfall for years 2010 to 2015 and an average for all data available for Lucas Heights (ANSTO) Weather Station

Based on the facts that:

- The conditions in Mill Creek are likely to have been relatively stable prior to the fieldworks commencing; and
- The potential significance of the elevated rainfall event upon the monitoring data is considered to be relatively minor,

It is considered that the environmental conditions encountered during the fieldworks (and associated environmental monitoring data obtained) are likely to be reasonably representative of prevailing conditions within Mill Creek for the time of year monitored.

It is noted that the conditions encountered in Mill Creek during the fieldworks may actually be of a slightly lower quality than may have been encountered if the elevated rainfall event had not occurred.

6.3 In situ water quality

Results of the in situ water quality monitoring are provided in Table 6.1 below. Values outside the ANZECC (2000) assessment criteria for slightly disturbed aquatic ecosystems are highlighted in red.

Table 6.1 Results of *in situ* water quality

Site Code	Eco-Type	Time	Temp. (°C)	EC (µS/cm)	pH	DO (%sat)	DO (mg/L)	Turbidity (NTU)	Alkalinity (mg/L)
MCUP	Upland river	16:10	20.29	207	6.59	39.3	3.85	27.1	44
MC1	Lowland river	13:58	21.42	324	7.66	81.2	7.18	115	42
MC2	Lowland river	13:29	20.66	369	7.59	93.1	8.36	358	74
MC3	Lowland river	11:27	20.77	274	7.15	73.8	6.6	125	38
MC4	Lowland river	10:29	20.61	269	7.34	84.5	7.59	54.5	30.6
ANZECC (2000)	Upland river	N/A	N/A	30-350	6.5-8.0	90-110	N/A	2 - 25	N/A

assessment criteria	Lowland river			125-2200		85-110		6 - 50	
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Table 6.1 identifies the following key points:

- Dissolved oxygen (DO) values were below the lower assessment criteria at all monitoring locations except for MC2. At monitoring locations MC1, MC3 and MC4 (all downstream of the LHRRP), DO values were only slightly below the relevant assessment criteria. As such, DO conditions at those locations were unlikely to be an issue of significance in relation to the macroinvertebrate communities and aquatic ecosystem processes in Mill Creek. The low DO value observed at MCUP suggests a reducing environment due to the degradation of organic materials and potentially the oxidation of iron content of the groundwater naturally entering the Creek as baseflow. This is a natural state for a coastal upland swamp environment which this monitoring location resembles due to its limited catchment area and upland coastal location.
- Turbidity values were outside the upper assessment criteria at all monitoring locations. As previously mentioned, an elevated rainfall event occurred during the 24 hours prior to the GHD fieldworks commencing. The runoff and increased stream flow during this event is the most likely explanation for these elevated turbidity values. If high turbidity is a consistent condition within Mill Creek, elevated suspended solids and sedimentation are likely to influence macroinvertebrate communities and aquatic ecosystem processes in this watercourse.

6.4 Habitat condition

The habitat condition results and in-field assessments undertaken at each of the monitoring locations are provided Appendix A. These results and assessments are summarised in the following sections.

Visual Assessment

The geomorphic nature of the sites was generally similar and characteristic of a small coastal lowland (below 150 m altitude) catchment. The active channel was well defined and mode stream width was approximately 4 m in the upper reaches to 6 m in the lower reaches, bank height ranges from 0.5 m to 1.5, and bankfull widths ranged from 10 m to 20 m. Substrates were predominantly a mix of bedrock, boulder, gravel, sand and clay/silt, with the former and the latter dominating across the sites. Flow habitat types were generally half pool and half run with some riffle occurring at the downstream most site (MC4) although this was over bedrock, so not suitable for macroinvertebrate riffle sampling.

The uppermost site MCUP was the exception as it was at approximately 170 m altitude and considered upland (above 150 m). The habitat was similar to that of a coastal upland swamp rather than a true riverine habitat and this was reflected by the comparatively broader channel and lower banks.

All sites downstream of the LHRRP had a mostly natural and continuous riparian vegetation zone with the community almost completely dominated by native species. A healthy mix of ground cover, shrub layer and over story trees was present at all sites with the exception of MCUP which had fewer trees above 10 m height and MC3 which had some clearing due to access by recreational users, resulting in lower cover of ground and shrub species. The macrophytes in the riparian zone were generally emergent forms and were predominantly natives with cover ranging between 5-20% of the available habitat across the sites.

NSW AUSRIVAS Visual Assessment of Disturbance Related to Human Activities

The results from this in-field assessment are summarised in Table 6.2 below.

Table 6.2 Results of NSW AUSRIVAS Visual Assessment of Disturbance Related to Human Activities

Site Code	Water Quality	Instream	Riparian Zone	Catchment	Total Score	Category Description
MCUP	1	1	2	2	6	Moderate disturbance
MC1	2	2	1	4	9	High disturbance
MC2	1	1	1	3	6	Moderate disturbance
MC3	2	2	1	2	7	Moderate disturbance
MC4	1	1	0	1	3	Little disturbance

Notes: A key to the scoring and colour coding system is provided in

Table 5.2

Table 6.2 identifies the following key points:

- Habitat at three of the five sites (MCUP, MC2 and MC3) were assessed to have 'Moderate disturbance'
- Habitat at MC1 (immediately downstream of the LHRRP) was assessed to have 'High disturbance' principally due to the extensive changes to the catchment due to the LHRRP
- Habitat at MC4 (furthest monitoring location downstream from the LHRRP) was assessed to have 'Little disturbance'. Aquatic and riparian habitat at this monitoring location was in a reasonably pristine condition, suggesting that if any impacts are occurring in the Mill Creek catchment, the natural condition of the catchment downstream may provide a good buffer and aid recovery processes.

Modified Riparian, Channel and Environmental (RCE) inventory

The results from this in-field assessment are provided in Table 6.3 below.

Table 6.3 Results of the RCE Assessment

RCE Category	MCUP	MC1	MC2	MC3	MC4
Land-use pattern beyond immediate riparian zone	3	4	4	3	4
Width of riparian strip of woody vegetation	3	4	4	3	4
Completeness of riparian strip of woody vegetation	2	2	3	2	4
Vegetation of the riparian zone within 10 m of channel	3	3	4	4	4
Stream bank structure	3	4	4	4	4
Bank undercutting	4	2	2	2	4
Channel form	2	3	3	3	2
Riffle/pool Sequence	3	2	2	2	3
Retention devices in streams	2	3	3	2	3
Channel sediment accumulation	1	2	2	1	4
Stream bottom	2	2	2	1	3
Stream detritus	3	2	3	2	4
Aquatic vegetation	2	2	2	2	2
RCE Total Score	33	35	38	31	45
RCE Status	Very Good	Very Good	Very Good	Good	Excellent
Recommended Actions	Selected alterations and monitoring for changes	Selected alterations and monitoring for changes	Selected alterations and monitoring for changes	Minor alterations needed	Bio-monitoring and protection of the existing status

Notes: A key to the scoring and colour coding system is provided in Table 5.3.

Table 6.3 identifies the following key points:

- Monitoring locations in close proximity to the LHRRP (MCUP, MC1 and MC2) were assessed as 'Very Good' as the immediate riparian and instream habitats were generally considered to be in good condition
- MC3 was assessed as 'Good' primarily due to disturbance of riparian habitat, the prevalence of stream bank in-stability and associated increases in sedimentation.
- MC4 was assessed as 'Excellent' which is principally due to the near pristine / natural state of the riparian habitat in the immediate riparian zone and the surrounding catchment.

Reference site selection criteria

The results from this in-field assessment are provided in Table 6.4 below.

Table 6.4 Results of Reference Site Selection Criteria Assessment

Reference Condition Selection Criteria	MCUP	MC1	MC2	MC3	MC4
Agriculture and Forestry	5	5	5	5	5
Sand and Gravel Extraction	3	2	4	2	4
Upstream Urban Areas	4	3	4	4	4
Point Source Pollution	5	2	5	3	4
Dams and Weirs	3	2	4	4	4
Flow Regime Alteration	3	2	4	4	4
Vegetation Alteration	3	4	4	3	4
Riparian Zone/Streambank Erosion	4	3	4	2	4
Geomorphic Change	4	3	3	3	4
Instream Habitat Alteration	4	3	3	3	4
Total Score	38	29	40	33	41
Reference Site Suitability	Sub-optimal	Marginal	Sub-optimal	Marginal	Sub-optimal

Notes: A key to the scoring and colour coding system is provided in Table 5.4.

Table 6.4 identifies the following key points:

- Habitat condition at MCUP, MC2 and MC4 was assessed to be 'Sub-optimal'
- Habitat condition at MC1 and MC3 was assessed to be 'Marginal'. At MC1, this was primarily due to the disturbance of the ground surface associated with the LHRRP, associated changes to riparian vegetation and identified sediment deposition. At MC3, this was primarily associated with disturbance to the ground surface associated with recreational vehicle activities. These activities appear to be causing an influence on the integrity of the stream banks and causing increased levels of sediment deposition (eroded from unsealed dirt tracks) in close proximity to this monitoring location.

6.5 Macroinvertebrates

The macroinvertebrate results and subsequent assessments undertaken at / for each of the monitoring locations are provided Appendix A and Appendix B. These results and assessments are summarised in the following sections.

6.5.1 Taxa Richness and SIGNAL Indices

This section presents and assesses the results for the following taxa richness indices:

- Taxa Richness Index
- EPT¹⁷ Taxa Index
- SIGNAL 2 Taxa Richness Index?
- SIGNAL 2 Biotic Index (Chessman, 2003)
- SIGNAL-SF (Sydney Families)

A total of 46 macroinvertebrate taxa were identified across the five monitoring locations (see Appendix B for a complete list). A breakdown of these results is provided in Table 6.5 below.

Table 6.5 Macroinvertebrate indices for Mill Creek monitoring locations

Monitoring Location	Taxa Richness Index	EPT Taxa Richness Index	SIGNAL 2 Taxa Richness Index	SIGNAL 2 (Order) Index	SIGNAL 2 (Family) Index	SIGNAL (Sydney Families) Index
MCUP	24	2	20	3.57	3.05	5.24
MC1	25	4	23	4.00	3.39	5.29
MC2	27	2	24	3.35	3.33	5.05
MC3	20	3	17	4.47	3.59	5.31
MC4	19	4	17	4.83	3.76	6.14

Table 6.5 identifies the following key points:

- MC2 displayed the highest taxa richness (27) and MC4 the lowest (19)
- MC1 displayed the highest (4) EPT taxa richness with MC2 displaying the joint lowest with MCUP (both 2)
- MC2 displayed the highest SIGNAL 2 taxa richness (24) with MC3 and MC4 displaying the joint lowest (17)

Figure 6.2 provides a graphical representation of these results contained in Table 6.5.

¹⁷ In this context, EPT stands for **E**phemeroptera (mayflies), **P**lecoptera (stoneflies) and **T**richoptera (caddisflies).

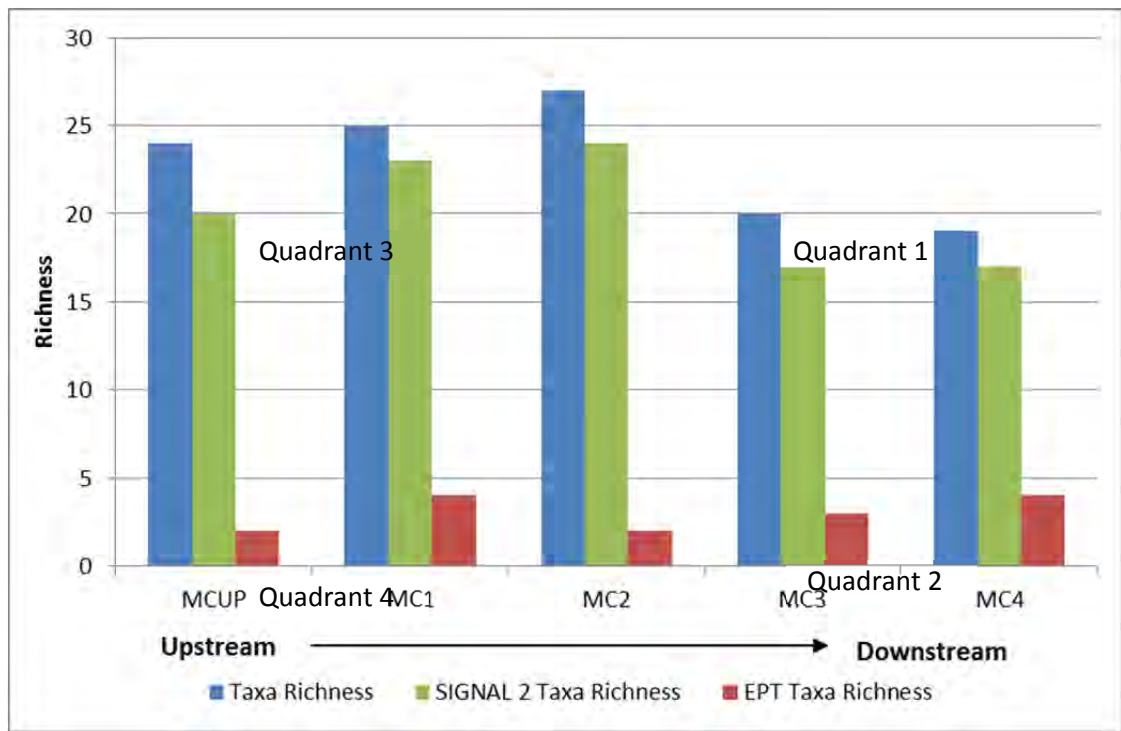


Figure 6.2 Macroinvertebrate richness scores for monitoring locations

6.5.2 SIGNAL

Figure 6.3 below plots SIGNAL 2 scores against richness values and compares results to the interim NSW boundaries according to Chessman (2003).

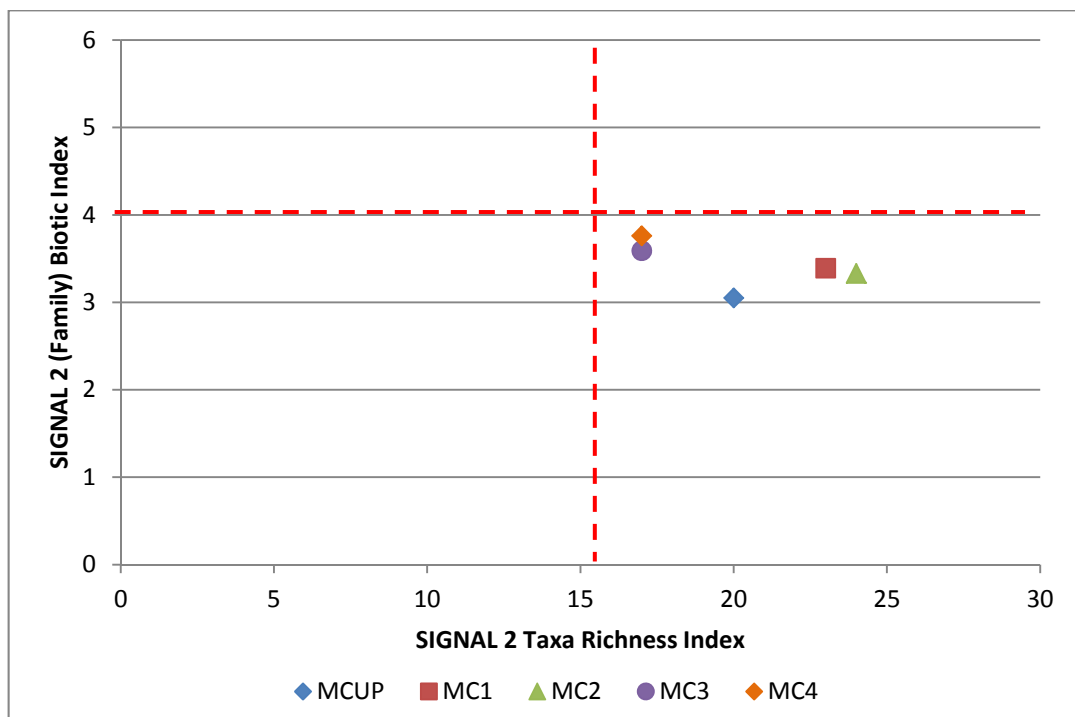


Figure 6.3 SIGNAL 2 biplot for monitoring locations displaying the quadrants according to the interim NSW boundaries

Figure 6.3 identifies the following key points:

- SIGNAL 2 biotic index scores placed all monitoring locations in Quadrant 2 as scores for all locations were below a score of 4.0 and above the richness value of 15.5. Results in Quadrant 2 typically indicate elevated salinity or nutrient levels. These elevated levels may occur naturally or as a result of human activities. Whatever the source, the relatively high number of macroinvertebrate taxa identified across the monitored locations suggests that physical conditions are sufficient to support diverse macroinvertebrate life.
- The Signal 2 taxa richness scores for the three monitoring locations closest to the LHRRP are higher than those for the two locations furthest away from the LHRRP, but the SIGNAL 2 Biotic Index scores were higher at the downstream sites. This demonstrates that the sensitivity to pollution of the taxa at the sites closer to the LHRRP is lower than those further downstream, suggesting some nutrient enrichment may be occurring that could be reducing by dilution downstream

Figure 6.4 below presents the SIGNAL 2 (Order), SIGNAL 2 (Family) and SIGNAL-SF (Sydney Families) results.

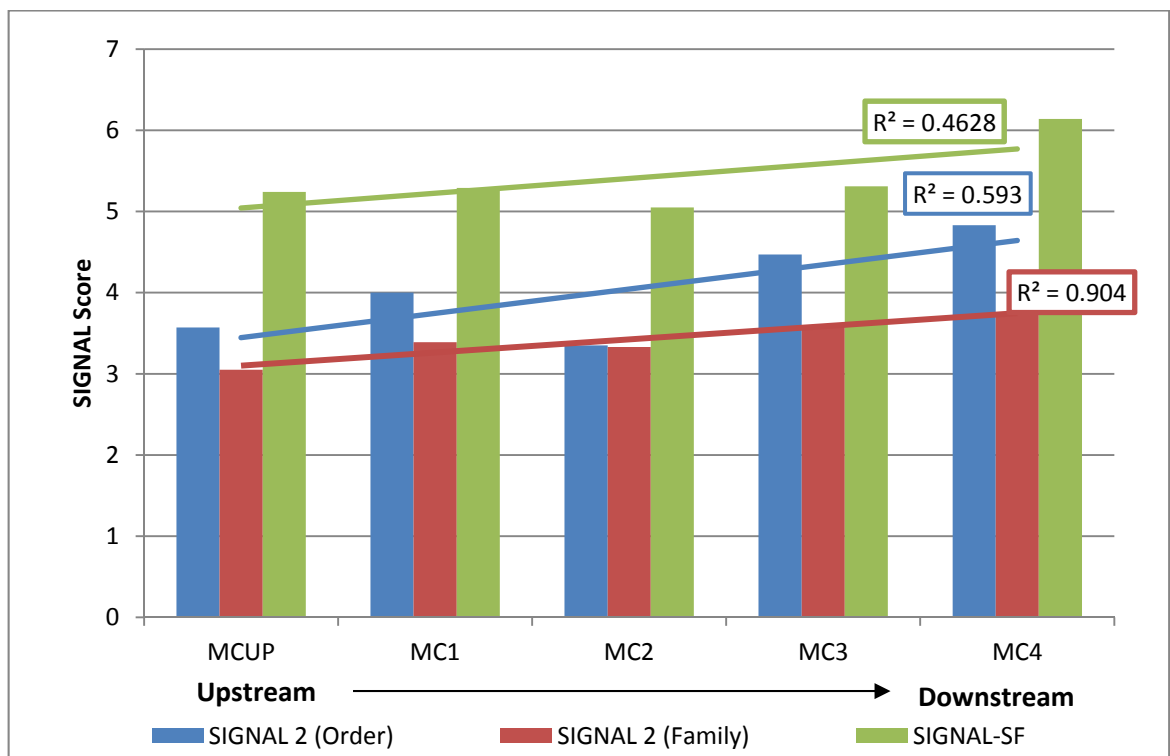


Figure 6.4 SIGNAL results displaying a linear trend line for each of the SIGNAL index scores

Figure 6.4 below identifies that across all SIGNAL indices there was a general trend of increasing scores with increasing distance downstream. A linear trend line demonstrated that the SIGNAL 2 (Family) biotic index correlated most closely with this trend.

These results may suggest that the SIGNAL indices are more responsive to stream discharge (a surrogate of catchment area in rainfall/runoff based streams) rather than indicative of water quality. However; a comprehensive suite of water quality chemical conditions (e.g. total phosphorus, total nitrogen, ammonia) was not measured during this project. The water quality may be influencing the community close to the LHRRP but becoming diluted downstream. Further testing and verification of this assumption would be required to make any significant conclusions to the application of SIGNAL-SF in the vicinity of the LHRRP.

6.5.3 NSW AUSRIVAS – Autumn Edge Model

A summary of AUSRIVAS results is provided in Table 6.6 below.

Table 6.6 Summary of results from NSW AUSRIVAS Autumn Edge Model

Site Code	O/E50	Band	Band Name
MCUP	0.84	A	Reference condition
MC1	0.74	B	Significantly impaired
MC2	0.73	B	Significantly impaired
MC3	0.45	C	Severely impaired
MC4	0.81	B	Significantly impaired

Notes: A key to the scoring and colour coding system is provided in Table 5.5.

Table 6.6 identifies the following key point:

- AUSRIVAS analysis of macroinvertebrate communities revealed the majority of monitoring locations to be rated a Band B indicating they were ‘significantly impaired’. Exceptions to this were MCUP which was assessed as Band A, or ‘reference condition’, and MC3 which was Band C, indicating it was ‘severely impaired’. These results suggest that at the majority of monitored locations, fewer macroinvertebrate families than expected were actually observed. This indicates that potential impact either on water quality or habitat quality or both, has resulted in loss of taxa (refer to note in Section 6.1)

Figure 6.5 below graphically displays the AUSRIVAS results, the upper Band limits and monitoring locations relative to the LHRRP.

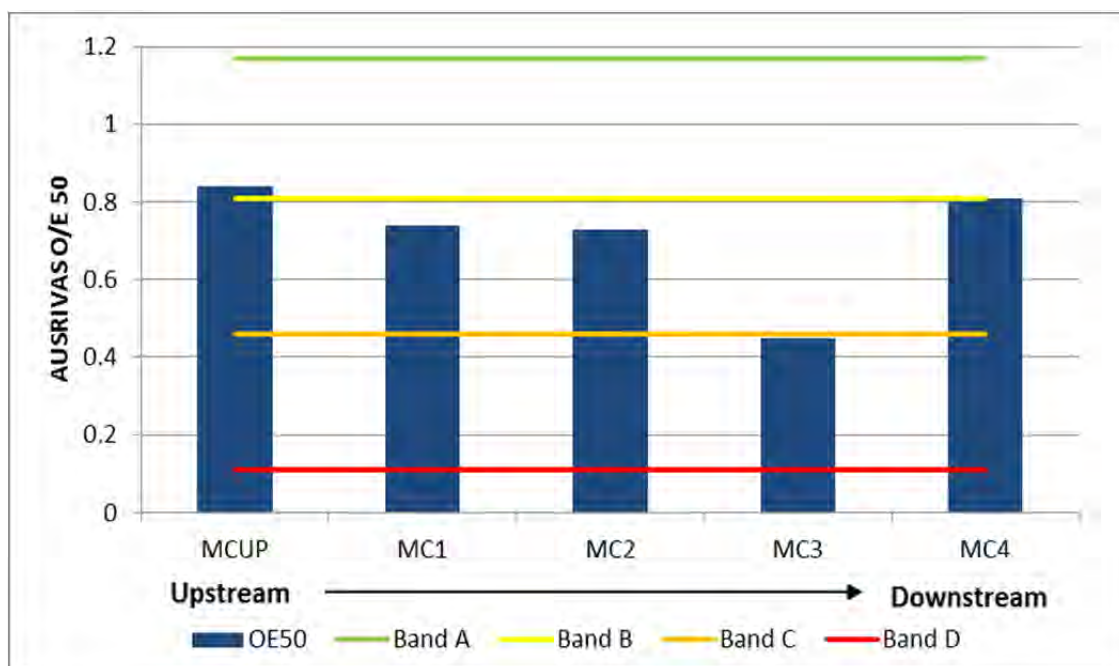


Figure 6.5 AUSRIVAS results displaying the upper Band limits and monitoring locations relative to the LHRRP

Figure 6.5 identifies the following key points:

- The upstream monitoring location (MCUP) was assessed as band A (‘Reference condition’) but the OE50 value was at the lower end of the bandwidth. This monitoring location was located upstream of an artificially created ‘Duck Pond’ dam and the persistent pool at this location may be a result of this dam. As previously mentioned, the aquatic habitat at MCUP more closely resembled a coastal upland swamp than a riverine

habitat. The temporal stability of the habitat and its resident macroinvertebrate community may explain the higher OE50 at MCUP, compared to other monitoring locations further downstream. Alternatively, as this site is upland (above 150 m), it would be assessed against a different set of reference sites compared to the other study sites and as such AUSRIVAS results between this upstream site and the downstream study sites may not be effectively compared.

- The monitoring locations that were rated as Band B ('Significantly impaired') (MC1, MC2 and MC4) scored OE50 values just below the upper limit of the bandwidth (0.81). This means that these locations were not far off being classified as Band A ('Reference condition'). As this was a one-off sampling event that immediately followed an elevated rainfall event, all macroinvertebrate taxa may not have been captured during the fieldworks. As such, these values could be considered an indication of community composition. These monitoring locations may not be consistently assessed as 'Significantly impaired' and may show improvement in future as further sampling may provide additional taxa and results for the macroinvertebrate communities may oscillate around this value.
- MC3 was assessed as Band Width C ('Severely impaired') suggesting that many fewer families were observed than expected. This implies a loss of macroinvertebrate biodiversity due to substantial impacts on water and/or habitat quality. The influence of habitat quality may be a key driver for the reduced OE50 score at this monitoring location as the habitat condition assessments suggested local scale site degradation of habitat, associated with recreational vehicle use.

In addition to the Band widths, AUSRIVAS adds the taxa information for taxa expected to occur at any given sample location (given the environmental variables) for comparison with the observed field taxa at any given sample location.

Appendix C contains a table that identifies the taxa which AUSRIVAS expected to be present at the monitoring locations, but which were not observed during this project. Key points from this table are as follows:

- Approximately 81% of the taxa which were expected but were not observed had a SIGNAL 2 (Family) grade equal to or above 4
- Eighteen taxa that form the sensitive EPT Orders were expected but not observed. The average SIGNAL 2 (Family) grade of these EPT taxa was 7.44, while the SIGNAL-SF was 8.39. This shows that the taxa not observed were dominated by those with high sensitivities to pollution and/or changes to habitat conditions. This is not an unexpected finding and is generally the case for macroinvertebrate communities in urbanised and disturbed landscapes

Further sampling in spring and/or an ongoing macroinvertebrate monitoring program, at each of the locations monitored during this project would allow for a more comprehensive analysis of macroinvertebrate community composition. This would permit analysis using a combined season model which is likely to provide for a more holistic assessment of macroinvertebrate communities and aquatic ecosystem health.

6.6 2013/2014 River health report card

In 2013-14 the River Health Monitoring Program entered its fifth year of monitoring in the Georges River Catchment. River Health monitors three important ecological indicators to provide an assessment of catchment health; water quality, vegetation and macroinvertebrates. A copy of the River Health Georges River Report Card is contained in Appendix D and also publicly available online <<http://www.georgesriver.org.au/>>.

For 2013 - 2014, Mill Creek downgradient of the site reported an overall River Health Grade grade of A+ which suggests excellent conditions.

For 2013 – 2014, Barden Creek downgradient of the site received an overall River Health Grade of A+ which suggests excellent conditions.

This corresponds with the findings of this report which are that habitat and macroinvertebrate populations are in general in good condition and that any impacts of the LHRRP on Mill Creek are spatially limited as further downstream the health of Mill Creek was found to be in an excellent condition.

7. Discussion

A multiple lines and levels of evidence approach was used to assess the potential impacts of the LHRRP on the aquatic ecosystem of Mill Creek. *In situ* water quality, aquatic and riparian habitat condition and macroinvertebrate communities were monitored and assessed against relevant guidelines and following standard protocols. It is noted that this section should be read with consideration of the issues previously outlined in Section 6.1.

Results of the *in situ* water quality monitoring suggested that dissolved oxygen was slightly below the relevant assessment criteria at the majority of the monitoring locations with the exception of the upstream site (MCUP) which was well below the relevant assessment criteria. Values slightly below Guidelines are not likely to be a substantial issue for aquatic macroinvertebrates or aquatic ecosystem processes. Furthermore there is little evidence to attribute the dissolved oxygen values to catchment scale landuse changes related to the LHRRP as monitoring locations downstream of the LHRRP displayed dissolved oxygen values that were higher than those observed at the upstream site.

Elevated turbidity levels were recorded across all monitoring locations including the upstream site (MCUP). An elevated rainfall event occurred in the 24 hours prior to the fieldworks commencing which is likely to have been a significant factor in the turbidity levels observed. There was a consistent increase in turbidity levels between MCUP and MC2 and then a consistent decrease in these levels between MC2 and MC4. The reasons for this are currently unclear. However, it is noted that the catchment surrounding Mill Creek downstream of the LHRRP is chiefly a forested natural area criss-crossed by a number of recreational vehicle and mountain bike tracks. Whilst it is likely that runoff from the LHRRP would contain higher sediment loads than under natural conditions, runoff from these recreational tracks may contribute to suspended solids and sediment input into Mill Creek downstream of the LHRRP.

Whilst the aquatic and riparian habitat assessment methods used during this project may be limited in their application to the small coastal catchment that is Mill Creek, they have been consistently applied across all monitoring locations allowing comparisons to be made. The NSW AUSRIVAS assessment of disturbance related to human activities found MC1 to have a 'High disturbance' level, but this is not unexpected given the change in catchment landuse associated with the LHRRP. The recovery in this disturbance to 'Moderate disturbance' at MC2 and MC3, and 'Little disturbance' at MC4 shows that the extent of impacts of the LHRRP may be spatially limited to the immediate habitat.

The results of the assessment of the monitoring locations against the modified Riparian, Channel and Environmental (RCE) inventory categories assessed the monitoring locations in close proximity to the LHRRP as 'Very Good' as the immediate riparian and instream habitats were generally considered to be in good condition. MC3 was assessed as 'Good' primarily due to disturbance of riparian habitat, the prevalence of stream bank in-stability and associated increases in sedimentation. MC4 was assessed as 'Excellent' which is principally due to the near pristine / natural state of the riparian habitat in the immediate riparian zone and the surrounding catchment.

Assessment of site habitat condition against the reference site selection criteria found site suitability for MCUP, MC2 and MC4 to be 'Sub-optimal' while MC1 and MC3 were considered 'Marginal'. At MC1, this was primarily due to the disturbance of the ground surface associated with the LHRRP, associated changes to riparian vegetation and identified sediment deposition. At MC3, this was primarily associated with disturbance to the ground surface associated with recreational vehicle activities not on the LHRRP site. These activities appear to be causing damage to stream banks

The general trends in macroinvertebrate community indices across the monitoring locations were relatively consistent between several of the indices including richness and AUSRIVAS ratings. In a downstream direction from MCUP to MC2 there was a general increase in these indices then an abrupt decline was identified at MC3 (compared to MC2). MC4 displayed a recovery of these AUSRIVAS rating but richness values at this monitoring location remained relatively low.

SIGNAL 2 (Family) values possibly best explain the trends in macroinvertebrate community composition displaying a generally consistent increase with increasing distance downstream (as measured from MCUP) with a high R^2 value (0.904) for the linear line of best fit. Whilst this may suggest that some impact is occurring downstream of the LHRRP, the upstream monitoring location (MCUP) scored the lowest SIGNAL 2 (Family) score and MC2 scored lower than MC1. This trend may suggest that the permanency of aquatic habitat, which is likely to become more permanent with increasing distance downstream, may be a factor in the persistence of macroinvertebrate taxa.

Assessment of the pollution tolerances of taxa present found most monitoring locations had communities dominated by pollution tolerant taxa, although some sensitive taxa were present. While this may seem a cause for concern these ratings are relatively good. Recent studies of the Georges River catchment found that urban streams throughout the catchment contain macroinvertebrate communities dominated by pollution tolerant species with little or no pollution sensitive species present (Tippler *et al.*, 2014). This suggests that macroinvertebrate communities present at the monitoring locations were generally in a healthy condition given the extent of catchment disturbance associated with a development such as the LHRRP.

AUSRIVAS assessment of macroinvertebrate communities' revealed MCUP was rated as 'Reference condition' (Band A), MC3 as 'Severely impaired' (Band C) and the remainder as 'Significantly impaired' (Band B). The decline from Band A to Band B immediately downstream of the LHRRP is not unexpected and given that MC1 was at the top end on the bandwidth for Band B, its score could be assessed as relatively high. The decline to Band C at MC3 is likely due to a decline in taxonomic diversity, also displayed in the richness results discussed above. This may be attributed to several factors but is likely due to the decline in aquatic and riparian habitat condition that may be linked to nearby recreational vehicle use.

It is noted that River Health Monitoring Program monitors three important ecological indicators to provide an assessment of catchment health; water quality, vegetation and macroinvertebrates (refer Section 6.6) and that their conclusions reinforce the statements made above.

8. Conclusions

This report has been prepared to assess the condition of aquatic habitats within and downstream of the LHRRP. Due to climatic conditions and required timing of the fieldworks, the time at which the fieldworks were undertaken is likely to have been below optimal in terms of encountering the monitoring locations along Mill Creek in their highest order condition in relation to water quality, habitat condition and/or macroinvertebrate populations. This said, it is considered that the environmental conditions encountered during the fieldworks (and associated environmental monitoring data obtained) are likely to be reasonably representative of prevailing conditions within Mill Creek for the time of year monitored.

The uppermost site (MCUP) is at approximately 170 m altitude and considered upland (above 150 m). The creek has a comparatively broader channel and lower banks at this location. All sites downstream of the LHRRP had a mostly natural and continuous riparian vegetation zone with the community almost completely dominated by native species. The geomorphic nature of these sites was generally similar and characteristic of a small coastal lowland (below 150 m altitude) catchment. Habitat condition was generally good, although disturbance to the ground surface associated with recreational vehicle activities was observed at MC3, leading to increased levels of sediment deposition near this site.

A relatively high number of macroinvertebrate taxa were identified across the monitored locations suggesting that physical conditions are sufficient to support diverse macroinvertebrate life. Assessment of the pollution tolerances of taxa present found most monitoring locations had communities dominated by pollution tolerant taxa, although some sensitive taxa were present.

Based on the results of the field survey and data analysis, the following conclusions are made:

- Results of the *in situ* water quality monitoring suggested that dissolved oxygen was slightly below the ANZECC assessment criteria at the majority of the monitoring locations. Electrical conductivity and pH were within the recommended ranges. The LHRRP and off-site recreational vehicle users may be having some minor impacts on Mill Creek in relation to turbidity values, although turbidity may have been affected by a recent rainfall event.
- Habitat was found to be generally in good condition. The LHRRP may be having some minor impacts on Mill Creek in relatively close proximity to the LHRRP (MC1), as condition here is lower than at the upstream site. Habitat condition improves at MC2. A decline at MC3 is likely to be the result of disturbance caused by recreational vehicle users. Aquatic and riparian habitat at MC 4 (located furthest from the LHRRP) was in a reasonably pristine condition. The recovery of habitat condition at this monitoring location suggests that any impacts of the LHRRP are spatially limited and that the natural condition of the surrounding catchment downstream will ensure minimal impacts to the Georges River receiving environment.
- Macroinvertebrate communities present at the monitoring locations were generally in a healthy condition. Communities were dominated by pollution tolerant taxa, although some sensitive taxa were present. Recent studies of urban streams in the Georges River catchment found few or no pollution-sensitive taxa, suggesting that Mill Creek is one of the better condition streams in the area. Key drivers of losses in taxonomic diversity in Mill Creek are currently unclear and are spatially limited and which may be linked to off-site activities in certain locations (such as recreational vehicle use).
- The proposal should result in a lower potential for impacts on the Mill Creek aquatic environment due to the proposed reprofiling of the site, increasing over time the capped

and revegetated areas and via a number of best practice operational controls documented in the OEMPs.

- Further investigation of the habitat condition and macroinvertebrate populations is recommended to confirm the preliminary findings contained within this report. It is recommended that this work be undertaken every three years commencing soon after reprofiling works commence in Area E.

It is noted that River Health Monitoring Program monitors three important ecological indicators to provide an assessment of catchment health; water quality, vegetation and macroinvertebrates (refer Section 6.6) and that their findings reinforce the conclusions of this report. That is, any impacts of the LHRRP on Mill Creek are spatially limited as further downstream the health of Mill Creek was found to be in an excellent condition.

Appendices

Appendix A – GHD Aquatic Ecosystem Database Field Data Report



Site Code

Site Name and Location

Sample Date

MC-1

Mill Creek Immediately downstream of SITA Lucas Heights

2/03/2015

Site/Date Code (PK)

MC-1_02Mar15

Latitude

-34.036060

Longitude

150.964730

Upstream



Downstream



In situ Water Quality

Time	Temp. (°C)	pH	EC (µS/cm)	Dissolved Oxygen (% sat, mg/L)	Turb. (NTU)	Alkalinity (mg/L)
13:58	21.42	7.66	324	81.2	115	42

Macroinvertebrate Indices

Total Taxa Richness	25
EPT Richness	4
SIGNAL 2 (Order)	4.00
SIGNAL 2 (Family)	3.39
SIGNAL-SF	5.29

AUSRIVAS Results

O/E 50*	0.74	Fewer families than expected. Potential impact either on water quality or habitat quality or both, resulting in loss of taxa.
Band	B	
Band Name	Significantly impaired	

* Ratio of Observed taxa/Expected taxa
1 = Reference Condition

**NSW AUSRIVAS Assessment of Disturbance
Related to Human Activities (Turak et al, 2004)**

Site Assessment	Ranking	Description
Water Quality	2	Moderate disturbance
Instream	2	Moderate disturbance
Riparian Zone	1	Little disturbance
Catchment	4	Extreme disturbance
Score	9 / 16	
Category	High disturbance	

Lower scores indicate less disturbances and better site condition

Reference Site Selection Criteria (DNRM, 2001)

1= Very Major Impact; 5= Indiscernible Impact

Agriculture and Forestry	5	Flow Regime Alteration	2
Sand and Gravel Extraction	2	Vegetation Alteration	4
Upstream Urban Areas	3	Riparian Zone/ Stream Bank Erosion	3
Point source Pollution	2	Geomorphic Change	3
Dams and Weirs	2	Instream Habitat Alteration	3
Score	29 / 50		
Reference Site Suitability	Marginal		

Higher scores indicate better quality sites



Site Code

Site Name and Location

Sample Date

MC-1

Mill Creek Immediately downstream of SITA Lucas Heights

2/03/2015

Modified RCE: Riparian, Channel, and Environmental Inventory (Chessman et al, 1997)

	<u>Category</u>	<u>Value</u>	<u>Description</u>
Land-use pattern beyond immediate riparian zone	4		Undisturbed native vegetation
Width of riparian strip of woody vegetation	4		More than 30 m
Completeness of riparian strip of woody vegetation	2		Breaks at intervals of 10-50 m
Vegetation of the riparian zone within 10 m of channel	3		Mixed native and exotic trees and shrubs
Stream bank structure	4		Bank fully stabilised by trees, shrubs, concrete
Bank undercutting	2		Frequent along all parts of the stream
Channel form	3		Medium; width:depth ratio 8:1 to 15:1
Riffle/pool Sequence	2		Natural channel without riffle/pool sequence
Retention devices in streams	3		Rocks/logs present; limited damming effect
Channel sediment accumulation	2		Bars of sand and silt common
Stream bottom	2		Bottom heavily silted but stable
Stream detritus	2		Mainly fine detritus mixed with sediment
Aquatic vegetation	2		Substantial macrophyte growth; little algal growth
RCE Total Score	35	/52	Very Good

Higher scores indicate less disturbances and better site condition

**Recommended actions to
address riparian condition**

Selected alterations and monitoring for changes

Habitat, Geomorphology and Flow

Length of reach surveyed	100	(m)			
Pool	50%	Riffle	0%	Run	50%
		Min	Mean	Max	
Stream Widths (m)	1	5	8		
Bankfull Width (m)	18				
Flow level during survey	Normal				
Stream Bank Erosion	Little				

Riparian Vegetation

Type	% Cover	Description	
Trees >10m	15%	Eucalyptus	
Trees <10m	25%	Eucalyptus, Banksia, Casuarina	
Shrubs	50%	Native shrubs	
Ground Cover	30%	Native grasses and ferns	
Est. % Native	90%	Est. % Exotic	10%

AUSRIVAS Environmental Variables

Model: NSW - Autumn - Edge

ALKALINITY	42	LATITUDE	-34.036060
ALTITUDE	107	LOGDFSM	3.347330
BEDROCK	15	LOGSLOPE1KUS	2.602060
BOULDER	0	LONGITUDE	150.964730
COBBLE	0	RAINFALL	950



Site Code

Site Name and Location

Sample Date

MC-1

Mill Creek Immediately downstream of SITA Lucas Heights

2/03/2015

Macroinvertebrate Sample Data and Summary of Results

Macroinvertebrate Sample Details

Habitat	Edge	Replicate	Habitat Feature	% Cover	Substrate Composition	% Cover
Method	Sweep		Detritus (leaves/twigs)	35%	Bedrock	15%
Collected By	Adrian Dickson		Sticks (< 2 cm)	10%	Boulder (>200 mm)	0%
Picked By	Adrian Dickson		Branches (2-15 cm)	5%	Cobble (60-200 mm)	0%
Sample Depth	30 (cm)		Logs (> 15 cm)	2%	Pebble (20-60 mm)	0%
Habitat Feature	% Cover		Algae	0%	Gravel (2-20 mm)	0%
Blanketing Silt	100%		Macrophytes	15%	Sand (0.02-2 mm)	30%
Shading	60%		Overhanging Habitat	80%	Silt/Clay (<0.02 mm)	55%
Sample Comment						

Macroinvertebrate Orders Present

CommonName	Class/ Order	N Families
Mites	Acarina	1
Beetles	Coleoptera	1
Microcrustaceans	Crustacea	1
Flies (larvae)	Diptera	4
Mayflies	Ephemeroptera	2
Snails	Gastropoda	1
True Bugs	Hemiptera	5
Alderflies	Megaloptera	1
Dragonflies and Damselflies	Odonata	6
Caddisflies	Trichoptera	2
Flatworms	Turbellaria	1



Site Code

Site Name and Location

Sample Date

MC2

Mill Creek Adjacent to MTB track

2/03/2015

Site/Date Code (PK)

MC2_02Mar15

Latitude

-34.032050

Longitude

150.965860

Upstream



Downstream



In situ Water Quality

Time	Temp. (°C)	pH	EC (µS/cm)	Dissolved Oxygen (% sat, mg/L)	Turb. (NTU)	Alkalinity (mg/L)
13:29	20.66	7.59	369	93.1	358	74

Macroinvertebrate Indices

Total Taxa Richness	27
EPT Richness	2
SIGNAL 2 (Order)	3.35
SIGNAL 2 (Family)	3.33
SIGNAL-SF	5.05

AUSRIVAS Results

O/E 50*	0.73	Fewer families than expected. Potential impact either on water quality or habitat quality or both, resulting in loss of taxa.
Band	B	
Band Name	Significantly impaired	

* Ratio of Observed taxa/Expected taxa
1 = Reference Condition

**NSW AUSRIVAS Assessment of Disturbance
Related to Human Activities (Turak et al, 2004)**

Site Assessment	Ranking	Description
Water Quality	1	Little disturbance
Instream	1	Little disturbance
Riparian Zone	1	Little disturbance
Catchment	3	High disturbance
Score	6	/ 16
Category	Moderate disturbance	

Lower scores indicate less disturbances and better site condition

Reference Site Selection Criteria (DNRM, 2001)

1= Very Major Impact; 5= Indiscernible Impact

Agriculture and Forestry	5	Flow Regime Alteration	4
Sand and Gravel Extraction	4	Vegetation Alteration	4
Upstream Urban Areas	4	Riparian Zone/ Stream Bank Erosion	4
Point source Pollution	5	Geomorphic Change	3
Dams and Weirs	4	Instream Habitat Alteration	3
Score	40	/ 50	
Reference Site Suitability	Sub-optimal		

Higher scores indicate better quality sites



Site Code

Site Name and Location

Sample Date

MC2

Mill Creek Adjacent to MTB track

2/03/2015

Modified RCE: Riparian, Channel, and Environmental Inventory (Chessman et al, 1997)

	<u>Category</u>	<u>Value</u>	<u>Description</u>
Land-use pattern beyond immediate riparian zone	4		Undisturbed native vegetation
Width of riparian strip of woody vegetation	4		More than 30 m
Completeness of riparian strip of woody vegetation	3		Breaks at intervals of more than 50 m
Vegetation of the riparian zone within 10 m of channel	4		Native tree and shrub species
Stream bank structure	4		Bank fully stabilised by trees, shrubs, concrete
Bank undercutting	2		Frequent along all parts of the stream
Channel form	3		Medium; width:depth ratio 8:1 to 15:1
Riffle/pool Sequence	2		Natural channel without riffle/pool sequence
Retention devices in streams	3		Rocks/logs present; limited damming effect
Channel sediment accumulation	2		Bars of sand and silt common
Stream bottom	2		Bottom heavily silted but stable
Stream detritus	3		Some wood, leaves, etc. with much fine detritus
Aquatic vegetation	2		Substantial macrophyte growth; little algal growth
RCE Total Score	38	/52	Very Good

Higher scores indicate less disturbances and better site condition

**Recommended actions to
address riparian condition**

Selected alterations and monitoring for changes

Habitat, Geomorphology and Flow

Length of reach surveyed	100	(m)			
Pool	50%	Riffle	0%	Run	50%
	Min	Mean	Max		
Stream Widths (m)	0.3	4	6		
Bankfull Width (m)	10				
Flow level during survey	Normal				
Stream Bank Erosion	Some				

Riparian Vegetation

Type	% Cover	Description	
Trees >10m	20%	Eucalyptus	
Trees <10m	15%	Eucalyptus, Banksia, Casuarina	
Shrubs	15%	Native shrubs	
Ground Cover	35%	Ferns	
Est. % Native	90%	Est. % Exotic	10%

AUSRIVAS Environmental Variables

Model: NSW - Autumn - Edge

ALKALINITY	74	LATITUDE	-34.032050
ALTITUDE	105	LOGDFSM	3.427324
BEDROCK	10	LOGSLOPE1KUS	2.176091
BOULDER	10	LONGITUDE	150.965860
COBBLE	0	RAINFALL	950



Site Code

Site Name and Location

Sample Date

MC2

Mill Creek Adjacent to MTB track

2/03/2015

Macroinvertebrate Sample Data and Summary of Results

Macroinvertebrate Sample Details

Habitat	Edge	Replicate	Habitat Feature	% Cover	Substrate Composition	% Cover
Method	Sweep		Detritus (leaves/twigs)	40%	Bedrock	10%
Collected By	Adrian Dickson		Sticks (< 2 cm)	15%	Boulder (>200 mm)	10%
Picked By	Adrian Dickson		Branches (2-15 cm)	10%	Cobble (60-200 mm)	0%
Sample Depth	20 (cm)		Logs (> 15 cm)	5%	Pebble (20-60 mm)	0%
Habitat Feature	% Cover		Algae	0%	Gravel (2-20 mm)	5%
Blanketing Silt	100%		Macrophytes	5%	Sand (0.02-2 mm)	45%
Shading	25%		Overhanging Habitat	15%	Silt/Clay (<0.02 mm)	30%
Sample Comment						

Macroinvertebrate Orders Present

CommonName	Class/ Order	N Families
Mites	Acarina	1
Beetles	Coleoptera	2
Microcrustaceans	Crustacea	1
Flies (larvae)	Diptera	3
Mayflies	Ephemeroptera	1
Snails	Gastropoda	3
True Bugs	Hemiptera	6
Alderflies	Megaloptera	1
Dragonflies and Damselflies	Odonata	6
Worms	Oligochaeta	1
Caddisflies	Trichoptera	1
Flatworms	Turbellaria	1



Site Code

Site Name and Location

Sample Date

MC3

Mill Creek End of Little Forest access track

2/03/2015

Site/Date Code (PK)

MC3_02Mar15

Latitude

-34.026380

Longitude

150.971780

Upstream



Downstream



In situ Water Quality

Time	Temp. (°C)	pH	EC (µS/cm)	Dissolved Oxygen (% sat, mg/L)	Turb. (NTU)	Alkalinity (mg/L)
11:27	20.77	7.15	274	73.8	125	38

Macroinvertebrate Indices

Total Taxa Richness	20
EPT Richness	3
SIGNAL 2 (Order)	4.47
SIGNAL 2 (Family)	3.59
SIGNAL-SF	5.31

AUSRIVAS Results

O/E 50*	0.45	Many fewer families than expected. Loss of macroinvertebrate biodiversity due to substantial impacts on water and/or habitat quality.
Band	C	
Band Name	Severely impaired	

* Ratio of Observed taxa/Expected taxa
1 = Reference Condition

**NSW AUSRIVAS Assessment of Disturbance
Related to Human Activities (Turak et al, 2004)**

Site Assessment	Ranking	Description
Water Quality	2	Moderate disturbance
Instream	2	Moderate disturbance
Riparian Zone	1	Little disturbance
Catchment	2	Moderate disturbance
Score	7	/ 16
Category	Moderate disturbance	

Lower scores indicate less disturbances and better site condition

Reference Site Selection Criteria (DNRM, 2001)

1= Very Major Impact; 5= Indiscernible Impact

Agriculture and Forestry	5	Flow Regime Alteration	4
Sand and Gravel Extraction	2	Vegetation Alteration	3
Upstream Urban Areas	4	Riparian Zone/ Stream Bank Erosion	2
Point source Pollution	3	Geomorphic Change	3
Dams and Weirs	4	Instream Habitat Alteration	3
Score	33	/ 50	
Reference Site Suitability	Marginal		

Higher scores indicate better quality sites



Site Code

Site Name and Location

Sample Date

MC3

Mill Creek End of Little Forest access track

2/03/2015

Modified RCE: Riparian, Channel, and Environmental Inventory (Chessman et al, 1997)

<u>Category</u>	<u>Value</u>	<u>Description</u>
Land-use pattern beyond immediate riparian zone	3	Mixed native vegetation and pasture/exotics
Width of riparian strip of woody vegetation	3	Between 5 and 30 m
Completeness of riparian strip of woody vegetation	2	Breaks at intervals of 10-50 m
Vegetation of the riparian zone within 10 m of channel	4	Native tree and shrub species
Stream bank structure	4	Bank fully stabilised by trees, shrubs, concrete
Bank undercutting	2	Frequent along all parts of the stream
Channel form	3	Medium; width:depth ratio 8:1 to 15:1
Riffle/pool Sequence	2	Natural channel without riffle/pool sequence
Retention devices in streams	2	Rocks/logs present but unstable; no damming
Channel sediment accumulation	1	Braiding by loose sediment
Stream bottom	1	Bottom mainly loose and mobile sandy sediment
Stream detritus	2	Mainly fine detritus mixed with sediment
Aquatic vegetation	2	Substantial macrophyte growth; little algal growth
RCE Total Score	31	/52 Good

Higher scores indicate less disturbances and better site condition

**Recommended actions to
address riparian condition**

Minor alterations needed

Habitat, Geomorphology and Flow

Length of reach surveyed	100	(m)			
Pool	50%	Riffle	0%	Run	50%
	Min	Mean	Max		
Stream Widths (m)	4	5	12		
Bankfull Width (m)	20				
Flow level during survey	Normal				
Stream Bank Erosion	Little				

Riparian Vegetation

Type	% Cover	Description	
Trees >10m	35%	Eucalyptus	
Trees <10m	25%	Eucalyptus, Banksia, Casuarina	
Shrubs	15%	Native shrubs and rushes	
Ground Cover	20%	Some ferns	
Est. % Native	90%	Est. % Exotic	10%

AUSRIVAS Environmental Variables

Model: NSW - Autumn - Edge

ALKALINITY	38	LATITUDE	-34.026380
ALTITUDE	95	LOGDFSM	3.550228
BEDROCK	20	LOGSLOPE1KUS	2.113943
BOULDER	0	LONGITUDE	150.971780
COBBLE	0	RAINFALL	950



Site Code

Site Name and Location

Sample Date

MC3

Mill Creek End of Little Forest access track

2/03/2015

Macroinvertebrate Sample Data and Summary of Results

Macroinvertebrate Sample Details

Habitat	Edge	Replicate	Habitat Feature	% Cover	Substrate Composition	% Cover
Method	Sweep		Detritus (leaves/twigs)	20%	Bedrock	20%
Collected By	Adrian Dickson		Sticks (< 2 cm)	5%	Boulder (>200 mm)	0%
Picked By	Adrian Dickson		Branches (2-15 cm)	5%	Cobble (60-200 mm)	0%
Sample Depth	30 (cm)		Logs (> 15 cm)	0%	Pebble (20-60 mm)	0%
Habitat Feature	% Cover		Algae	0%	Gravel (2-20 mm)	10%
Blanketing Silt	100%		Macrophytes	25%	Sand (0.02-2 mm)	30%
Shading	35%		Overhanging Habitat	70%	Silt/Clay (<0.02 mm)	40%
Sample Comment	Adult dragon and damsels observed depositing eggs near macrophyte beds					

Macroinvertebrate Orders Present

CommonName	Class/ Order	N Families
Mites	Acarina	1
Beetles	Coleoptera	4
Microcrustaceans	Crustacea	1
Flies (larvae)	Diptera	2
Mayflies	Ephemeroptera	2
Snails	Gastropoda	1
True Bugs	Hemiptera	1
Water Slaters	Isopoda	1
Alderflies	Megaloptera	1
Dragonflies and Damselflies	Odonata	4
Caddisflies	Trichoptera	1
Flatworms	Turbellaria	1



Site Code

Site Name and Location

Sample Date

MC4

Mill Creek Downstream

2/03/2015

Site/Date Code (PK)

MC4_02Mar15

Latitude

-34.023670

Longitude

150.981040

Upstream



Downstream



In situ Water Quality

Time	Temp. (°C)	pH	EC (µS/cm)	Dissolved Oxygen (% sat, mg/L)	Turb. (NTU)	Alkalinity (mg/L)
10:29	20.61	7.34	269	84.5	54.5	30.6

Macroinvertebrate Indices

Total Taxa Richness	19
EPT Richness	4
SIGNAL 2 (Order)	4.83
SIGNAL 2 (Family)	3.76
SIGNAL-SF	6.14

AUSRIVAS Results

O/E 50*	0.81	Fewer families than expected. Potential impact either on water quality or habitat quality or both, resulting in loss of taxa.
Band	B	
Band Name	Significantly impaired	

* Ratio of Observed taxa/Expected taxa
1 = Reference Condition

**NSW AUSRIVAS Assessment of Disturbance
Related to Human Activities (Turak et al, 2004)**

Site Assessment	Ranking	Description
Water Quality	1	Little disturbance
Instream	1	Little disturbance
Riparian Zone	0	No evidence of disturbance
Catchment	1	Little disturbance
Score	3	/ 16
Category	Little disturbance	

Lower scores indicate less disturbances and better site condition

Reference Site Selection Criteria (DNRM, 2001)

1= Very Major Impact; 5= Indiscernible Impact

Agriculture and Forestry	5	Flow Regime Alteration	4
Sand and Gravel Extraction	4	Vegetation Alteration	4
Upstream Urban Areas	4	Riparian Zone/ Stream Bank Erosion	4
Point source Pollution	4	Geomorphic Change	4
Dams and Weirs	4	Instream Habitat Alteration	4
Score	41	/ 50	

Reference Site Suitability **Sub-optimal**

Higher scores indicate better quality sites



Site Code

Site Name and Location

Sample Date

MC4

Mill Creek Downstream

2/03/2015

Modified RCE: Riparian, Channel, and Environmental Inventory (Chessman et al, 1997)

<u>Category</u>	<u>Value</u>	<u>Description</u>
Land-use pattern beyond immediate riparian zone	4	Undisturbed native vegetation
Width of riparian strip of woody vegetation	4	More than 30 m
Completeness of riparian strip of woody vegetation	4	Riparian strip without breaks in vegetation
Vegetation of the riparian zone within 10 m of channel	4	Native tree and shrub species
Stream bank structure	4	Bank fully stabilised by trees, shrubs, concrete
Bank undercutting	4	None, or restricted by tree roots or man-made
Channel form	2	Shallow; width:depth ratio greater than 15:1
Riffle/pool Sequence	3	Long pools with infrequent short riffles
Retention devices in streams	3	Rocks/logs present; limited damming effect
Channel sediment accumulation	4	Little or no accumulation of loose sediments
Stream bottom	3	Mainly stones with some cover of algae/silt
Stream detritus	4	Mainly unsilted wood, bark, leaves
Aquatic vegetation	2	Substantial macrophyte growth; little algal growth
RCE Total Score	45	/52 Excellent

Higher scores indicate less disturbances and better site condition

**Recommended actions to
address riparian condition**

Biomonitoring and protection of the existing status

Habitat, Geomorphology and Flow

Length of reach surveyed	100	(m)			
Pool	15%	Riffle	10%	Run	75%
	Min	Mean	Max		
Stream Widths (m)	0.5	6	8		
Bankfull Width (m)	10				
Flow level during survey	Normal				
Stream Bank Erosion	Little				

Riparian Vegetation

Type	% Cover	Description	
Trees >10m	35%	Eucalyptus, Casuarina	
Trees <10m	50%	Eucalyptus, Acacia, Banksia, Casuari	
Shrubs	20%	Native shrubs	
Ground Cover	20%	Grasses and ferns	
Est. % Native	95%	Est. % Exotic	5%

AUSRIVAS Environmental Variables

Model: NSW - Autumn - Edge

ALKALINITY	30.6	LATITUDE	-34.023670
ALTITUDE	89	LOGDFSM	3.651278
BEDROCK	30	LOGSLOPE1KUS	1.778151
BOULDER	5	LONGITUDE	150.981040
COBBLE	5	RAINFALL	950



Site Code

Site Name and Location

Sample Date

MC4

Mill Creek Downstream

2/03/2015

Macroinvertebrate Sample Data and Summary of Results

Macroinvertebrate Sample Details

Habitat	Edge	Replicate	Habitat Feature	% Cover	Substrate Composition	% Cover
Method	Sweep		Detritus (leaves/twigs)	30%	Bedrock	30%
Collected By	Adrian Dickson		Sticks (< 2 cm)	15%	Boulder (>200 mm)	5%
Picked By	Adrian Dickson		Branches (2-15 cm)	10%	Cobble (60-200 mm)	5%
Sample Depth	30 (cm)		Logs (> 15 cm)	5%	Pebble (20-60 mm)	5%
Habitat Feature	% Cover		Algae	0%	Gravel (2-20 mm)	15%
Blanketing Silt	90%		Macrophytes	15%	Sand (0.02-2 mm)	15%
Shading	60%		Overhanging Habitat	65%	Silt/Clay (<0.02 mm)	25%
Sample Comment						

Macroinvertebrate Orders Present

CommonName	Class/ Order	N Families
Mites	Acarina	1
Beetles	Coleoptera	3
Microcrustaceans	Crustacea	1
Shrimp, Prawns and Yabbies	Decapoda	1
Flies (larvae)	Diptera	3
Mayflies	Ephemeroptera	2
Snails	Gastropoda	2
Alderflies	Megaloptera	1
Dragonflies and Damselflies	Odonata	3
Caddisflies	Trichoptera	2



Site Code

Site Name and Location

Sample Date

MCUP

Mill Creek Upstream of Duck Pond

2/03/2015

Site/Date Code (PK)

MCUP_02Mar15

Latitude

-34.051190

Longitude

150.966730

Upstream



Downstream



In situ Water Quality

Time	Temp. (°C)	pH	EC (µS/cm)	Dissolved Oxygen (% sat, mg/L)	Turb. (NTU)	Alkalinity (mg/L)
16:10	20.29	6.59	207	9.3	0.85	27.1

Macroinvertebrate Indices

Total Taxa Richness	24
EPT Richness	2
SIGNAL 2 (Order)	3.57
SIGNAL 2 (Family)	3.05
SIGNAL-SF	5.24

AUSRIVAS Results

O/E 50*	0.84	Most/all of the expected families found. Water quality and/or habitat condition roughly equivalent to reference sites. Impact on water quality and habitat condition does not result in a loss of macroinvertebrate diversity.
Band	A	
Band Name	Reference condition	

* Ratio of Observed taxa/Expected taxa
1 = Reference Condition

**NSW AUSRIVAS Assessment of Disturbance
Related to Human Activities (Turak et al, 2004)**

Site Assessment	Ranking	Description
Water Quality	1	Little disturbance
Instream	1	Little disturbance
Riparian Zone	2	Moderate disturbance
Catchment	2	Moderate disturbance
Score	6	/ 16
Category	Moderate disturbance	

Lower scores indicate less disturbances and better site condition

Reference Site Selection Criteria (DNRM, 2001)

1= Very Major Impact; 5= Indiscernible Impact

Agriculture and Forestry	5	Flow Regime Alteration	3
Sand and Gravel Extraction	3	Vegetation Alteration	3
Upstream Urban Areas	4	Riparian Zone/ Stream Bank Erosion	4
Point source Pollution	5	Geomorphic Change	4
Dams and Weirs	3	Instream Habitat Alteration	4
Score	38 / 50		
Reference Site Suitability	Sub-optimal		

Higher scores indicate better quality sites



Site Code

Site Name and Location

Sample Date

MCUP

Mill Creek Upstream of Duck Pond

2/03/2015

Modified RCE: Riparian, Channel, and Environmental Inventory (Chessman et al, 1997)

<u>Category</u>	<u>Value</u>	<u>Description</u>
Land-use pattern beyond immediate riparian zone	3	Mixed native vegetation and pasture/exotics
Width of riparian strip of woody vegetation	3	Between 5 and 30 m
Completeness of riparian strip of woody vegetation	2	Breaks at intervals of 10-50 m
Vegetation of the riparian zone within 10 m of channel	3	Mixed native and exotic trees and shrubs
Stream bank structure	3	Banks firm but held mainly by grasses and herbs
Bank undercutting	4	None, or restricted by tree roots or man-made
Channel form	2	Shallow; width:depth ratio greater than 15:1
Riffle/pool Sequence	3	Long pools with infrequent short riffles
Retention devices in streams	2	Rocks/logs present but unstable; no damming
Channel sediment accumulation	1	Braiding by loose sediment
Stream bottom	2	Bottom heavily silted but stable
Stream detritus	3	Some wood, leaves, etc. with much fine detritus
Aquatic vegetation	2	Substantial macrophyte growth; little algal growth
RCE Total Score	33	/52 Very Good

Higher scores indicate less disturbances and better site condition

**Recommended actions to
address riparian condition**

Selected alterations and monitoring for changes

Habitat, Geomorphology and Flow

Length of reach surveyed		100	(m)		
Pool	70%	Riffle	0%	Run	30%
		Min	Mean	Max	
Stream Widths (m)		3	4	6	
Bankfull Width (m)		15			
Flow level during survey		Normal			
Stream Bank Erosion		Little			

Riparian Vegetation

Type	% Cover	Description	
Trees >10m	10%	Casuarina	
Trees <10m	25%	Casuarina	
Shrubs	25%	Native shrubs and rushes	
Ground Cover	10%	Native and exotic grasses and herbs	
Est. % Native	85%	Est. % Exotic	15%

AUSRIVAS Environmental Variables

Model: NSW - Autumn - Edge

ALKALINITY	44	LATITUDE	-34.051190
ALTITUDE	157	LOGDFSM	2.602060
BEDROCK	0	LOGSLOPE1KUS	1.778151
BOULDER	5	LONGITUDE	150.966730
COBBLE	5	RAINFALL	950



Site Code

Site Name and Location

Sample Date

MCUP

Mill Creek Upstream of Duck Pond

2/03/2015

Macroinvertebrate Sample Data and Summary of Results

Macroinvertebrate Sample Details

Habitat	Edge	Replicate	Habitat Feature	% Cover	Substrate Composition	% Cover
Method	Sweep		Detritus (leaves/twigs)	15%	Bedrock	0%
Collected By	Adrian Dickson		Sticks (< 2 cm)	5%	Boulder (>200 mm)	5%
Picked By	Adrian Dickson		Branches (2-15 cm)	5%	Cobble (60-200 mm)	5%
Sample Depth	30 (cm)		Logs (> 15 cm)	0%	Pebble (20-60 mm)	5%
Habitat Feature	% Cover		Algae	0%	Gravel (2-20 mm)	10%
Blanketing Silt	70%		Macrophytes	20%	Sand (0.02-2 mm)	15%
Shading	60%		Overhanging Habitat	40%	Silt/Clay (<0.02 mm)	60%
Sample Comment						

Macroinvertebrate Orders Present

CommonName	Class/ Order	N Families
Mites	Acarina	1
Beetles	Coleoptera	3
Microcrustaceans	Crustacea	3
Flies (larvae)	Diptera	4
Mayflies	Ephemeroptera	1
True Bugs	Hemiptera	5
Leeches	Hirudinea	1
Dragonflies and Damselflies	Odonata	4
Caddisflies	Trichoptera	1
Flatworms	Turbellaria	1

Appendix B - Macroinvertebrate Data

AUSRIVAS Taxa Code	Class/Order	Family/Sub-family	MCUP	MC1	MC2	MC3	MC4
IF619999	Turbellaria	DugesIIDae	4	1	1	3	
KG059999	Gastropoda	Lymnaeidae			1		
KG069999	Gastropoda	Ancylidae			1		
KG079999	Gastropoda	Planorbidae					1
KG089999	Gastropoda	Physidae		3	7	6	2
LH019999	Hirudinea	Glossiphoniidae	3				
LO999999	Oligochaeta	Oligochaeta			1		
MM999999	Acarina	Acarina	14	1	3	7	13
OG999999	Crustacea	Cladocera	2				
OH999999	Crustacea	Ostracoda	4	5	1	2	2
OJ999999	Crustacea	Copepoda	1				
OR999999	Isopoda	Isopoda				1	
OV019999	Decapoda	Parastacidae					1
QC069999	Coleoptera	Halplidae				1	
QC099999	Coleoptera	Dytiscidae	11	4	4	4	3
QC109999	Coleoptera	Gyrinidae			1		1
QC119999	Coleoptera	Hydrophilidae	12			3	2
QC209999	Coleoptera	Scirtidae	18				
QC379999	Coleoptera	Psephenidae				1	
QD079999	Diptera	Culicidae	3				
QD099999	Diptera	Ceratopogonidae	2	1	2	1	
QD249999	Diptera	Stratiomyidae		1			
QDAE9999	Diptera	Tanypodinae	1	6	12		4
QDAF9999	Diptera	Orthocladinae					1
QDAJ9999	Diptera	Chironominae	5	10	7	18	16
QE029999	Ephemeroptera	Baetidae	6	3	3	1	1
QE069999	Ephemeroptera	Leptophlebiidae					6
QE089999	Ephemeroptera	Caenidae		1		1	
QH549999	Hemiptera	Hydrometridae			2		
QH569999	Hemiptera	Veliidae	4	2	4		
QH579999	Hemiptera	Gerridae		2	1		
QH619999	Hemiptera	Nepidae		1			
QH649999	Hemiptera	Gelastocoridae			2	1	
QH659999	Hemiptera	Corixidae	6	6	1		
QH669999	Hemiptera	Naucoridae	13				
QH679999	Hemiptera	Notonectidae	18	12	10		
QH689999	Hemiptera	Pleidae	8				
QM029999	Megaloptera	Sialidae		2	1	1	5
QO029999	Odonata	Coenagrionidae	36	24	5	3	1
QO039999	Odonata	Isostictidae		1	1	1	1

AUSRIVAS Taxa Code	Class/Order	Family/Sub-family	MCUP	MC1	MC2	MC3	MC4
QO079999	Odonata	Megapodagrionidae		4	7	3	2
QO129999	Odonata	Aeshnidae	3	7	7		
QO179999	Odonata	Libellulidae	5	10	3	1	
QO309999	Odonata	Hemicorduliidae	2	3	3		
QT089999	Trichoptera	Ecnomidae		5	1		2
QT259999	Trichoptera	Leptoceridae	5	1		3	3

Appendix C - AUSRIVAS Macroinvertebrate Taxa Expected to occur but not Observed

AUSRIVAS Taxa Code	Class/Order	Family/Sub-family	SIGNAL 2 Grade (Family)	SIGNAL-SF Grade
IF419999	Turbellaria	Temnocephalidae	5	8
IJ019999	Nematomorpha	Gordiidae	5	6
KG029999	Gastropoda	Hydrobiidae	4	3
KG049999	Gastropoda	Thiaridae	4	
KP029999	Bivalvia	Corbiculidae	4	3
OP029999	Amphipoda	Ceinidae	2	
OP039999	Amphipoda	Eusiridae	7	8
OR129999	Isopoda	Cirolanidae	2	
OT019999	Decapoda	Atyidae	3	6
OT029999	Decapoda	Palaemonidae	4	3
QC089999	Coleoptera	Noteridae	4	1
QC139999	Coleoptera	Hydraenidae	3	6
QC189999	Coleoptera	Staphylinidae	3	
QC349999	Coleoptera	Elmidae	7	7
QD019999	Diptera	Tipulidae	5	7
QD069999	Diptera	Dixidae	7	9
QD109999	Diptera	Simuliidae	5	4
QD119999	Diptera	Thaumaleidae	7	9
QD229999	Diptera	Athericidae	8	8
QDAD9999	Diptera	Podonominae	6	
QE039999	Ephemeroptera	Oniscigastriidae	8	9
QE059999	Ephemeroptera	Coloburiscidae	8	8
QH529999	Hemiptera	Mesoveliidae	2	6
QH539999	Hemiptera	Hebridae	3	5
QL019999	Lepidoptera	Crambidae	3	
QM019999	Megaloptera	Corydalidae	7	7
QO049999	Odonata	Protoneuridae	4	4
QO059999	Odonata	Lestidae	1	7
QO089999	Odonata	Synlestidae	7	7
QO139999	Odonata	Gomphidae	5	6
QO169999	Odonata	Corduliidae	5	5
QP029999	Plecoptera	Austroperlidae	10	10
QP039999	Plecoptera	Gripopterygidae	8	9
QP049999	Plecoptera	Notonemouridae	6	8
QT019999	Trichoptera	Hydrobiosidae	8	8
QT039999	Trichoptera	Hydroptilidae	4	6
QT049999	Trichoptera	Philopotamidae	8	8
QT069999	Trichoptera	Hydropsychidae	6	6
QT079999	Trichoptera	Polycentropodidae	7	10
QT139999	Trichoptera	Tasimiidae	8	8
QT159999	Trichoptera	Conoesucidae	7	7
QT179999	Trichoptera	Helicopsychidae	8	10
QT189999	Trichoptera	Calocidae	9	9
QT219999	Trichoptera	Philorheithridae	8	9

AUSRIVAS Taxa Code	Class/Order	Family/Sub-family	SIGNAL 2 Grade (Family)	SIGNAL-SF Grade
QT229999	Trichoptera	Odontoceridae	7	10
QT239999	Trichoptera	Atriptectididae	7	8
QT249999	Trichoptera	Calamoceratidae	7	8
Average SIGNAL Grade			5.66	6.98
% SIGNAL Grade \geq 4 (Interim NSW SIGNAL 2 Score)			81%	N/A
Total EPT Taxa			18	
Average SIGNAL Grade of EPT Taxa			7.44	8.39

Appendix D – 2013 / 2014 River Health Georges River Report Card



2013 - 2014 RIVER HEALTH GEORGES RIVER REPORT CARD



OVERALL RIVER HEALTH

Results from 2013-14 River Health monitoring show the overall grade for the Georges River catchment marginally decreased when compared to the previous year, a result which is likely attributed to severe weather events negatively impacting water quality. However, this result does not indicate significant change and the overall ecological condition of the catchment remained 'Fair'.

After a wet start to the 2013 winter, annual rainfall across the catchment was below average. Warm and dry weather in spring 2013 and autumn 2014 was punctuated by periods of intense rainfall causing flash flooding in many of the urban creeks

throughout the catchment. As a result, many of these creeks recorded degraded water quality caused by an influx of stormwater.

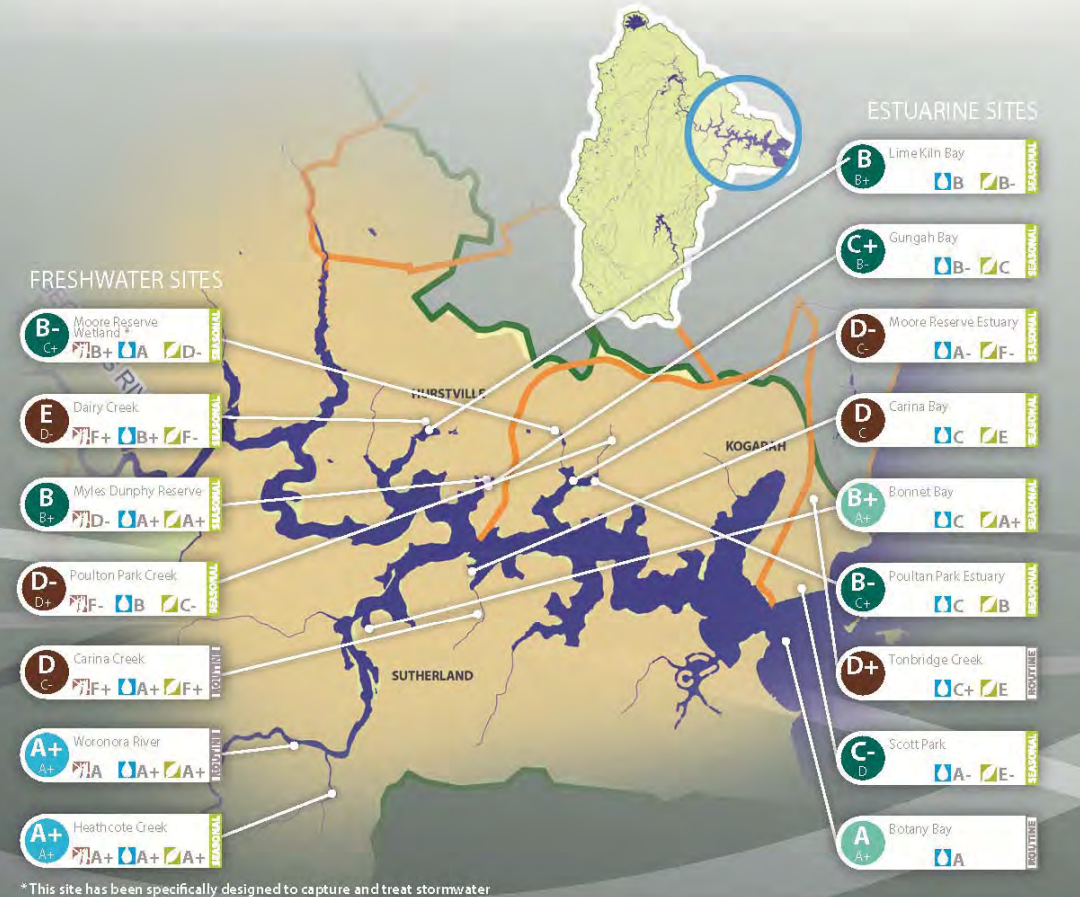
Urban stormwater combined with degraded and fragmented riparian vegetation corridors negatively affect macroinvertebrate communities. Urban streams throughout the catchment revealed macroinvertebrate communities dominated by pollution tolerant species with little or no pollution sensitive species present.

This contrasts with waterways in the non-urban areas of the catchment where diverse

macroinvertebrate communities rich in pollution sensitive species were recorded. These waterways are not affected by stormwater, and therefore maintain 'Good' to 'Excellent' ecological condition displaying greater resilience to the variable rainfall experienced in 2013-14.

Estuary conditions in the Georges River were 'Fair'. Intense rainfall events of 2013-14 followed by long periods of sunshine resulted in occasional algal blooms. In addition, litter consisting mainly of plastics, was visible throughout the year in the estuarine reaches of the Georges River.

B-
OVERALL SCORE
GEORGES RIVER



LOWER GEORGES RIVER | 7 FRESHWATER SITES 9 ESTUARINE SITES



RIVER HEALTH REPORT CARD 2013 - 2014

A SNAP-SHOT OF RIVER HEALTH

In 2013-14 the River Health Monitoring Program entered its fifth year of monitoring in the Georges River catchment.

River Health monitors three important ecological indicators to provide an assessment of catchment health; water quality, vegetation and macroinvertebrates.

By combining results of ecological indicators a greater understanding of the Georges river system is gained. In particular, River Health is investigating the pressures and impacts of an increasingly urbanised catchment.

River Health encourages participation of community members in monitoring activities. Volunteers work

alongside ecologists collecting data integral to assessing the ecological condition of Georges River.

Since 2009, volunteers have contributed over 4,000 hours of field work to the program while gaining a valuable insight into dynamic nature of the Georges River system.



MACROINVERTEBRATES

Macroinvertebrates are small animals without a backbone, such as snails, worms, and dragonfly nymphs. They live in freshwater creeks and streams and are particularly sensitive to changes in water quality. River Health surveys macroinvertebrates in spring and autumn each year. Monitoring these animals provides an increased understanding of how aquatic ecosystems within the Georges River catchment respond to environmental pressures.



WATER QUALITY

Water quality is an important factor to maintaining a healthy ecosystem. River Health monitors water quality in streams, wetlands and estuaries of the Georges River throughout the year. Monitoring water quality is providing us with a better understanding of how urbanisation and changed land use practices are affecting the health of the river estuarine ecosystems.



VEGETATION

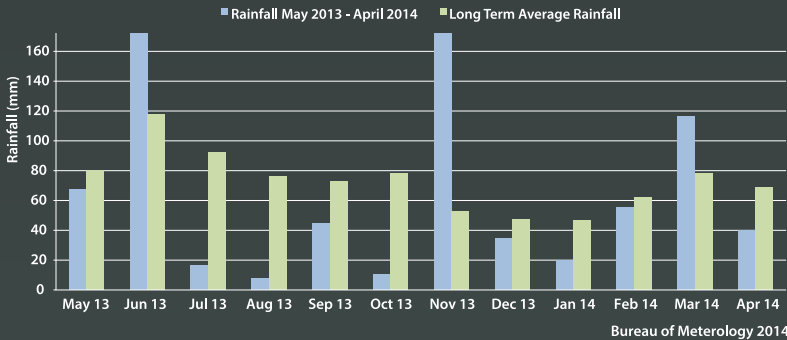
Healthy vegetation communities are important for maintaining a functioning ecosystem. Vegetation plays a major role in providing habitat, nutrient cycling, regulation of temperature and filtration of urban runoff. River Health assesses riparian (stream bank) and estuarine vegetation every three years. By monitoring these communities we are gaining a better understanding of their role in maintaining healthy ecosystems in the Georges River Catchment.

GEORGES RIVER

The Georges River catchment covers an area of approximately 960 km² and has a population of over 1 million people. It begins its journey 60km south west of Sydney near the town of Appin and flows north towards Liverpool, before turning east at Chipping Norton Lakes and enters the sea at Botany Bay.

The river has a number of important tributaries including Bunbury Curran Creek, Cabramatta Creek, Prospect Creek, Mill Creek and the Woronora River. Land use within the catchment includes industrial, agricultural and mining while approximately 45% remains in natural or near natural condition.

GEORGES RIVER CATCHMENT SEASONAL RAINFALL



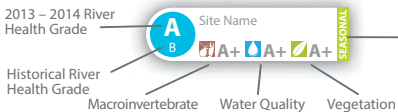
GRADING SYSTEM

River Health indicators are assessed against environmental guidelines allowing the award of a grade between A+ and F-.

GRADE	CONDITION
A+	EXCELLENT
A - B+	GOOD
B - C-	FAIR
D+ - F-	POOR

INTERPRETING GRADING ICONS

This diagram shows an example grading box. Use this example to interpret the results from the individual sub catchments.



GEORGES RIVER COUNCILS ARE IMPROVING RIVER HEALTH



HURSTVILLE CITY COUNCIL HURSTVILLE GOLF COURSE

Hurstville City Council has completed the construction of a large scale stormwater harvesting and reuse project to secure the future irrigation needs of the Hurstville Golf Course. The scheme will harvest over 50 ML of stormwater per year and save 21ML of potable water per annum. The improved water quality and enhanced biodiversity which has resulted from the project will provide significant environmental benefits for Lime Kiln Bay, within the Georges River in Sydney.

LIVERPOOL CITY COUNCIL

In 2013-14, Liverpool City Council has undertaken environmental restoration works in the Georges River catchment to the value of \$368,000 covering an approximate area of 76,000m². Council also supports 11 environment groups undertaking bush regeneration, one Streamwatch group and delivers environmental education to the community.

ROCKDALE CITY COUNCIL HAWTHORNE STREET NATURAL AREA

Hawthorne St Natural Area in Ramsgate is a 'show piece' of original flora and fauna of western Botany Bay. Many habitats are present here including Kurnell Dune Forest and Swamp Oak Floodplain Forest - both endangered ecological communities. It also provides habitat to threatened fauna and is key fish breeding habitat. Rockdale Council, along with Bushcare volunteers, corporate groups and Riverkeeper teams are undertaking bush regeneration on-site to rehabilitate bushland and re-establish creek bank vegetation.

FAIRFIELD CITY COUNCIL BARAGOOA ST BANK STABILISATION PROJECT

A 46m length of severely eroded creek bank has been stabilised using sandstone rocks, coir logs, in-stream large woody debris and landscaping works. An upstream bund has been constructed to control a localised break out point, resulting in creek flows being held within banks. The woody debris centralises creek flows during minor storm events and provides fauna habitat. Landscaping with native vegetation also provides important habitat for local wildlife and improves diversity, water quality and aesthetics of the area.



KOGARAH CITY COUNCIL CARSS PARK ENVIRONMENTALLY FRIENDLY SEAWALL

Urban waterways are fragmented environments, resulting in the loss of natural habitats and a decline in biodiversity. The Carss Park seawall project aims to reconnect the foreshore by replicating natural intertidal habitats, including saltmarsh, rocky intertidal and mudflats, through constructing an environmentally friendly seawall. The Carss Park seawall will create diverse, intertidal habitats resulting in the migration of organisms through the Georges River and increasing the biodiversity of the Kogarah foreshore.



SUTHERLAND SHIRE COUNCIL IMPROVING CARINA CREEK

In 2013-14 Sutherland Shire Council invested \$60,000 on works along Carina Creek between Wiak Rd and Carina Bay. This included noxious weed control, bush regeneration and 1,500 seedlings planted. Members of Optus Rockcorps also gave their time to improve riparian vegetation at Carina Bay Reserve. Volunteers and council staff planted 50 x 200mm trees and undertook weed removal in the bushland below Riverview Rd.

WOLLONDILLY SHIRE COUNCIL 1ST APPIN SCOUT GROUP

1st Appin scout group were successful in receiving a grant from Keep Australia Beautiful to implement a program to reduce the problem of litter and waste around Kennedy Creek. They partnered with Wollondilly Shire Council to;

- Setup a public recycling and waste disposal station and signage in the car park
- Install signage identifying the location of the public toilets.
- Engage Appin primary school in council's 'Adopt an Environment' program with a focus on waste reduction, recycling and composting.



CAMPBELLTOWN CITY COUNCIL DRAIN STENCIL PROGRAM

A community inspired drain stencilling program with local primary schools promotes environmental stewardship through catchment education workshops. Participating schools then apply their learned knowledge to design drain stencils that aim to change community behaviors to reduce pollutants entering our stormwater and their impacts on our waterways and catchments. The designs are used to produce stencils for stormwater drain lids with messages that promote awareness of the connectivity of the stormwater systems within the natural environment.



BANKSTOWN CITY COUNCIL LAKE GILLAWARNA

In 2013-14 Bankstown City Council completed a water quality and natural area improvement project at Lake Gillawarna, Georges Hall. The project involved planting 29,000 locally native plants in and around the lake; restoration and rehabilitation of habitat features on the main island within the lake; control of invasive weeds and feral aquatic species such as European Carp; and creating two visitor interaction areas.



The GRCCC represents member councils in the Georges River catchment of NSW including Bankstown, Campbelltown, Fairfield, Hurstville, Kogarah, Liverpool, Rockdale, Sutherland and Wollondilly.

The River Health Monitoring Program is being undertaken in association with Georges River Environmental Education Centre and the Cooks River Alliance. River Health is funded by the member councils of the GRCCC.

Acknowledgments: The River Health Monitoring Program was developed by C. Tippler, A. Hanlon and P. Birtles and is modeled on the following existing programs: 1. EHMP (2008). Ecosystem Health Monitoring Program 2006-07 Annual Technical Report. South East Queensland Healthy Waterways Partnership, Brisbane. Centre for Environmental Management, Central Queensland University. 2. IWC (2009). Cobaki and Terranora Ecosystem Health Monitoring Program. 2009 technical report. International Water Centre, Brisbane. 3. Story A.W, Anderson L.E, Lynas J & Melville F (2007). Port Curtis Ecosystem Health Report Card. Port Curtis Integrated Monitoring Project (PCIMP). Cover Photography by C. Ebejer. © 2013 - 2014 River Health Georges River Report Card.



Georges River, NSW
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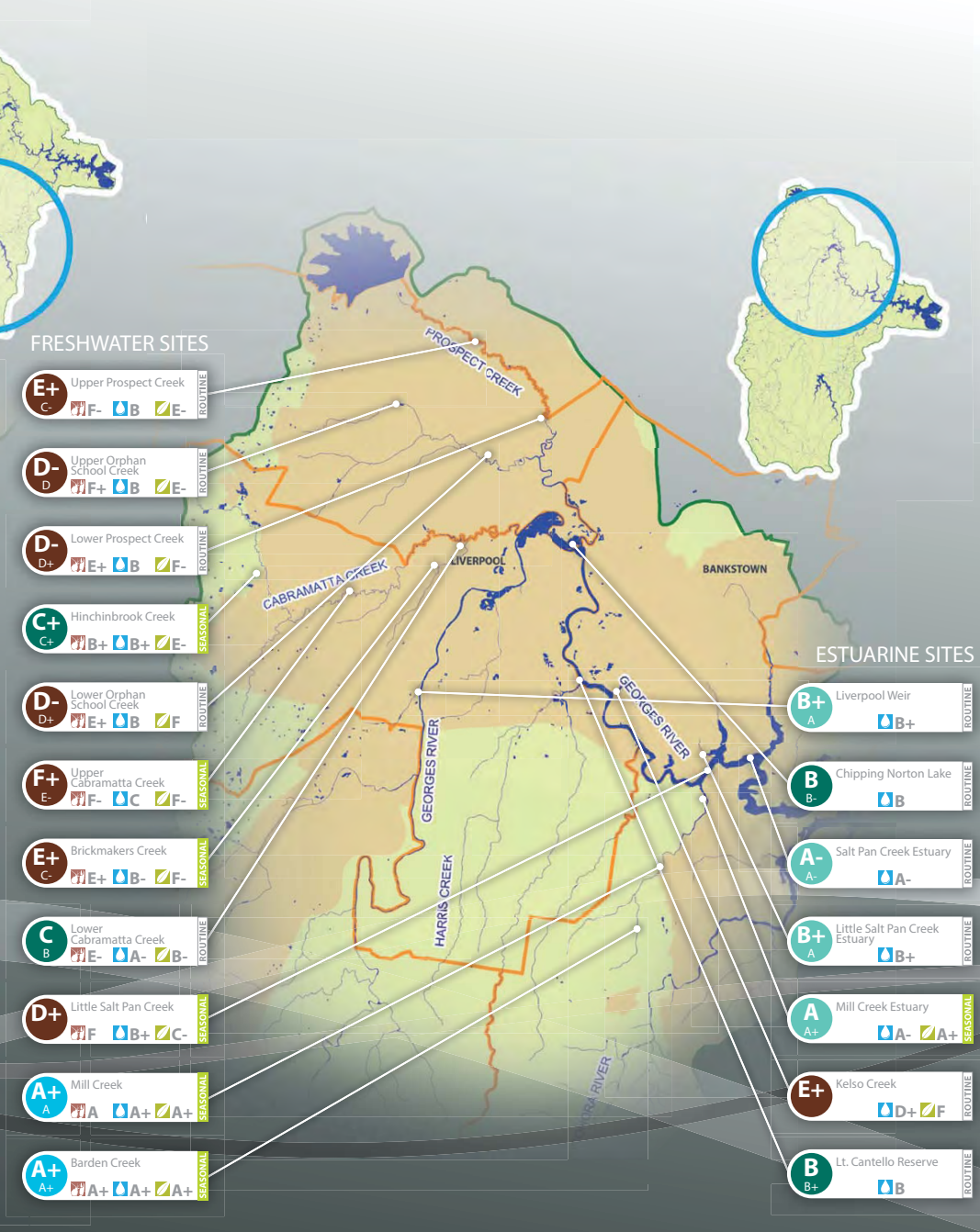
FRESHWATER SITES

- A-** Georges River at Cambridge Avenue
ROUTINE
- B-** Bunbury Curran Creek
SEASONAL
- A** Georges River at Simmo's Beach
ROUTINE
- A+** Georges River at Ingleburn Weir
SEASONAL
- A** O'Hares Creek at the Woolwash
SEASONAL
- A+** Georges River at the Woolwash
ROUTINE
- A+** Stokes Creek
SEASONAL
- A+** Cobbong Creek
SEASONAL
- B-** Georges River at Kennedy Grove
ROUTINE
- B** Georges River Downstream Brennans Creek
SEASONAL
- B** Brennans Creek
SEASONAL
- A+** Upper Georges River
ROUTINE
- A+** Illuka Creek
SEASONAL
- A+** Maddens Creek
ROUTINE



FRESHWATER SITES

- E+** Upper Prospect Creek
ROUTINE
- D-** Upper Orphan School Creek
ROUTINE
- D+** Lower Prospect Creek
ROUTINE
- C+** Hinchinbrook Creek
SEASONAL
- D+** Lower Orphan School Creek
ROUTINE
- F+** Upper Cabramatta Creek
SEASONAL
- E+** Brickmakers Creek
SEASONAL
- C** Lower Cabramatta Creek
ROUTINE
- D+** Little Salt Pan Creek
SEASONAL
- A+** Mill Creek
SEASONAL
- A+** Barden Creek
SEASONAL



ESTUARINE SITES

- B+** Liverpool Weir
ROUTINE
- B** Chipping Norton Lake
ROUTINE
- A-** Salt Pan Creek Estuary
ROUTINE
- B+** Little Salt Pan Creek Estuary
ROUTINE
- A** Mill Creek Estuary
SEASONAL
- E+** Kelso Creek
ROUTINE
- B** Lt. Cantello Reserve
ROUTINE

UPPER GEORGES RIVER | 14 FRESHWATER SITES

MID GEORGES RIVER | 11 FRESHWATER SITES 7 ESTUARINE SITES



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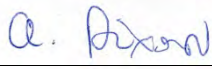
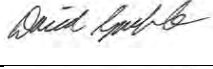

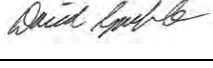
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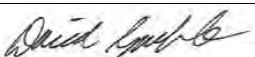
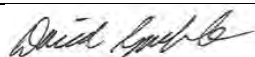
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