WestConnex

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Submissions and Preferred Infrastructure Report

Appendices

Volume 2

March 2016

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Volume 2

Appendices

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Environmental Impact Statement

Submission Author Reference Table

Appendix A

March 2016

WestConnex

Submission author identification numbers with reference to report sections

Issues raised in submissions from community groups, individual community members and other stakeholders have been grouped into common issues, which are described in this Appendix. Submission authors can locate the issues raised in their submission and the relevant section of the report where these have been addressed. Each submission author has been assigned a submission author identification number based on their submission form number assigned by DP&E on receipt of the submission. A submission author can access their submission form number by locating their submission on the DP&E website.

Community members whose submission author identification numbers are located in **Table 3-2** in **Chapter 3** (Submissions received) against a particular form letter number may use this form letter number to navigate this Appendix.

Where a submitter has provided additional comments within a form letter, those additional comments are represented by the submission author identification number (as opposed to the form letter number) and cross referenced against the relevant responses in this Appendix.

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No issues raised in community submissions were categorised under this category	0
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Submission author identification number	Number of submitters who raised this issue
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No issues raised in community submissions were categorised under this category	0

Submission author identification number	Number of submitters who raised this issue
Project development and alternatives	
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Section 5.4.12 Strategic alternatives - active transport instead of project	
11, 12, 20, 54, 89, 135, 139, 164, 166, 181, 241, 357, 384, 402, 471, 487, 691, 847, 877, 891, 1101, 1194, 1327, 1457, 1471, 1553, 1594, 1664, 1707, 1739, 1742, 1747, 1771, 1782, 1798, 1834, 1850, 1857, 1880, 1891, 1905, 1916, 1930, 1931, 1939, 1942, 1953, 1958, 2009, 2022, 2025, 2055, 2066, 2093, 2094, 2099, 2301, 3107, 5522, 5529, 5566, 5617, 5644, 5647, 5656, 5707, 5714, 5726, 5755, 5757, 5849, 5895, 6309, 6310, 6312, 6333, 6336, 6349, 6352, 6402, 6421, 8103, 8107, 8270, 8562, 8651, 8733, 9195, 9237, 9261, 9759, 12892; Form letter 1; Form letter 3; Form letter 8; Form letter 36; Form letter 50	722
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Section 5.4.14 Strategic alternatives – other	
12, 13, 19, 22, 25, 116, 119, 139, 141, 184, 187, 208, 215, 224, 231, 235, 250, 384, 428, 433, 436, 485, 487, 493, 499, 541, 545, 560, 648, 812, 899, 911, 966, 967, 973, 1208, 1221, 1264, 1332, 1352, 1448, 1451, 1471, 1535, 1546, 1549, 1562, 1579, 1621, 1651, 1663, 1664, 1681, 1684, 1711, 1728, 1736, 1745, 1753, 1757, 1759, 1793, 1800, 1812, 1834, 1840, 1854, 1867, 1877, 1880, 1889, 1891, 1892, 1904, 1906, 1917, 1927, 1936, 1938, 1957, 1960, 1964, 1994, 1996-1998, 2005, 2007, 2025, 2055, 2061, 2065, 2066, 2070, 2073, 2083, 2084, 2097, 2269, 2406, 3529, 5516, 5521, 5522, 5527, 5585, 5610, 5638, 5639, 5647, 5658, 5714, 5732, 5757, 5827, 5856, 5892, 5928, 6312, 6320, 6333, 6357, 6371, 6425, 8312, 8457, 8569, 8581, 8591, 8609, 8867, 8898, 8977, 9038, 9261, 9428, 9464, 9540, 9638, 9745, 9746, 10449, 12831, 12865; Form letter 4; Form letter 12; Form letter 15; Form letter 3; Form letter 6; Form letter 16; Form letter 8; Form letter 68; Form letter 19; Form letter 22; Form letter 23; Form letter 32; Form letter 34; Form letter 18; Form letter 36; Form letter 37; Form letter 24; Form letter 71; Form letter 43; Form letter 53; Form letter 61; Form letter 41; Form letter 42; Form letter 46; Form letter 51; Form letter 54; Form letter 58; Form letter 74; Form letter 76; Form letter 72; Form letter 69; Form letter 82; Form letter 56; Form letter 73; Form letter 87; Form letter 84; Form letter 75	3,323
Section 5.4.15 Future proofing - tunnels (stubs caverns, tunnel excavation width)	
No issues raised in community submissions were categorised under this category	0
Section 5.4.16 Future proofing – surface	
No issues raised in community submissions were categorised under this category	0
Section 5.4.17 Property acquisition alternatives	
1538, 1571, 1695	3
Section 5.4.18 St Peters interchange	
179, 1753, 1781	3
Section 5.4.19 Kingsgrove and Bexley surface works	
No issues raised in community submissions were categorised under this category	0
Section 5.4.20 Arncliffe surface works	
No issues raised in community submissions were categorised under this category	0

Submission author identification number	Number of submitters who raised this issue
Project operation	
Section 5.5.1 General project design	
2, 22, 384, 691, 915, 1471, 1477, 1561, 1939, 1957, 2058, 2084, 3107; Form letter 8	412
Section 5.5.2 Active transport	
211, 1432, 1752, 1755, 1779, 1894, 1936, 1938, 2001, 2011, 2035; Form letter 84	14
Section 5.5.3 Tunnels	
No issues raised in community submissions were categorised under this category	0
Section 5.5.4 Operational facilities	
No issues raised in community submissions were categorised under this category	0
Section 5.5.5 Ventilation facilities	
4, 302, 546, 604, 911, 1763, 1764, 1880, 1892	9
Section 5.5.6 Connectivity	
No issues raised in community submissions were categorised under this category	0
Section 5.5.7 Surface infrastructure at Kingsgrove	
9	1
Section 5.5.8 Surface infrastructure at Bexley	
No issues raised in community submissions were categorised under this category	0

Submission author identification number	Number of submitters who raised this issue
Project operation	
Section 5.5.9 Surface infrastructure at Arncliffe	
No issues raised in community submissions were categorised under this category	0
Section 5.5.10 Surface infrastructure at the St Peters interchange	
9	1
Section 5.5.11 Local road upgrades	
4, 14, 22, 32-35, 58, 176, 179, 198, 648, 691, 725, 847, 850, 911, 933, 1243, 1511, 1561, 1645, 1773, 1802, 1828, 1858, 1880, 1921, 1939, 2009, 2038, 2068, 2073, 2084, 7963, 8179, 8609, 8867, 8882, 9038, 9102, 9208, 9487, 9638, 9731, 9745, 12866, 12892, 12896; Form letter 18; Form letter 26; Form letter 37; Form letter 71; Form letter 41; Form letter 42; Form letter 60; Form letter 45; Form letter 63; Form letter 89; Form letter 72; Form letter 85	1,028
Section 5.5.12 Wayfinding	
No issues raised in community submissions were categorised under this category	0
Section 5.5.13 Landfill	
No issues raised in community submissions were categorised under this category	0

Submission author identification number	Number of submitters who raised this issue
Construction work	
Section 5.6.1 Construction program and staging	
237, 1723	2
Section 5.6.2 Construction methods	
648, 817, 850, 1012, 1579, 1645, 1843; Form letter 17; Form letter 18; Form letter 26; Form letter 27; Form letter 29; Form letter 31; Form letter 37; Form letter 42; Form letter 60; Form letter 73; Form letter 65; Form letter 75	764
Section 5.6.3 Location and layout of ancillary facilities	
882, 1643, 1720, 1770, 1800, 1892, 2058, 2061, 2073, 2103, 8561, 8575	12
Section 5.6.4 Hours of work	
384, 636, 850, 1548, 1711, 1800, 1828, 1840, 1880, 1939, 2083, 8867, 12892; Form letter 14; Form letter 13; Form letter 15; Form letter 38; Form letter 49; Form letter 45; Form letter 51; Form letter 54; Form letter 76; Form letter 72; Form letter 87; Form letter 85; Form letter 83	984
Section 5.6.5 Landfill closure during construction	
No issues raised in community submissions were categorised under this category	0
Section 5.6.6 Utilities	
No issues raised in community submissions were categorised under this category	0
Section 5.6.7 Safety	
210, 1746, 1949	3

Submission author identification number	Number of submitters who raised this issue
Consultation	
Section 5.7.1 Level and quality of consultation	
22, 39, 119, 156, 250, 312, 357, 384, 411, 428, 431-433, 492, 504, 506, 507, 546, 604, 636, 638, 648, 690, 691, 725, 746, 768, 806, 817, 820, 850, 859, 927, 940, 1012, 1037, 1045, 1064, 1264, 1279, 1352, 1403, 1432, 1451, 1499, 1535, 1545, 1560, 1561, 1566, 1579, 1619, 1656, 1659, 1703, 1723, 1749, 1751, 1754, 1757, 1759, 1765, 1779, 1788, 1793, 1800, 1804, 1811, 1813, 1820, 1821, 1840, 1843, 1858, 1873, 1880, 1890, 1892, 1904, 1910, 1916, 1919, 1927, 1936, 1938, 1939, 1957, 1959, 1963, 1964, 1996-1998, 2009, 2038, 2055, 2061, 2064, 2070, 2083, 2084, 2097, 2102, 2189, 2232, 2258, 2259, 2261, 2477, 2572, 2725, 3107, 3551, 4701, 5516, 5536, 5538, 5556, 5573, 5600, 5624, 5627, 5655, 5663, 5669, 5688, 5829, 5921, 6342, 8108, 8278, 8304, 8390, 8567, 8594, 8609, 8724, 8733, 8867, 8882, 8985, 9001, 9038, 9142, 9147, 9183, 9186, 9208, 9212, 9347, 9402, 9428, 9466, 9476, 9520, 9528, 9610, 9633, 9638, 9731, 9745, 9746, 9811, 11964, 12831, 12894; Form letter 14; Form letter 4; Form letter 13; Form letter 15; Form letter 17; Form letter 11; Form letter 16; Form letter 18; Form letter 21; Form letter 23; Form letter 26; Form letter 27; Form letter 29; Form letter 30; Form letter 31; Form letter 32; Form letter 34; Form letter 35; Form letter 38; Form letter 10; Form letter 71; Form letter 43; Form letter 61; Form letter 39; Form letter 41; Form letter 42; Form letter 46; Form letter 47; Form letter 48; Form letter 50; Form letter 49; Form letter 60; Form letter 51; Form letter 52; Form letter 58; Form letter 62; Form letter 74; Form letter 88; Form letter 76; Form letter 89; Form letter 72; Form letter 78; Form letter 69; Form letter 82; Form letter 80; Form letter 81; Form letter 55; Form letter 56; Form letter 57; Form letter 73; Form letter 75; Form letter 65; Form letter 70; Form letter 67; Form letter 87; Form letter 84; Form letter 68; Form letter 77; Form letter 79; Form letter 83	4,514
Section 5.7.2 Consultation during exhibition	
No issues raised in community submissions were categorised under this category	0
Section 5.7.3 Future consultation	
210, 1571, 1578, 1703, 1746, 1770, 1843, 1890, 9183, 12865, 12896	11
Section 5.7.4 Endorsement of other submissions	
22, 1804, 1927, 2066, 8103, 9610, 9849	7
Section 5.7.5 Access to documents	
200, 384, 1765, 1821, 1843, 1927, 1996-1998, 2008, 2009, 2084, 2097, 2412, 5516, 9103, 12831	17

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Traffic	
Section 5.8.1 Level and quality of traffic assessment for the construction period	
850, 911, 1728, 1939, 1996-1998, 2009, 2097, 2102, 12831, 12865; Form letter 64; Form letter 66	105
Section 5.8.2 Construction traffic numbers and routes	
198, 648, 1221, 1385, 1560, 1561, 1576, 1643, 1880, 1996-1998, 2061, 2065, 2097, 2102, 8561, 12831, 12865; Form letter 38; Form letter 47; Form letter 63; Form letter 85	330
Section 5.8.3 Impact on network performance due to construction	
485, 545, 1012, 1038, 1656, 1770, 1788, 1880, 1939, 1996-1998, 2038, 2097, 2102, 5582, 5670, 5800, 5924, 5930, 9428, 9466, 9476, 12831, 12865; Form letter 15; Form letter 23; Form letter 30; Form letter 69; Form letter 80; Form letter 81; Form letter 57; Form letter 70; Form letter 90; Form letter 87	857
Section 5.8.4 Impact on public transport and emergency services during construction	
No issues raised in community submissions were categorised under this category	0
Section 5.8.5 Impacts on pedestrians and cyclists during construction	
806, 1835, 1843, 1936, 1949, 1996-1998, 2061, 2097, 2102, 5910, 8567, 12831	14
Section 5.8.6 Traffic safety during construction	
1539, 1576, 2061, 12865	4
Section 5.8.7 Impacts on local roads (eg closures) during construction	
250, 648, 1227, 1548, 1561, 1746, 1763, 1764, 1770, 1774, 1779, 1880, 1890, 1936, 1996-1998, 2038, 2061, 2064, 2070, 2084, 2097, 2102, 9158, 12831; Form letter 18; Form letter 26; Form letter 35; Form letter 37; Form letter 42; Form letter 60; Form letter 51; Form letter 74	589
Section 5.8.8 Cumulative impacts of traffic during construction	
428, 850, 1545, 1552, 1728, 1880, 1996-1998, 2009, 2065, 2073, 2097, 2102, 5960, 9812, 12831; Form letter 66	65

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Traffic	
Section 5.8.9 Level and quality of operational traffic assessment	
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Submission author identification number	Number of submitters who raised this issue
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Human Health	
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Section 5.12.3 Impacts to utilities and roads	
No issues raised in community submissions were categorised under this category	0
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Social and economic	
Section 5.14.8 Construction impacts on facilities	
No issues raised in community submissions were categorised under this category	0
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No issues raised in community submissions were categorised under this category	0
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No issues raised in community submissions were categorised under this category	0
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No issues raised in community submissions were categorised under this category	0

Submission author identification number	Number of submitters who raised this issue
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No issues raised in community submissions were categorised under this category	0
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No issues raised in community submissions were categorised under this category	0
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No issues raised in community submissions were categorised under this category	0

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No issues raised in community submissions were categorised under this category	0
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No issues raised in community submissions were categorised under this category	0

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No issues raised in community submissions were categorised under this category	0

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New M5

Environmental Impact Statement

Green and Golden Bell Frog Habitat Creation and Captive Breeding Plan

Appendix B

March 2016

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DOCUMENT TRACKING

Item	Detail
Project Name	Habitat Creation and Captive Breeding Plan – Green and Golden Bell Frog at Arncliffe
Project Number	15WOL-3386
Project Manager	Meredith Henderson 02 4201 2200 Suite 204, Level 2, 62 Moore St, Austinmer NSW 2515
Prepared by	Meredith Henderson and Dr Arthur White
Reviewed by	Mark Adams
Approved by	Mark Adams
Status	FINAL
Version Number	2
Last saved on	2 March 2016
Cover photo	*Litoria aurea* (Green and Golden Bell Frog) hiding among reeds (Eco Logical Australia)

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Abbreviations

Abbreviation	Description
Bd	*Batrachochytrium dendrobatidis*
EIS	Environmental Impact Statement
ELA	Eco Logical Australia Pty Ltd
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
HCCB	Habitat Creation and Captive Breeding Plan
ppt	Parts per trillion
Roads and Maritime	NSW Roads and Maritime Services
RTA	Roads and Traffic Authority
SMC	Sydney Motorway Corporation
TSC Act	*Threatened Species Conservation Act 1995*
UoN	The University of Newcastle
WCX M5 AT	WestConnex M5 Asset Trust

Executive summary

The proposed construction of the New M5 is likely to result in impacts on the Arncliffe population of the Green and Golden Bell Frog. The EIS for the project included provisions for the management of these impacts which included the creation of additional habitat and as an insurance against the possible loss of the population from the site, the establishment of a captively bred population with the intention to release the captively bred stock. These actions would provide for greater security of the species in the Arncliffe area.

This plan should be read in conjunction with the overarching strategic Green and Golden Bell Frog Plan of Management (ELA 2016), which was included in the New M5 Environmental Impact Statement as Appendix S to the Biodiversity Assessment Report.

The population has been monitored since 1999/2000. Data on the population estimates between 2002/03 and 2014/15 were presented in the EIS. Since then further survey has been undertaken and information about the 2015/16 monitoring period is provided here. Together this data indicates that the population was relatively stable between 2003/04 and 2013/14. During the last two survey seasons, the population has declined. This population requires intense management to prevent further decline.

This plan outlines the actions required to establish new habitat and the management of that habitat to assist in the management of the frog population. Information about the management of the existing RTA frog ponds including the management of impacts arising from the construction of the New M5 can be found in the Green and Golden Bell Frog Management (ELA 2016).

This plan also outlines the requirements for the establishment of a captive breeding program for the Arncliffe population. Previous plans, such as the Management Plan for the Green and Golden Bell Frog Key Population on the lower Cooks River (DECC 2008a), advocated the establishment of a captive breeding colony to act as an insurance against stochastic events. This Habitat Creation and Captive Breeding Plan provides details on the process involved in establishing a captive breeding colony, key performance indicators and reporting requirements.

A draft of the Habitat Creation and Captive Breeding Plan was peer reviewed by two external peer reviewers.

1 Introduction

Roads and Maritime Services (Roads and Maritime) is seeking approval to construct and operate the New M5, which would comprise a new, tolled multi-lane road link between the existing M5 East Motorway, east of King Georges Road, and St Peters. The project would also include an interchange at St Peters and connections to the existing road network. The project was declared to be State Significant Infrastructure (SSI) and approval is being sought under Part 5.1 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). In addition to State approval, the project is a controlled action under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Construction activities associated with the project are expected to result in direct impacts to foraging habitat and indirect impacts to the habitat of *Litoria aurea* (Green and Golden Bell Frog) at Arncliffe. The impacts to the breeding ponds relate to indirect impacts from construction approximately 32 metres from the ponds. Direct impacts involve removal of around 7.82 hectares of foraging, sheltering and dispersal habitat on the golf course. In addition, permanent road facilities are proposed on land owned by Roads and Maritime, adjacent to the existing purpose built breeding ponds

1.1 Purpose of Plan

The proposed works for the construction of the New M5 would result in some impacts to the habitat of the Green and Golden Bell Frog at Arncliffe. The EIS included provisions for the management of these impacts which included the creation of additional habitat and the establishment of a captively bred population. These actions would provide for greater security of this species in the Arncliffe area. This plan outlines the actions required to ensure that habitat created is suitable and that the captive breeding program meets the required standards.

This document provides the basis for an adaptive management approach to the management of captive breeding and habitat creation program. Over time, more data will become available on how the population is responding to the potential construction and operation impacts of the New M5 and will be included in any subsequent versions of this plan.

This plan is informed by various management plans developed for the species and the site (**Figure 1**).

1.2 Structure of plan

This plan should be read in conjunction with the Green and Golden Bell Frog Plan of Management - Arncliffe (ELA 2016), which describes likely impacts, construction mitigation measures and actions to improve the habitat values of the RTA breeding ponds on the Kogarah Golf Course. The Plan of management is included in the New M5 Environmental Impact Statement as Appendix S to the Biodiversity Assessment Report. This plan is divided into two main sections to address the creation of new habitat and, the establishment of a captive breeding colony.

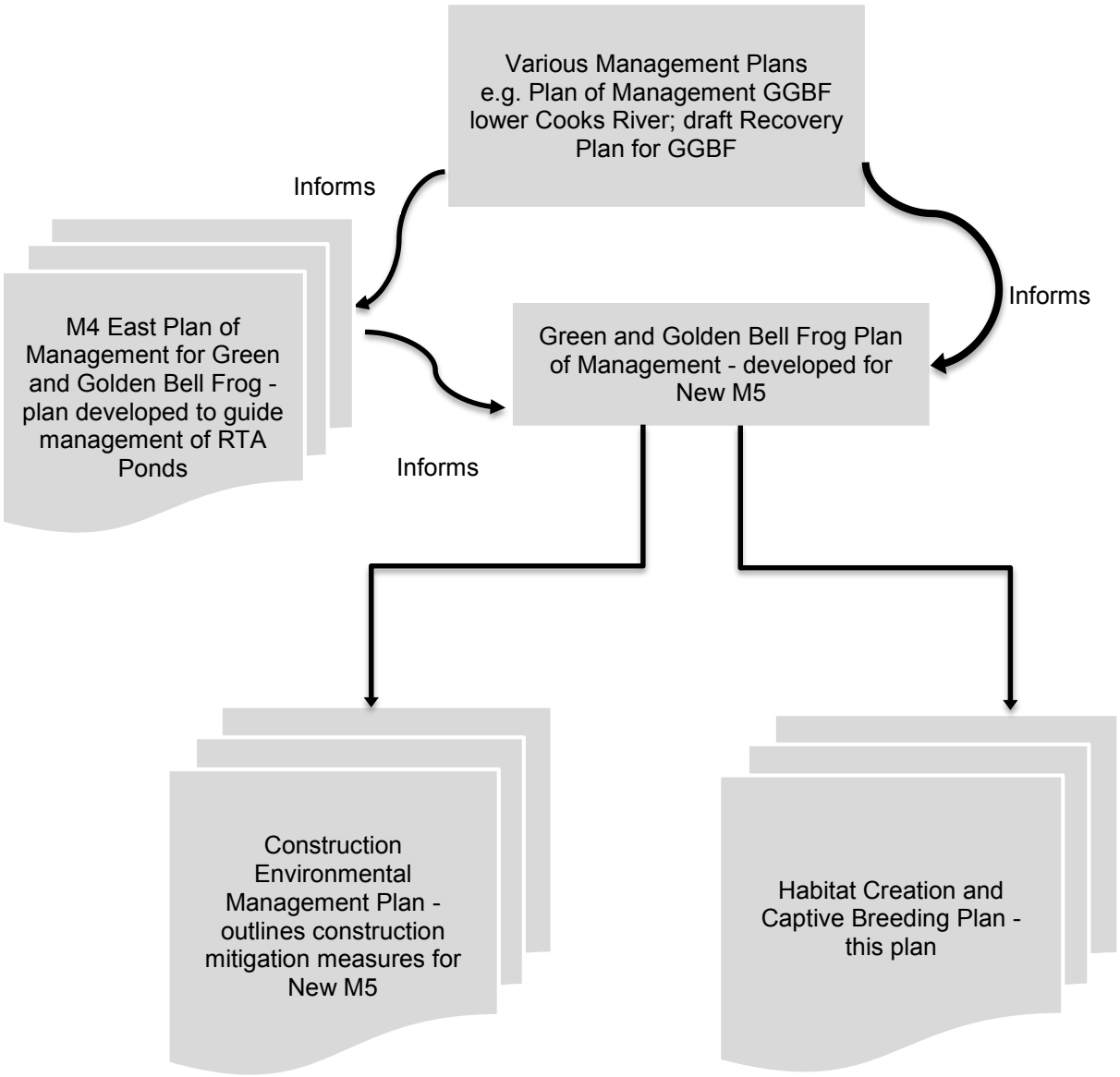

Figure 1: Relationship of this plan to other management plans

2 Habitat Creation Plan

2.1 Site description

The proposed new Marsh Street ponds are to be located on a parcel of land to the east of the Marsh Street and West Botany Street intersection (the site) (**Figure 2**). The site is owned by NSW Roads and Maritime Services (Roads and Maritime).

2.2 Objectives

Green and Golden Bell Frog need various habitats for different aspects of their life cycle including foraging, breeding, sheltering, over-wintering and dispersal. They will also use different habitats or habitat components on a temporal or seasonal basis. The objectives of the habitat creation plan are to provide with a high level of certainty that habitat created at Marsh Street provides greater security of the Green and Golden Bell Frog at Arncliffe by:

- providing enough detail to allow construction of new habitat at Marsh Street
- outlining the management actions that should take place in the new habitat
- outline key performance indicators for the management of the ponds.

2.3 Overall design

The design of the Marsh Street habitat area and ponds consists of:

- three Green and Golden Bell Frog breeding ponds, located along the western boundary of the site consisting of:
  - one pond of around 1.5 metres in depth; and
  - two ponds of around 0.8 metres in depth.
- water supply systems, including a header tank (with capacity of around 200 kilolitres), pipes and a drainage swale to fill and drain the ponds
- a serviced work shed, around 10 square metres, to support maintenance and monitoring activities, and to store equipment
- perimeter fencing, designed to enable frog passage along the eastern and northern perimeter of the site and to limit predators and un-authorised access
- permanent vehicle access off Eve Street.

A concept design and detailed construction activities for the Marsh Street ponds is provided in the preferred infrastructure report, which is provided as Section 7 of this Submissions report.

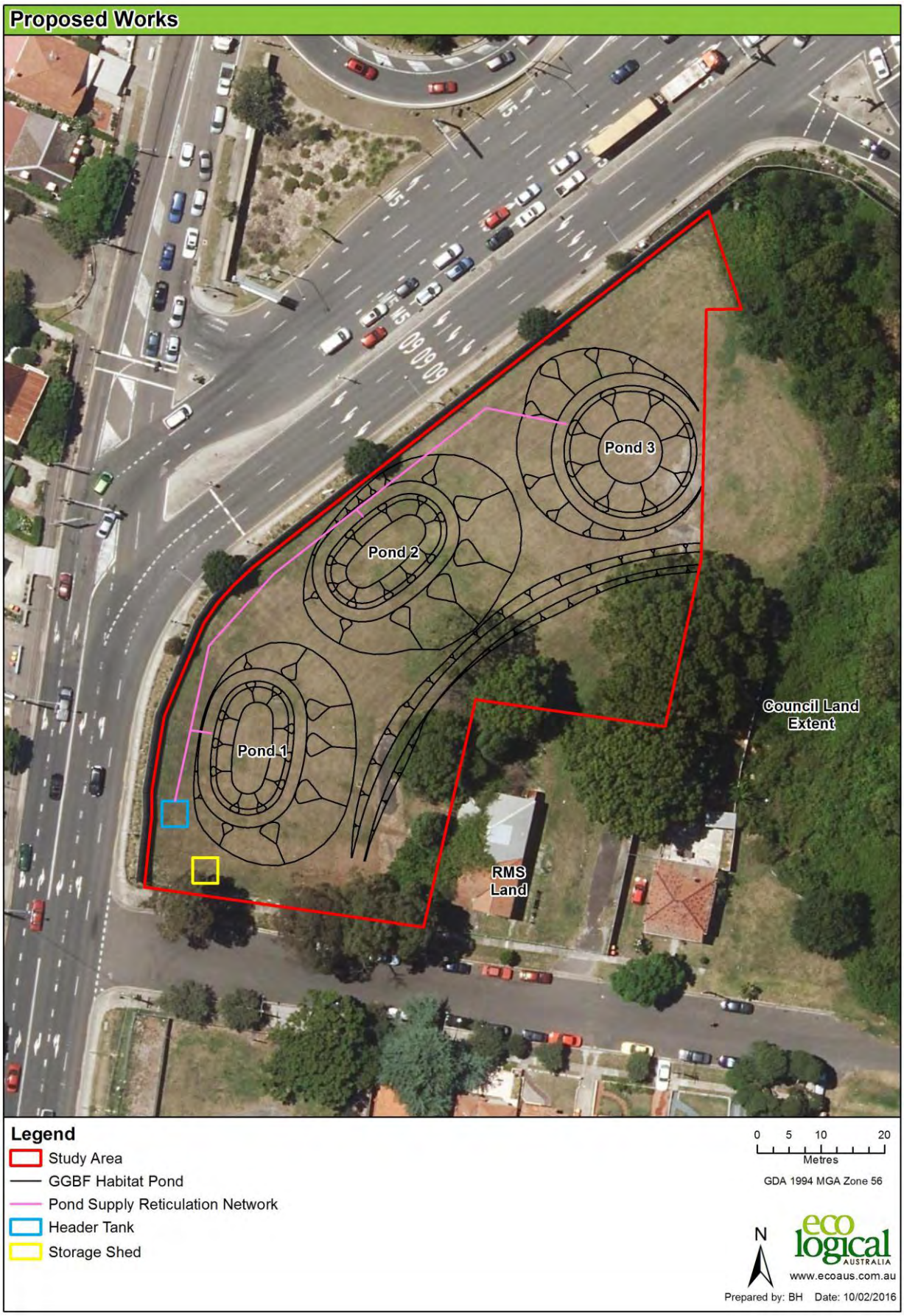

Figure 2: Proposed design for Marsh Street habitat area

2.4 Site preparation

The development of the site would involve several key steps. While this document does not provide detailed design specifications, it outlines the requirements to establish habitat at Marsh Street.

2.4.1 Establish perimeter fencing

Fencing of site would need to be done to minimise predation by foxes. Foxes have been sighted at the RTA ponds and may be responsible for a decline in the number of frogs present as a result of predation. By establishing a fence, occurrence of predators can be monitored, response to incursions conducted and the fence maintained.

Boundary fencing to be 1.8 metres high urban controlled access road boundary fencing (Roads and Maritime Model Drawing MD.R201.B02.A) with modifications for frog-exclusion. Part of the perimeter fencing where it adjoins Eve Street, Marsh Street and West Botany Street should be frog proof and constructed with design features adequate to prevent frog movement. This is to prevent frogs from moving into hostile environments. The fence barrier is to be constructed from shade cloth or similar material. It is to be supported by wire to maintain a vertical surface at least 80 centimetres above ground level. At least 15 centimetres of the bottom edge is to be buried into the soil. A horizontal top section, 20 centimetres wide, is to be included on both sides (also wire supported). A solid plastic layer at the base must also be added to at least 0.5 metres high to prevent rats from chewing through the shade cloth.

2.4.2 Removal of unwanted vegetation

The assessment of the site as part of the preferred infrastructure report identified there were some exotic and non-indigenous native trees present. The remainder of the site was exotic grassland. The trees would need to be removed for construction and also to minimise shading of the ponds. When ponds are shaded for long periods, frogs tend to not favour these areas. The vegetation removed should be disposed of appropriately. If there are some plants (non-toxic) that could be used to create over wintering habitat, they should be piled neatly for use later in the program.

2.4.3 Earthworks to reform the land contours

There would be three ponds constructed, as well as a swale to allow for shelter and dispersal. The site is generally flat towards West Botany Street, but gently slopes away towards the M5 East Motorway. A correction in this land form would be required to enable the creation of the ponds and the swale.

The three ponds should not be at the same level. The ponds need to be stepped in height, with pond one the highest and pond three the lowest. Reformation of the land would need to be done to allow for this design.

The three ponds would be of the following dimensions:

- ponds one and two around 20 metres at the longest axes and about 0.8 metres in depth, with the lowest points around five metres in length (**Figure 3**)
- pond three around 25 metres at the longest axis and about 1.5 metres in depth, with the lowest point around 10 metres in length (**Figure 4**).

The sides of ponds one and two would slope up to the ground level.

Pond three would contain submerged steps on the pond sides to allow for potted aquatic plants to be put in place. Pond three would be roughly circular. The pond profile will be stepped - the steps (or ledges) will be formed of rock or gabion and these ledges will support the pots that will contain the emergent plants. There will be no raised bund or lip around the pond.

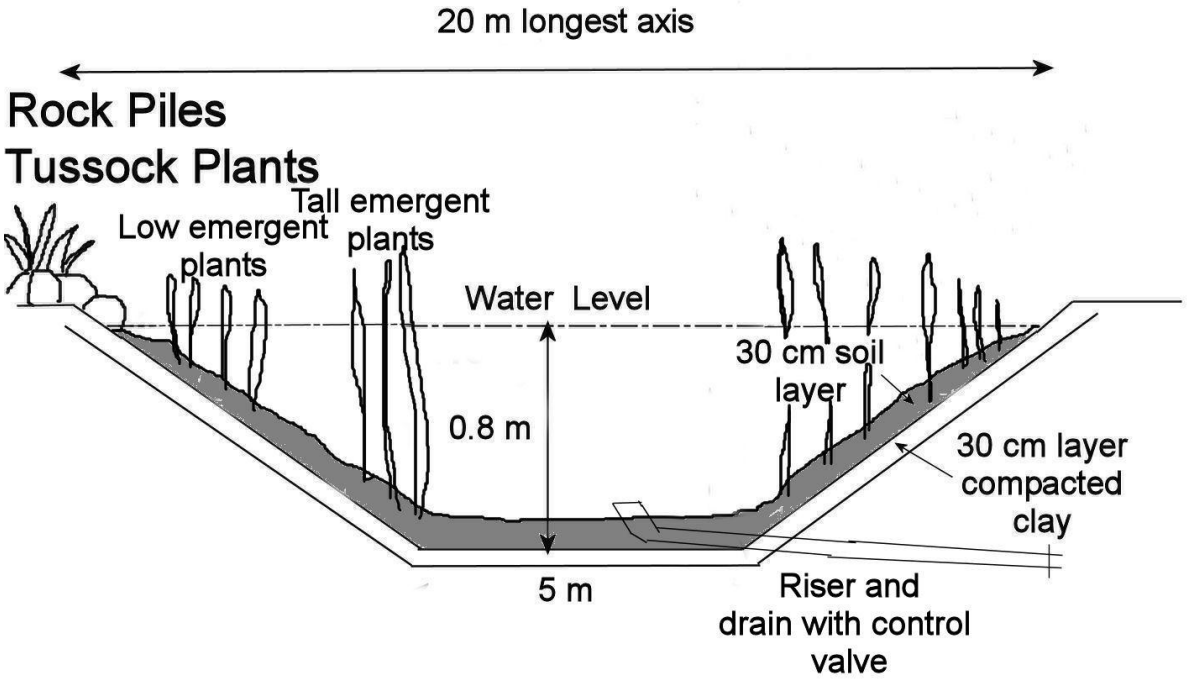

Figure 3: Concept design for ponds one and two

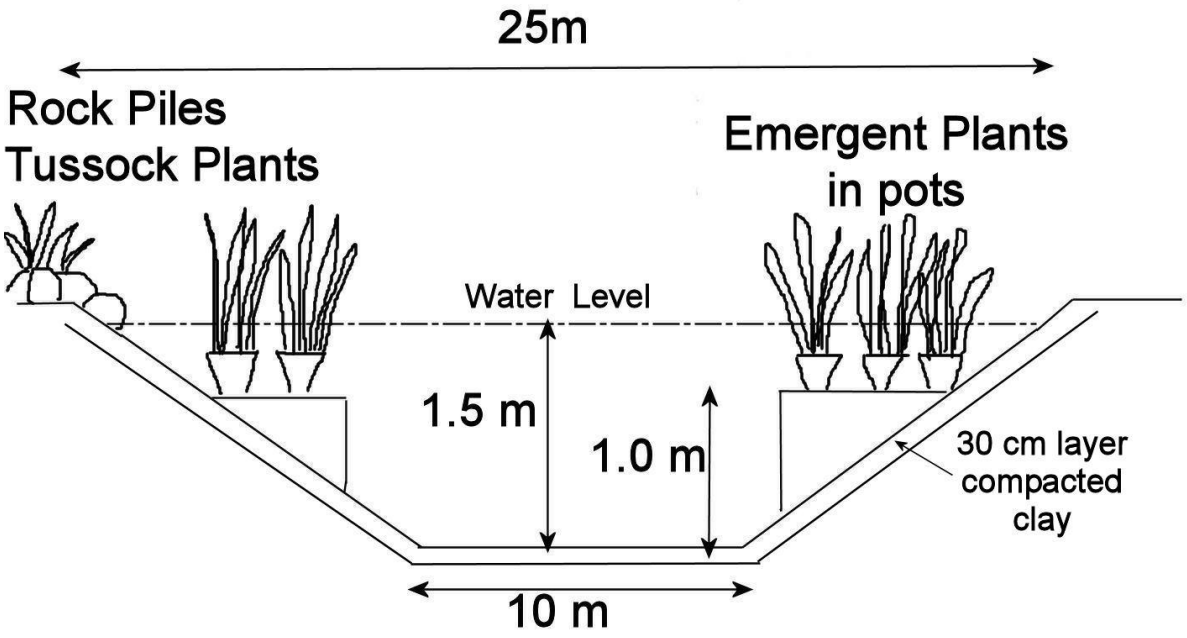

Figure 4: Concept design for pond three

A rock platform with fixing for small outboard motor is to be provided in each pond, extending into open water for pond mixing.

2.4.4 Creation of swale

To the south and east of the three frog ponds, a drainage and habitat swale would be created. This swale would be capable of receiving water from two of the three ponds via a piped drainage outlet. The swale would need to be of a suitable size to allow for ponds to be periodically drained, while being able to withstand any erosion. This swale would be planted with species suitable for shelter and foraging habitat (**Table 2**).

2.4.5 Water supply

The relatively small size of the site and the dominance of the site by frog habitat means that an onsite detention basin cannot be incorporated into the current design.

A new potable water supply would therefore need to be established. The reference design indicates that this would be from Eve Street, close to the West Botany Street intersection. A header tank of 200 kilolitres would be required to allow pressure to fill the three ponds. Water needs to be aged in the storage tank so that chlorine can be lost from the water prior to use in ponds. Chlorine is toxic to Green and Golden Bell frog tadpoles.

The water supply should also provide for reticulated water supply to fill ponds as well as drainage pipes so that ponds can be emptied if and when required. Pond three will need to have its own water supply but no drain (because the pond will be set so low into the ground it cannot be gravity drained). Any drainage works required for this pond (e.g. should it become contaminated with fish or unwanted pollutants) will need to be carried out by an external pump.

2.4.6 Creation of terrestrial refugia

Terrestrial refugia would be established in close proximity to the ponds. Green and Golden Bell frogs are found in a considerable variety of wetlands (see DECC 2008b, Pyke et al. 2002, Heard et al. 2006, Heard et al. 2012, Mahony et al. 2013), and the ideal or preferred habitat is a matter of some contention.

Therefore the structural components of the proposed ponds are designed to include features that are common to many wetlands where bell frogs occur. The two nearby created RTA ponds have supported a Green and Golden Bell Frog population for over a decade. Therefore the structure of the ponds are based around the design of these ponds.

2.4.7 Line ponds

The three ponds would be lined with compacted clay to a depth of about 0.3 metres. The compacted clay provides a relatively waterproof barrier to eliminate or minimise leaks from the ponds. Following the clay lining, an additional layer of topsoil to a depth of 0.3 metres would be placed in ponds one and two. This topsoil would provide a substrate for planting aquatic vegetation.

2.4.8 Provide storage shed

A small storage shed with water, power and sewer connections would be constructed with vehicle access off Eve Street. This would allow for safe storage of maintenance gear.

2.4.9 Planting ponds

Emergent aquatic plants should be planted into ponds one and two directly into the topsoil layer lining the sides of the ponds. Plants should be planted into pots and placed on the submerged steps for pond three.

The plants should follow those recommended in the best practice guidelines for Green and Golden Bell Frog habitat (DECC 2008c). Aquatic plants suggested in the guideline includes species listed below (**Table 1**).

Table 1: List of recommended aquatic plants

Species	Local	Species	Local
Alisma plantago aquatica	✓	*Isolepis nodosa*	✓
Amphibromus neesii	×	*Juncus kraussii* subsp. *australiensis*	✓
Baumea articulata	✓	*Juncus usitatus*	✓
Baumea rubiginosa	✓	*Lepironia articulata*	✓
Bolboschoenus caldwellii	✓	*Philydrum lanuginosum*	✓
Bolboschoenus fluviatilis	✓	*Phragmites australis*	✓
Carex appressa	✓	*Baloskion tetraphyllum* subsp. *meiostachyum*	✓
Carex fascicularis	✓	*Schoenoplectus mucronatus*	✓
Cotula coronopifolia	✓	*Schoenoplectus validus*	✓
Crinum pedunculatum	✓	*Suaeda australis*	✓
Eleocharis acuta	✓	*Triglochin procerum*	✓
Eleocharis sphacelata	✓	*Triglochin striata*	✓
Gahnia sieberiana	✓		

While the plants listed above are recommended, the likely plants to be used at this site include *Baumea rubiginosa*, *Bolboschoenus caldwellii*, *Eleocharis sphacelata*, *Philydrum lanuginosum*, *Schoenoplectus validus* and *Triglochin procerum*. These plants are generally available in the quantities likely to be required. The planting should be diverse and not a monoculture of one species. Optimal planting densities are not known and not specified in any of the guideline documents (DECC 2008a, 2008c).

2.4.10 Planting pond banks

The edge of the ponds and pond banks would need to be vegetated. Plants should be locally indigenous and suited to the creation of sheltering and foraging habitat for the frogs. Species have been suggested in the best practice guideline (DECC 2008c). The species include those listed below (**Table 2**).

Table 2: Tussock plants to be used around pond banks

Species	Species
Bothriochloa macra	*Microlaena stipoides*
Chloris truncata	*Paspalum distichum*
Dianella caerulea	*Pennisetum alopecuroides*
Dianella revoluta	*Poa labillardieri*
Eragrostis elongata	*Poa sieberiana*
Imperata cylindrica	*Rytidosperma caespitosum*
Lomandra longifolia	*Themeda triandra*

Local seed should be sought and horticultural varieties avoided. Some local councils may have native plant nurseries from which plants could be sourced. Alternatively, a specialist native plant nursery should be engaged to provide the appropriate number of plants. Plant species and planting densities will be determined by the selected bush regenerator/landscaper, in consultation with, the supervising site ecologist and site construction manager.

All landscaping materials are to be certified as disease-free, particularly in regard to the frog chytrid fungus.

To facilitate the establishment of plants and to increase planting success, the following techniques and guidelines are preferred methods:

- planting can occur at any time of year, although optimal times are early spring and early autumn
- planting should commence as soon as practicable after completion of the ponds
- when first planted, plants should be drench watered rather than lightly watered to encourage a deep root system
- if very dry conditions are experienced immediately after planting, then the watering of recently planted seedlings should be undertaken every week up until six weeks post planting
- *Jutemate*© and "tree" guards should be considered for use around plantings if they are likely to improve plant growth, minimise mortality and inhibit weeds
- plantings will require regular maintenance such as watering, protection from damage and replacement of dead seedlings.

The planting of weed species listed on the Weeds Australia NSW weeds list (www.weeds.org.au) is prohibited for the life of the project.

No exotic perennial grasses listed on the Final Determination of the NSW Scientific Committee for the key threatening process *Invasion of native plant communities by exotic perennial grasses,* are allowed to be introduced, planted, sown or laid on the site.

2.4.11 Planting around ponds

Planting between the ponds would include similar measures to the planting of the banks. These plantings would provide for dispersal, shelter and foraging habitat. Suitable ground cover plantings will be provided using native species such as those listed in **Section 2.4.10**. Tussock vegetation should be prolifically planted along boundaries to the site and in the areas between ponds and along overflow channels. While best practice guidelines nominate appropriate plant species (DEC 2008c), no density information is available. The plantings will be diverse.

All measures listed in **Section 2.4.10** will be used to maximise success of planting as well as minimising weeds.

2.4.12 Establish supplementary feeder sites

Supplementary feeding sites should be considered early in the creation of this habitat. This is because the diversity of grasses is low and subsequently the diversity of invertebrates is also likely to be low. Although relatively little has been published about the dietary preferences of this species, apparently prey items include a variety of insects as well as other frogs. The establishment of composting bins will encourage proliferation of insects. These prey items would colonise across the site encouraging frogs to disperse through the site. At least one bin per pond will be established.

2.4.13 Test ponds

Ponds should be tested for leakages and repaired to ensure levels are able to be maintained. Prior to introduction of any Green and Golden Bell Frogs, the following parameters should be tested:

- water temperature
- turbidity
- dissolved oxygen
- salinity not greater than 5 parts per trillion (ppt)
- pH
- that ponds are predator free (i.e. absence of *Gambusia holbrooki* (Plague Minnow)).

2.5 Habitat features

2.5.1 Breeding

Ponds one and two are designed to provide for suitable breeding habitat. These ponds will be shallow enough to receive adequate solar radiation and thus warming of the water which is assumed to encourage breeding. Emergent vegetation in ponds would need to be managed to limit shading (see **section 2.6.1** for a description of the management requirements).

The size of the ponds would be much greater than 40 m^2, which have been shown to be preferred by male calling bell frogs (Bower et al. 2013) and may improve breeding success. The ability to seasonally dry and flood the ponds is another important feature of this habitat as this mimics seasonal variations in natural wetlands and may also be preferred by bell frogs (Bower et al. 2013).

2.5.2 Feeding

The planted out banks and spaces in between the ponds would provide feeding habitat suitable for the frogs. In addition to these planted areas, the supplementary feeder sites would also provide prey items. Maintenance of high quality feeding habitat would be important to encourage population increases for this species.

2.5.3 Sheltering

The pond banks, aquatic vegetation, boulder field, swale and tussocky areas in between the ponds would provide sheltering habitat for adults. Rock piles and some of the emergent vegetation would also provide for basking habitat for the adult frogs. While aquatic vegetation would provide sheltering habitat for tadpoles.

2.5.4 Dispersal

One of the challenges for this site would be to provide dispersal habitat that could eventually encourage movement between the RTA ponds and this site. The current design does not achieve this but could be considered in the future. There are records of frogs from the spoon drain that run along Eve Street, but it is not known what the likelihood would be of frogs using this area currently. There are few refugia along this route to the RTA ponds and dispersing frogs would be exposed to predation and potentially vehicle strike.

The underpass that was constructed between the RTA ponds and the Marsh Street wetlands is not used by the Green and Golden Bell Frog (DECC 2008a). Based on a large survey and sampling at the site, there is no evidence or observations of Green and Golden Bell Frogs using this underpass. The reasons for this are not known as this species is known to be able to disperse distances longer than the underpass length (Hamer et al. 2008, Wassens et al. 2008) and have been reported to use culverts.

2.5.5 Overwintering

Translocations of Green and Golden Bell Frogs to other areas in Sydney have failed because of the lack of suitable over-winter habitat (White and Pyke 2015). While the provision of boulder fields in the RTA ponds could be considered as over wintering habitat, no frogs have been found using these fields for this purpose.

A recent study into the types of over wintering habitat that may be used found that vegetated mounds may provide this habitat type (White and Pyke 2015). The study, which was conducted at Arncliffe and Woonona, found that frogs used both covered and uncovered vegetation mounds, however only one frog was ever encountered in a torpid state, while the remaining frogs using the mounds were still active.

While the relationship between the different designs tested is not well understood, the provision of this habitat type is considered to be vital to ensure frogs are able to seek refuge during the colder months. In addition to the habitat provision, control of predators such as rats must also be undertaken. This is because rats are known predators of bell frogs and may gravitate towards this habitat feature in search of prey.

From the scant evidence available, the type and use of overwinter habitat remains poorly known and therefore no single design is preferred. A range of options must therefore be provided and the use of each option evaluated independently.

2.6 Management of habitat features

2.6.1 Breeding

The site will be intensively managed and monitored in perpetuity. Ponds will be drained or flooded as required to replicate wetting and drying cycles in natural wetlands. This is thought to encourage Green and Golden Bell Frog colonisation into the ponds. Draining of the ponds is also observed at the RTA ponds to be an effective method to manage Plague Minnow which predate tadpoles. Ponds one and two would be periodically drained and flooded as part of the management of these ponds in response to observations of Plague Minnow. While there is not enough space or number of ponds to provide for testing of the effectiveness of this approach at this site, it has been known to work well in controlling Plague Minnow at the RTA Ponds.

Frog ponds require at least some open water and limited shading. The Sydney Olympic Park Authority and the best practice guidelines (DECC 2008c) recommended a maximum of 80 percent vegetation cover in the ponds. Experience from the RTA ponds at Arncliffe also show that managing plant growth by reducing cover in the breeding ponds is important.

Fences are to be maintained to exclude vertebrate mammal predators such as foxes and cats. The frog exclusion fencing would also need to be maintained to ensure that the fence retains integrity.

Presence of predatory fish should be monitored and if present, the ponds should be drained to kill these fish.

Annual or bi-annual salt flushing would be required to minimise the prevalence of chytrid. Salt flushing has worked well at the RTA ponds. Exposure at varying salt concentrations was found to limit growth and infective capacity of chytrid in an experiment on *Litoria peronii* (Stockwell et al. 2012). However caution should be applied when salt loading into ponds is proposed because the threshold in *Litoria peronii* was found to be close to the concentrations required to limit chytrid growth and infection Stockwell et al. 2012). That study found that exposure to salt concentrations of 5 parts per trillion (ppt)

and chytrid infection had a cumulative effect on that species. Salt flushing should therefore not exceed 5 ppt. Despite this, the experimental proof that chytrid can be managed in natural settings remains elusive.

2.6.2 Feeding, sheltering, dispersal

An appropriately qualified bush regenerator (at least Cert III in Conservation and Land Management) will be engaged for planting of the landscaped habitat area and for weed control activities. Weed control is to focus on controlling adverse impacts to constructed frog habitats. Weed control is to be undertaken as required, or on at least an annual basis. Weed monitoring would be undertaken on a bi-annual basis with other site monitoring.

A diversity of plants will be retained as more diverse plantings are likely to result in greater invertebrate diversity. Plantings will not be dominated by one species only. The areas would be managed to ensure weeds do not invade planted areas.

Weed treatment methods are to be low impact, manual and as necessary with minimal herbicide application. No widespread spraying of herbicides is to occur in the created habitat area. Herbicide application should be limited to cut and paint techniques. If any hand spraying proves necessary/essential the type of herbicide used e.g. glyphosate, a sensitive formulation with a low toxicity surfactant should be selected, e.g. Round-Up Biactive®. However the addition of other surfactants to the formulation, as is often practised to improve herbicide effectiveness, must be avoided (DEC 2005). Hand spraying is only to occur in the non-active period for the frogs (i.e. cooler winter months) only after a pre clearing survey is conducted by the project ecologist.

Supplementary feeding areas should be checked to ensure that rodents or other pests are eradicated and that the compost is still providing frog prey items.

2.6.3 Overwintering

This habitat type should be monitored to ensure that it remains intact pre- and during the cooler months. The vegetation mounds should be visually inspected to ensure they have not collapsed. If the mounds are to be covered, the covers should provide adequate coverage over the mound frames. Covers used in White and Pyke (2015) were black plastic. A supply of this will be retained in the storage shed for use when and if covers fail. Failed covers must be replaced on the same day as failure is detected. Experimental and published evidence of over-wintering habitat use for Green and Golden Bell frogs remains limited.

3 Captive breeding plan

3.1 Background

As part of the original M5 East project opened in 2001, Roads and Maritime provided breeding ponds for the Green and Golden Bell Frog on Roads and Maritime owned land occupied by Kogarah Golf Club in Arncliffe.

This site is in the immediate vicinity of planned construction activity for the New M5 (Stage 2 of WestConnex). This site is to the east of the proposed Marsh Street frog habitat area.

3.2 Monitoring frog activity

Formal monitoring of the frogs in the area started in November 2000.

Monitoring was initially confined to the remaining areas of the Marsh Street wetland and Eve Street wetlands, however, with the construction of the two frog ponds at Arncliffe and the partial loss of the Marsh Street wetland, monitoring focussed almost entirely on the new frog habitats, the Kogarah Golf Course and the remaining portion of the Marsh Street wetland. The new frog habitats are known as the RTA ponds.

Monitoring has been ongoing with most survey work being carried out during the warmer months of the year (from August to May).

3.3 Early results

Surveys carried out over the summers of 1999-2000 and 2000/01 showed a progressive increase in the number of adult Green and Golden Bell Frogs found in the two frog ponds at Arncliffe and a decrease in the number of frogs in the Marsh Street wetlands.

A graph showing the results of the monitoring effort between 2002/03 and 2014/15 is shown below (**Figure 5**). This graph demonstrates presumed recent declines in the size of the population. While no specific study of the reasons for decline has been undertaken, Dr Arthur White believes this could be due to a range of factors including:

- excessive plant growth overshadowing of the existing frog ponds
- more extensive mowing of grassed areas on the Kogarah Golf Course increasing the risk of predation to frogs foraging on the golf course.

Roads and Maritime (M5 operations) has undertaken works within the frog ponds over summer 2015/16 which has removed the excessive plant growth in the existing frog ponds.

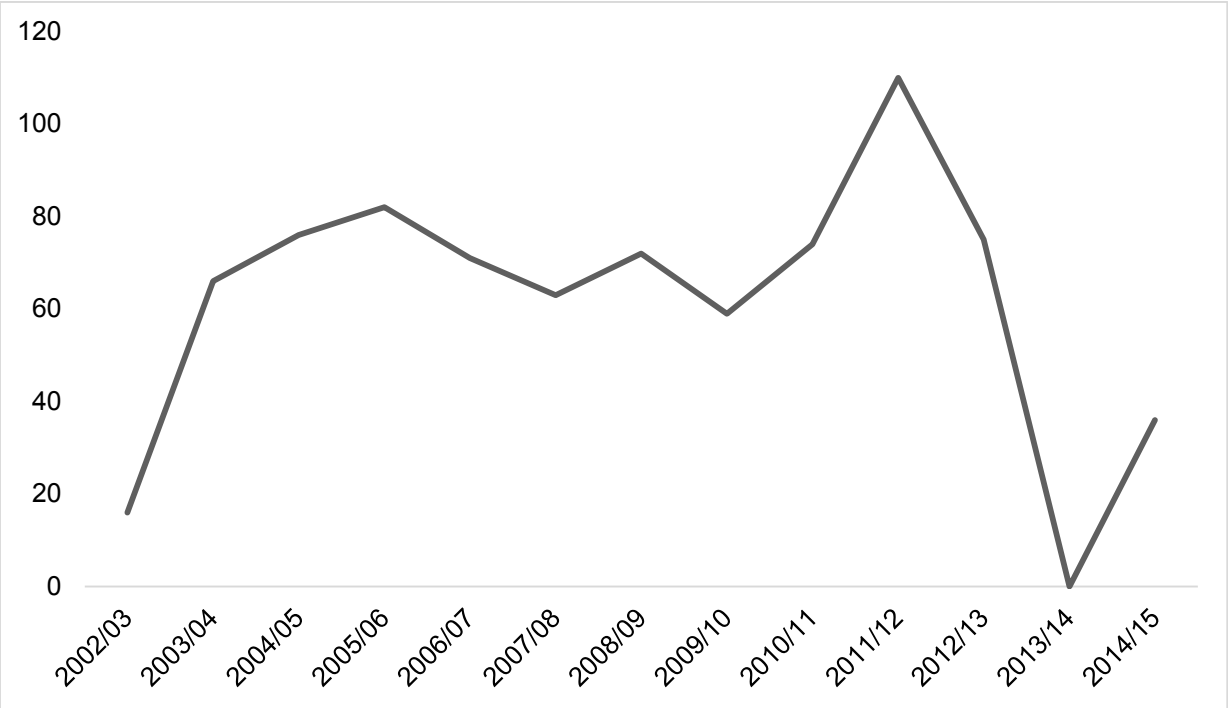

Figure 5: Maximum known number of adults between 2002/03 and 2014/15 at the RTA ponds (White unpubl. data)

The surveys have estimated the maximum known number of adults based on the Petersen-Lincoln index. Note that this estimate for 2013/14 could not be made due to the low numbers of frogs captured on the two successive nights surveyed in February 2014. The 'zero' does not mean there were no frogs present; it was that the estimate could not be reliably performed. No errors or confidence limits were calculated for any of these data.

Sex ratios are important to understand in populations of Green and Golden Bell Frog. This is because this species relies on a fast growth rates and rapid maturation to maintain the population (Pickett et al. 2014). These lifecycle attributes increase the importance of breeding events to enable replacement of adults in subsequent generations as adults generally do not live beyond two years (Bower et al. 2014). To enable successful breeding and to improve genetic diversity, there would need to be enough males and females to breed. The table below describes the proportion of females and males tagged per survey season for the area that includes the RTA ponds, Kogarah Golf Course and the Marsh Street wetlands (**Table 3**).

Population age structures were not provided in any of the RTA pond monitoring reports from White (White 2003 – 2015). Age structure are important to understand if there are enough adults of suitable breeding age to sustain the population.

Table 3: Proportion of male and female Green and Golden Bell Frogs from 2002/03 to 2014/15 (White unpubl. data)

Survey season	Female	Male	Unknown*
2002/03	0.3	0.7	-
2003/04	0.25	0.5	0.25
2004/05	0.4	0.6	-
2005/06	0.3	0.7	-
2006/07	0.35	0.65	-
2007/08	0.4	0.6	-
2008/09	0.2	0.8	-
2009/10	0.25	0.75	-
2010/11	0.3	0.7	-
2011/12	0.35	0.65	-
2012/13	0.45	0.55	-
2013/14	0	1	-
2014/15	0.25	0.75	-

* denotes that the individual captured would have been too young to determine sex. Proportions have been rounded to the nearest whole number.

3.4 Factors influencing frog numbers

The expert responsible for monitoring the frog population has determined that the current population is unlikely to remain without constant management and is considered to have poor long-term viability (White 2015). Since 2003, observations of tadpoles indicated that breeding has occurred in the RTA ponds in every year except 2014.

The population is thought to be small (less than 50 adult frogs). Threats to the population include habitat loss, modification and disturbance, presence of chytrid, habitat fragmentation, poor water quality, poisonous foliage from Camphor Laurel as well as pollutant issues and predatory threats (e.g. cats, Plague minnow, foxes, dogs and rats).

Testing for chytrid occurred in 2006/07. Only twelve frogs were tested and of these, seven had chytrid antibodies and four had detectable chytrid spores. Chytrid has clearly been present in the population for some time and the continued survival of the population, despite chytrid being present, is similar to the results found for other urban Green and Golden Bell Frog populations. No dead frogs with identifiable chytrid have ever been found at Arncliffe.

3.5 Breeding

Since 2003, breeding has occurred in the RTA ponds in every year except 2014. Tadpoles had been seen in the pond to the east of the Crescent Lake on the Kogarah Golf Course in November 2005 (A White, pers. comm. 2015). This is the only reference to tadpoles being found outside of the RTA breeding ponds. It is expected that these frogs dispersed from the RTA ponds. Dispersal of bell frogs from permanent wetlands to ephemeral wetlands has been reported by Hamer et al. (2008), and is a

well-recognised aspect of their ecology. However, the relative importance of breeding in ephemeral situations, to the long-term persistence of a local population remain unknown.

3.6 Current survey season

Between November 2015 and February 2016, survey of the RTA ponds and Kogarah Golf Course was undertaken.

Initially the survey design was based on the previous surveys conducted at Arncliffe, which were that each wetland was surveyed for two nights. However, to ensure the data met the assumptions of the Pollock's robust design for analysis in MARK, the survey was altered to ensure that recapture rates were above 20 percent per precinct. This meant surveying at one of the precincts night after night to meet the recapture rates required for analysis. For the survey in February 2016, survey was conducted for five consecutive nights to achieve a recapture rate of about 28 percent. See **Appendix A** for a description of the monitoring methods.

Data was collated and examined. The population program 'MARK' was used to analyse the field capture and recapture data with the aim to provide a robust population estimate and to understand dynamics of the frog population at the RTA ponds. However the recapture rates did not approach the rates required to perform the analysis. Recaptures in the first two surveys were zero and about 30 percent in the third. See **Appendix B** for the full report on the analyses performed.

The survey showed that in November 2015, only six adults were captured and in February 2016, only eight adults were captured. The sex ratio in November was 1F:5M and in February 2F:6M. Some of the animals that were captured and tagged in February were only one year old and could not be sexed. They are not included in the sex ratio of adults reported above.

Breeding was observed with tadpoles present at the site. In mid-January 2016 small *Litoria* tadpoles were found in a small open drain between the RTA ponds and the Kogarah Golf Course. When they were large enough, they were positively identified as Green and Golden Bell Frog tadpoles. This is the only evidence of breeding in the 2015/16 season.

3.7 Why captive breed?

Captive breeding has been suggested for this population previously in the Plan of Management for the Lower Cooks River (DECC 2008a) as an insurance in the event of the extinction of the wild population. That Management Plan was prepared to satisfy Action 11.3.4 of the Recovery Plan and Priority Action Statement (PAS) Action 21 for the Green and Golden Bell Frog. These required the then Department of Environment and Climate Change to prepare and implement a 'Green and Golden Bell Frog Management Plan' for each key population on NPWS estate and to liaise with other public authorities (e.g. local councils, government departments) to encourage the preparation and implementation of a 'Green and Golden Bell Frog Management Plan' for key populations occurring on other public lands.

The Plan of Management developed for this site in response to the New M5 (ELA 2016), suggested that part of a measure to provide greater security for this population included collection and captive breeding. A review by an independent expert agreed with establishing an ex-situ breeding colony. Both the creation of new habitat areas to be managed in perpetuity and the captive colony should provide for greater security of the population well after the New M5 construction is completed.

The population at Arncliffe has been stable between 2003 and 2012, however the population was relatively small, with a maximum known number of adults 110 in the 2012 population. Since 2012, there has been a rapid decline in the maximum number of known adults. In the 2013/14 survey season, the

population could not be reliably estimated (**Figure 5**). This is thought to have been as a result of two major factors: predation by foxes and a change in the areas of 'rough' on the golf course (A White, pers. comm.).

Even without the New M5 construction, it may have been necessary to consider an ex-situ population of the Arncliffe Green and Golden Bell Frogs. This is because the population is relatively small, making it vulnerable to stochastic events that may result in extinction in the area.

The Lower Cooks River plan (DECC 2008a) also suggested resolution of the population's genetics and comparison with other populations. This was to determine whether outcrossing between other populations would be possible if not beneficial. The population at Arncliffe may suffer from inbreeding. Inbreeding can lead to a reduction in reproductive success and therefore further decline in frog numbers. Franklin (1980) suggested that the minimum effective population size to avoid inbreeding depression and thus a loss of fitness is 50, and to avoid erosion of evolutionary potential this is 500. However a recent review by Frankham et al. (2014) suggested these numbers are closer to 250-500 to avoid inbreeding and 2,500-5,000 to avoid evolutionary erosion.

A molecular population genetic study of the population at Arncliffe revealed that this population is not a different species to other Green and Golden Bell Frog populations across the species' range. It should be possible to therefore outcross with other Green and Golden Bell Frog populations in the event that the captive adults do not successfully breed (Burns et al. 2004).

3.8 Captive breeding process

The intention of the captive-breeding program is to create a viable captive population of Green and Golden Bell Frogs that can serve as an insurance population. Secondly, it would provide tadpoles and young frogs for a seeding population to be established elsewhere (e.g. the Marsh Street frog habitat area).

An organisation or institution that has the suitable experience and has the demonstrated capacity will be the likely host for the captive frogs. This facility would hold the animals and breed them each spring/summer when habitat is available for the release of the progeny. Based on previous experience of captive breeding colonies, ten pairs of frogs is desirable (i.e. 20 adult frogs). The Arncliffe population is small and it is unlikely that 20 adults could be collected at the start of this program. Instead it is likely that some adults would be collected and the captive population will be supplemented by juvenile frogs (or even tadpoles) collected at Arncliffe at later dates. Collection will continue for as long as necessary to establish a captive colony.

3.8.1 Establish captive breeding facilities

The facility would need to provide a dedicated holding room for the Arncliffe Frogs. As the initial input of frogs is likely to be small, extra attention will need to be given to these frogs to ensure their health and readiness for breeding. Additional measures such as ultra-violet lamps and food supplements would also be required.

The facility would need to prepare a management program for the frogs that details how each pair would be housed and maintained. The dietary regimes and supplements would need to be detailed, as would all health checks (including skin swabs). Discussions on how to prepare this information is being undertaken by the Arncliffe Green and Golden Bell Frog expert, Dr Arthur White.

3.8.2 Collection of frogs for the captive colony

The source frogs for the captive colony would be collected from the Arncliffe population at different locations and times. In order of time, first frogs to be collected would be those collected during the pre-clearing surveys (from July 2016), then additional frogs would be collected from the golf course or RTA breeding ponds if required. These frogs may be collected during the routine monitoring nights or may be collected opportunistically.

3.8.3 Transportation of frogs

The frogs collected would be placed a medium-sized clip-lock plastic bag containing a small amount (5-10 millilitres) of bottled spring water. Each frog would be micro-chipped if not already tagged and the details of the frogs (sex, weight, condition, location, date) would be recorded on a database established for this population.

The frogs in the sealed plastic bags would be placed in a secure Esky for transportation to the facility. All frogs that are collected for the captive-breeding colony will be isolated. There they are screened for a range of pathogens including chytrid. If the frog has a low Bd score (named after the fungus, *Batrachochytrium dendrobatidis*, which causes chrytrid disease), it will be treated with a range of anti-fungal agents until all traces of chytrid are removed. It can then be transferred to the captive-breeding facility for possible use in the breeding program.

If the frogs has a high Bd score, it will be euthanased, as past experience has shown that these animals cannot be fully cleared of chytrid and that it ultimately reappears in the frog. When the frogs are deemed to be pathogen free they will be cleared from quarantine and relocated to the controlled breeding facility, where they would remain throughout the rest of their lives.

3.8.4 Husbandry

All animal husbandry will follow standards developed by an established keeping facility. While in captive care the frogs would need to be regularly weighed and measured to monitor growth, as well as examined for signs of injury or disease.

Frogs would not be paired until the female frog shows evidence of sexual development e.g. egg storage in oviduct or responses to calling male frogs. A paternity register would be kept for all mating attempts. Pair combinations would be varied each season to maximise genetic diversity.

Young tadpoles would be fed a mixed vegetable diet and would be given daily UVG exposure. Water in the tadpole tanks would be continuously recirculated and filtered. Tadpoles would need to be kept in tanks where water filtering allowed for removal of waste.

3.8.5 Veterinary care

Veterinary care would be required throughout the project. Veterinary work undertaken would include the following:

- pre- quarantine screening
- chytrid fungus swabs and testing
- microchipping
- on call consults and associated procedures
- pathology tests
- euthanasia
- pre-release screening and testing.

3.8.6 Tadpole relocation

Tadpoles with hind limb buds are the preferred stage for relocation into the ponds in the Frog Habitat Area at Arncliffe. Pickett et al. (2013) reported that tadpoles have an 80% mortality rate in the wild. By 'head-starting' the animals for release, the mortality could be reduced, because mortality rates in captivity are much lower. Young froglets may also be translocated. Some tadpoles may be released into the RTA ponds or other suitable ponds on Kogarah Golf Course and in the Marsh Street frog habitat area. Tadpoles may receive supplementary feed after being released and surveys would be undertaken to determine tadpole survival at the release sites.

Tadpoles would be transported in sealed plastic bags in an esky in bottled spring water. Holding bags would be allowed to become thermally stable in the water in the release ponds before the bags are opened. A test release should be performed to determine if the water quality is suitable for tadpoles prior to a major release of animals.

3.8.7 Duration of captive-breeding colony

It is expected that the captive-breeding colony will need to be operational for a minimum of three years. Extension beyond this horizon will be dependent on the habitat features established and the recovery of the local population to previous numbers. The program will remain until at least the population has bred and produced offspring over multiple years.

4 Monitoring and reporting

The activities in this plan would need to be monitored for success. While many aspects of the habitat creation could be measured (e.g. fencing integrity – no holes in fence) and corrective actions provided (e.g. fix holes in fence within two days of detection), the chief aim of the habitat creation is to ensure persistence of the population following introduction from the captive breeding program. The monitoring and reporting proposed focuses on the Green and Golden Bell Frog breeding success.

4.1 Monitoring

The aim of the monitoring program will be to determine the response of the Green and Golden Bell Frog population to the impacts associated with the works on the Kogarah Golf Course, as well as providing information for adaptive management on the effectiveness of the habitat created as part of the project. Therefore the frog monitoring would be carried out at the RTA ponds and Kogarah Golf Course during the entire construction works period. If frogs are released into the Marsh Street ponds, this area would be added to the monitoring and survey schedule.

The monitoring program is based on intense repeated surveys at particular times of the year. This format allows for local population estimations to be carried out as an ongoing check on the population response to any impacts associated with the works.

Tissue samples will be taken from all captured frogs to enable measurement of the genetic diversity of the local population.

All frog survey would need to be carried out in accordance with the *Hygiene protocol for the control of disease in frogs* (DECC 2008b) to minimise infection of frogs with chytrid disease.

4.2 Frog Survey - RTA ponds

The frog survey methodology will be based on Pollock's robust design (Pollock 1982). This design would allow the most rigorous population estimates to be made as well as provide data on emigration/immigration, population dynamics and turnover. This method relies on repeated sampling in sites in quick succession (to decrease the impact of immigration or emigration). It is also suitable for an enclosed population.

The survey area would be divided into three zones (RTA ponds, enhancement area and golf course east, golf course north areas). Animals would be captured during nocturnal surveys, marked and released within each survey zone. This needs to be done until recapture rates are sufficiently high and a set threshold level of 20 percent recaptures within each secondary survey period, and preferably closer to 40-50 percent. All precincts would need to be sampled in this way. This may mean surveying at one wetland or precinct for longer than six nights to achieve the recapture rates required.

All captured Green and Golden Bell Frogs would be measured, weighed, sexed and inspected for reproductive condition and signs of illness or injury. Frogs larger than 40 millimetres snout-vent length would be micro-chipped and tissue samples will be taken by web punching between the third and fourth hind toe. The frogs would then be released.

At the end of each period, a population estimate using MARK would be calculated. A suitably qualified and experienced statistician would analyse this data. This is to ensure that the analysis is conducted by a person who understands the design requirements for the survey and also the species' ecology.

4.3 Tadpole Survey – RTA ponds

The RTA ponds and golf course ponds would be sampled each month between September and March each year using long-handled sampling nets for tadpoles. Any tadpoles captured will be measured, staged (using standard staging in Gosner (1960)), identified (using Anstis 2013) and released.

Presence of tadpoles are taken to mean a successful breeding event.

4.4 Frog survey – Marsh Street ponds

Once Green and Golden Bell Frog individuals have been released to the Marsh Street ponds, they should be surveyed as described in **section 4.2**. Decisions about what precincts or zones should be established at this site would need to be agreed by independent frog experts and the project ecologist. At the very least, the Marsh Street ponds would be considered to be a completely separate precinct to the RTA ponds.

4.5 Key performance indicators

Key performance indicators are listed in **Table 4**. These indicators relate only to the higher level objective of the Plan of Management and the desired outcomes of these plans: the persistence of the Green and Golden Bell Frog population at Arncliffe. It is assumed that all efforts to manage and maintain the habitats at both the RTA ponds and Marsh Street would remain for the entire project construction and reinstatement of golf course areas post-demobilisation. These management actions should be in accordance with the mitigation measures in the Environmental Impact Statement, the Construction Environmental Management Plan and any other adaptive planning tool provided.

Table 4: Key performance indicators for RTA ponds and Marsh Street ponds

Issue	Indicator	Threshold	Response action	Who
RTA ponds population survival	Successful annual breeding during spring-summer for each year the works are in place	Tadpoles not present	Release tadpoles with hind limb buds from the captive colony into RTA ponds	Project ecologist and expert reviewers; captive breeding facility
Captive breeding	Release of tadpoles from at least three different parent combinations	No tadpoles produced	Outcross with other populations	Project ecologist, expert advisers and captive breeding facility
Marsh Street pond population establishment	Survival and development of frogs at release site to a point where successful breeding takes place over multiple years	No tadpoles produced	Check for other factors e.g. predators, water quality Second release of tadpoles Retain captive colony	Project ecologist, expert advisers and captive breeding facility

4.6 Reporting

An annual report on the monitoring and survey outcomes would be provided to Roads and Maritime. This report should be provided at the conclusion of the spring-summer survey season. This is to ensure that any decisions about introduction of tadpoles or any corrective action can be made as soon as possible.

Data analysis can be undertaken as soon as data is collected. Incorporation of data analysis would add value to more fully understanding the population dynamics and size. This analysis will be included into the annual report.

If any other corrective actions are required, these should be reported on an as needs basis. Examples would be the detection of holes in the frog proof fence, which should be reported and acted on immediately. Given these actions and triggers are unpredictable and unplanned, the reporting and response should be fit for purpose and respond to new information adaptively. This would allow for the likely uncertainty and provide flexibility in responding to emerging circumstances.

While there is not enough space at Marsh Street to design a fully replicated experimental approach for the habitat creation and captive breeding, consideration should be given to the production of a scientific paper.

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Appendix A Field survey method for January and February 2016

The below describes the field survey method employed during the January and February 2016 monitoring season for Green and Golden Bell Frog at Arncliffe. All monitoring was undertaken by Dr Arthur White and his associates.

Precinct	Date	Person Hours
Golf Course North	27/1/2016	4
Impact Area	28/1/2016	4
Enhancement Area	30/1/2016	4
RTA Ponds	31/1/2016	4
Enhancement Area	3/2/2016	4
RTA Ponds	4/2/2016	4
RTA Ponds	6/2/2016	4
RTA Ponds	7/2/2016	4
RTA Ponds	8/2/2016	4
RTA Ponds	9/2/2016	4

The Jan/Feb 2016 monitoring program was changed part way through the monitoring season to ensure that the data could be analysed using MARK. Instead of surveying the four precinct areas twice during the session, we repeatedly surveyed the RTA ponds for 5 nights during February. The data had shown that there were not enough frogs on the golf course to enable any sort of population estimate and only the RTA ponds had any hope of providing useful data but consecutive recaptures were required.

The survey routine for each night was the same. Each search area was surveyed for 2 hours by 2 survey staff (i.e. a total of 4 person hours) after sun down. Upon arrival at a waterbody on the site, GGBF mating calls were simulated for 2 minutes and that was followed by a 1 minute listening period. Further mating call simulations were done throughout the night as well.

After the listening period following the mating call simulations, a ground search commenced of the area for non-calling GGBFs using head-lamps. This often entailed a slow search of the low vegetation or ground cover. At larger water bodies, one survey member would slowly move around the perimeter of the pond searching, while the other survey member waded into the pond to search through emergent reeds and other aquatic vegetation.

Any GGBF that was caught was immediately placed in a sealed plastic bag so that it could not escape. When the two survey members reconvened after having completed the search of the waterbody, the frogs were processed and released. Processing involved sexing, measuring snout-vent length, weighing the frog and checking it for any signs of injury or disease. If the frog was a recapture its tag number and location was recorded on the field data sheet. If it was a new frog, a passive-induction tag was inserted beneath the skin on the right-hand side and the tag manipulated down into the groin of the frog.

Appendix B Results from MARK analysis

Methods for attempted modelling process of mark-recapture data using Robust Design

Population size estimates and apparent survival for the periods between survey events were modelled using Pollock's robust design. Pollock's robust design can be used to estimate population size at each primary period (N), apparent survival probability between primary periods (ϕ), temporary emigration between primary periods (γ), capture probability (*p*) and recapture probability (*c*). Apparent survival consists of two elements – deaths and emigration – that are not separable without directly measuring emigration or death independently in some way, which was not done in this study.

Robust design has a number of assumptions including: that capture and survival probability are independent of one another; secondary survey periods are closed to migration, mortalities and recruitment; marks are unique and are not lost; and survival probabilities are equal between individuals (Pollock 1982; Amstrup, McDonald et al. 2005; Nichols 2005). For the purposes of modelling sparse data, the assumption was made that capture and marking individuals did not alter their capture probabilities, and so *p* was made to equal *c* in many models (although these were also tested separately to see if improved, sensible estimates could be formed). The probability of temporary emigration occurring was also forced to equal zero in many cases due to the short time frame of surveys, which often maximises the number of estimable parameters. Standard goodness of fit tests used to test the assumption that every marked animal in the population has the same probability of recapture and survival is not available for robust design models (Burnham and Anderson 2002).

An *a priori* set of candidate models were fit to each data set to identify the most parsimonious model. Base models were created in program MARK, version 6.1 (White and Burnham 1999) with combinations of time varying (t) and constant (.) survival and capture/recapture probabilities and population sizes. Statistical models were interpreted using a multi-inference approach where Akaike's Information Criterion was used as an objective means of model selection (Burnham and Anderson 2001). Models were ranked from lowest to highest AIC_c and ΔAIC_c values were calculated by subtracting the lowest AIC_c score from that of each of the other models. Models with ΔAIC_c of less than two are considered to be the best of the candidate set in representing reality (Burnham and Anderson 2002). Akaike weights (*w*) were also calculated to quantify the relative strength of evidence in support of a particular model, given the data available (Burnham and Anderson 2002).

Results

Two models were attempted; one using the mark-recapture data from the entire site combined and one using the data from the RTA ponds only. The vast majority of the animals marked were recorded in the RMS ponds with no movement observed between the other precincts. Thus, modelling these ponds alone would likely break fewer assumptions than modelling the entire site together.

A total of 9 unique animals were marked during the survey period, with several others sighted but not captured. All of these except one were captured in the RTA ponds, with the remaining animal being caught once in the impact precinct and once in the enhancement precinct, suggesting some movement between precincts on occasion. Within the RTA ponds, a total of 2 unique individuals were captured during the first primary survey period with no recaptures; 4 unique individuals captured during the second primary survey period with no recapture; and 7 unique individuals captured during the third primary survey period with 2 recaptures.

Due to the limited number of recaptures – zero in either of the first two primary survey events and only 2 out of 7 (ca. 28%) in the third primary period – all models were unable to converge. This included the simplest *a priori* candidate model with the least parameters, where γ' and γ" were constrained to zero, ϕ and N were assumed to be constant and $p = c(.)$.

Generally speaking, a minimum of 20% recapture rate is required for models to converge and a higher rate of 40% plus is desirable for the models to be more robust.

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New M5

Environmental Impact Statement

Marsh Street Ponds – Traffic and Transport Impact Assessment

Appendix C

March 2016

WestConnex

WESTCONNEX NEW M5

Appendix C – Marsh Street ponds – Traffic and transport impact assessment

MARCH 2016

This document cover is to be replaced with a Roads and Maritime Services approved document cover. Refer to Roads and Maritime Services Visual Identity Manual.

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Roads and Maritime Services

WestConnex New M5

Appendix C – Marsh Street ponds – Traffic and transport impact assessment

March 2016

Prepared for

Roads and Maritime Services

Prepared by

AECOM Australia

Document controls

Title	Project title Document type
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Authorised by:	Caitlin Bennett Associate Director - Environment
	Date: 3 March 2016

Document status	Date
Final	3 March 2016

1 Introduction

1.1 Background

The traffic and transport impacts during the construction and operation of the New M5 project (the project) have been assessed and presented in the Technical working paper: Traffic and transport (AECOM, 2015), which formed part of the environmental impact statement (EIS) for the project.

The Green and Golden Bell Frog Plan of Management, which was prepared for the project, identified the provision of additional habitat on a parcel of land to the east of the Marsh Street and West Botany Street intersection, Arncliffe (the site), referred to as the Marsh Street ponds. However, no design detail was available at time of the EIS preparation.

The design of the proposed Marsh Street ponds has now been progressed as part of the project and a review of the potential impacts associated with the construction and operation of the ponds has been undertaken.

The inclusion of this habitat as part of the project requires supplementary assessment, as it would generate additional traffic impacts during the construction of the Marsh Street ponds.

1.2 Scope of this report

This report is an addendum to the Technical working paper: Traffic and transport (AECOM, 2015) and presents a summary of the construction traffic impacts of the Marsh Street ponds.

As the operation of the Marsh Street ponds would only involve minor maintenance activities, with infrequent and minor traffic generation, an assessment of the operational impacts has not been undertaken.

This report is to be read in conjunction with the Technical working paper: Traffic and transport (AECOM, 2015), which contains detailed descriptions and explanations on the assessment guidelines and methodologies used.

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2 Design change – Marsh Street ponds

2.1 Description of change

The Green and Golden Bell Frog Plan of Management identified the provision of new additional habitat at Marsh Street (refer to Appendix S of the EIS) as part of a broader package of mitigation and management measures to support the long term survival of the local population by expanding and enhancing the habitats available for the species. This additional habitat is referred to as the Marsh Street ponds.

The Marsh Street ponds would be located on a parcel of land to the east of the Marsh Street and West Botany Street intersection (the site) (**Figure 2-1**). The site is owned by Roads and Maritime Services (Roads and Maritime).

The Marsh Street ponds would consist of:

- Three Green and Golden Bell Frog ponds, located along the western boundary of the site consisting of:
  - One pond of around 1.5 metres in depth, about 25 metres long, which has been designed to provide refuge habitat; and
  - Two ponds of around 0.8 metres in depth, about 20 metres long, which have been designed to provide suitable breeding habitat.
- Water supply systems, including a header tank (with capacity of around 200 kilolitres), pipes and a drainage swale to fill and drain the ponds
- A serviced work shed, around 10 square metres, to support maintenance and monitoring activities and to store equipment
- Perimeter fencing, designed to enable frog passage along the eastern and northern perimeter of the site, and to prevent frog passage along the southern and western perimeter
- Permanent vehicle access off Eve Street.

A concept design of the Marsh Street ponds is provided in **Figure 2-1**.

The larger and deeper pond has been designed as the refuge pond and would be the only pond that would permanently contain water. The two smaller ponds would vary considerably in depth during each season (by water management) and may even be allowed to become dry for short periods. A rock platform with fixing for a small outboard motor is to be provided in each pond, extending into open water for pond mixing.

The edges of clay lined ponds would be planted with aquatic macrophytes. Pond banks and areas between the ponds would be planted with suitable plant species to provide shelter, foraging and dispersal habitat for the Green and Golden Bell Frog. Sandstone rocks would also be placed at suitable locations within the site to provide refuge close to the ponds.

To the south and east of the three ponds, a drainage and habitat swale would be created. This swale would be capable of receiving water from two of the three ponds via a piped drainage outlet. Drainage from the larger pond (when required) would be undertaken by an external pump. The swale would be of a suitable size to allow for ponds to be periodically drained, while being able to withstand erosion. This swale would be planted with species suitable for shelter and foraging habitat.

The water source to the ponds, and suitability of the source for this purpose, would be confirmed during detailed design. Potential sources (in order of preference) include:

- Stormwater harvesting via connections to Rockdale City Council's stormwater system at Eve Street
- Potable water. A connection to the Sydney Water main could also be constructed to provide a supply, or in the case of stormwater harvesting, a backup supply to the ponds during dry periods and/or

- Treated groundwater from the permanent water treatment plant located at the Arncliffe motorway operations complex.

Water discharged from the site would eventually flow through land owned by Rockdale City Council; into an existing vegetated drain which formed part of the original Marsh Street wetland, which flows into the Eve Street wetland (a Sydney Water asset). Overflow water from the Eve Street wetland is discharged also via an open drain into Muddy Creek (near its junction with the Cooks River).

Consultation with Rockdale City Council would continue during detailed design. This would include consultation with Rockdale City Council to ensure that the conveyance of water through its land is appropriately managed.

Roads and Maritime would also consult with Sydney Water with respect to connections to the water main. Any works would be in accordance with Sydney Water's requirements.

The management protocols of Marsh Street ponds have been detailed in a Green and Golden Bell Frog Habitat Creation and Breeding Plan (Eco Logical Australia, 2016), which is provided in Appendix B of this Submissions and Preferred Infrastructure report. This plan details the management protocols for the site during construction and operation. This includes (but is not limited to):

- Dosing the ponds with salt (sodium chloride) to control Chytrid disease (Chytrid is a skin fungal disease that can wipe out frog populations)
- Control of pond water levels
- Drainage of individual ponds for vegetation management to promote dieback and regrowth of aquatic macrophytes, and plague minnow control to ensure that pond communities do not become diverse and unsuitable for the frogs
- Vegetation management for the removal of trees to ensure adequate access to sunlight.

The design of the ponds is subject to detailed design, but would be consistent with the requirements of the Green and Golden Bell Frog Habitat Creation and Breeding Plan.

The Marsh Street ponds would be managed for conservation in perpetuity, such as through a biobanking agreement or through a community trust. The long term management framework would be determined in consultation with Rockdale City Council.

Figure 2-1 The Marsh Street ponds (indicative)

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Construction

Construction would take around six months to complete, and is expected to be completed no later than the end of 2019 (refer to **Table 2-1**). Works would occur during standard construction hours (Monday to Friday 7am to 6pm, Saturday 8am to 1pm).

Table 2-1 Indicative construction program (Marsh Street ponds)

Construction activity	Indicative construction timeframe (month)					
	1	2	3	4	5	6
Site establishment						
Pond construction works						
Plantings, construction of supporting infrastructure and landscaping						
Demobilisation						

A construction compound would not be established at the site. Any required construction support would be from the Arncliffe construction compound. Amenities would be provided at the site (such as a temporary office and portable toilet).

Site access would be provided off Eve Street, with construction vehicles accessing the site via Eve Street / West Botany Road intersection and exiting via the same intersection, West Botany Street and Wickham Street. During the peak construction period, around 10 movements (or five vehicles) per hour would be generated. The construction footprint for the site is depicted in **Figure 2-2**.

Opportunities to minimise vegetation clearance within the construction footprint would be explored during detailed design.

The key construction activities at the site would include:

- Site establishment including vegetation removal
- Bulk earthworks to form the three ponds and drainage network
- Stockpiling of materials and spoil
- Construction of the work shed, site access point and fencing, including a limited area of hardstand
- Utility connections, including stormwater, potable water (including installation of a header tank), sewer and electricity
- Landscaping and rehabilitation
- Demobilisation.

A 1.8 metre high hoarding would be provided along the Eve Street perimeter of the site. The existing road noise barriers along Marsh Street would not be impacted by the construction activity.

Excavated spoil, in excess of site requirements or spoil not suitable for re-use would be temporarily stockpiled on site prior to removal. Spoil would be managed in accordance with the Spoil Management Plan for the overall project.

The potential for encountering contaminated and acid sulfate soils during bulk earthworks would be confirmed during detailed design and management measures implemented to manage potential odour, soil and water quality impacts.

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Figure 2-2 The Marsh Street Ponds - Construction footprint

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3 Existing environment

3.1 Traffic

Volumes and mid-block performance

The existing traffic volumes and mid-block performance on West Botany Street were assessed in the vicinity of the site between Marsh Street and Wickham Street.

The existing traffic volumes and mid-block performance at the two locations are shown in **Table 3-1**.

The mid-block assessment indicates that:

- In the AM peak hour, northbound traffic on West Botany Street (between Marsh Street and Wickham Street) exceeds road capacity with a mid-block volume to capacity (V/C) ratio of 1.06 and a Level of Service (LoS) of F
- In the PM peak hour, the southbound traffic on West Botany Street (between Wickham Street and Brennans Road) performs poorly, with a mid-block V/C ratio of 0.87 and LoS of E.

Table 3-1 Existing mid-block performance (2016 without construction)

Location	Direction	Mid-Block Capacity	Light Vehicles	Heavy Vehicles	V/C	LoS
AM Peak Hour						
West Botany Street (Marsh Street – Wickham Street)	NB	2400	2310	92	1.06	F
	SB	3600	734	72	0.26	A
PM Peak Hour						
West Botany Street (Marsh Street – Wickham Street)	NB	2400	988	44	0.46	C
	SB	3600	2729	49	0.79	D

Intersection performance

The existing intersection performance in the vicinity of the site was reported for the Wickham Street/West Botany Street and Marsh Street/West Botany Street intersections. These are shown in **Table 3-2**.

While the intersections appear to perform well, they were observed to be congested during the peak hours. As noted in the Technical working paper: Traffic and transport (AECOM, 2015), the performance of intersections during construction was calculated based on standalone traffic models using SIDRA. This is considered suitable for testing the construction impacts, but may not reflect the true LoS for these intersections, as they form part of a wider coordinated system of signalised intersections.

Table 3-2 Existing intersection performance (2016 without construction)

Intersection/Peak	Light Vehicles	Heavy Vehicles	Average Delay	Level of Service
Wickham Street / West Botany Street				
AM Peak	2893	157	23	B
PM Peak	4175	82	12	A
Marsh Street / West Botany Street				
AM Peak	3359	203	7	A
PM Peak	3500	111	11	A

3.2 Public transport

The bus routes that currently operate in the vicinity of the site, as shown in **Figure 3-1**, are:

- Route 400 (Bondi Junction to Burwood), which travels along Marsh Street and Wickham Street at a frequency of 10–20 minutes during weekday peak hours
- Route 410 (Bondi Junction to Rockdale), which travels along Marsh Street and Wickham Street at a frequency of 20–30 minutes during weekday peak hours
- Route 422 (Tempe/Kogarah to Sydney), which travels along the Princes Highway and West Botany Street at a frequency of 10–15 minutes during weekday peak hours.

3.3 Active transport

As part of the current Marsh Street widening project being undertaken by Roads and Maritime, a cycle path is to be constructed on the southern side of Marsh Street. This would link into the existing Eve Street Cycleway, which runs along the north-eastern side of the M5 East Motorway adjacent to the Kogarah Golf Course, before passing under the motorway near the Eve Street wetland and continuing south towards Banksia Grove, as shown in **Figure 3-2**.

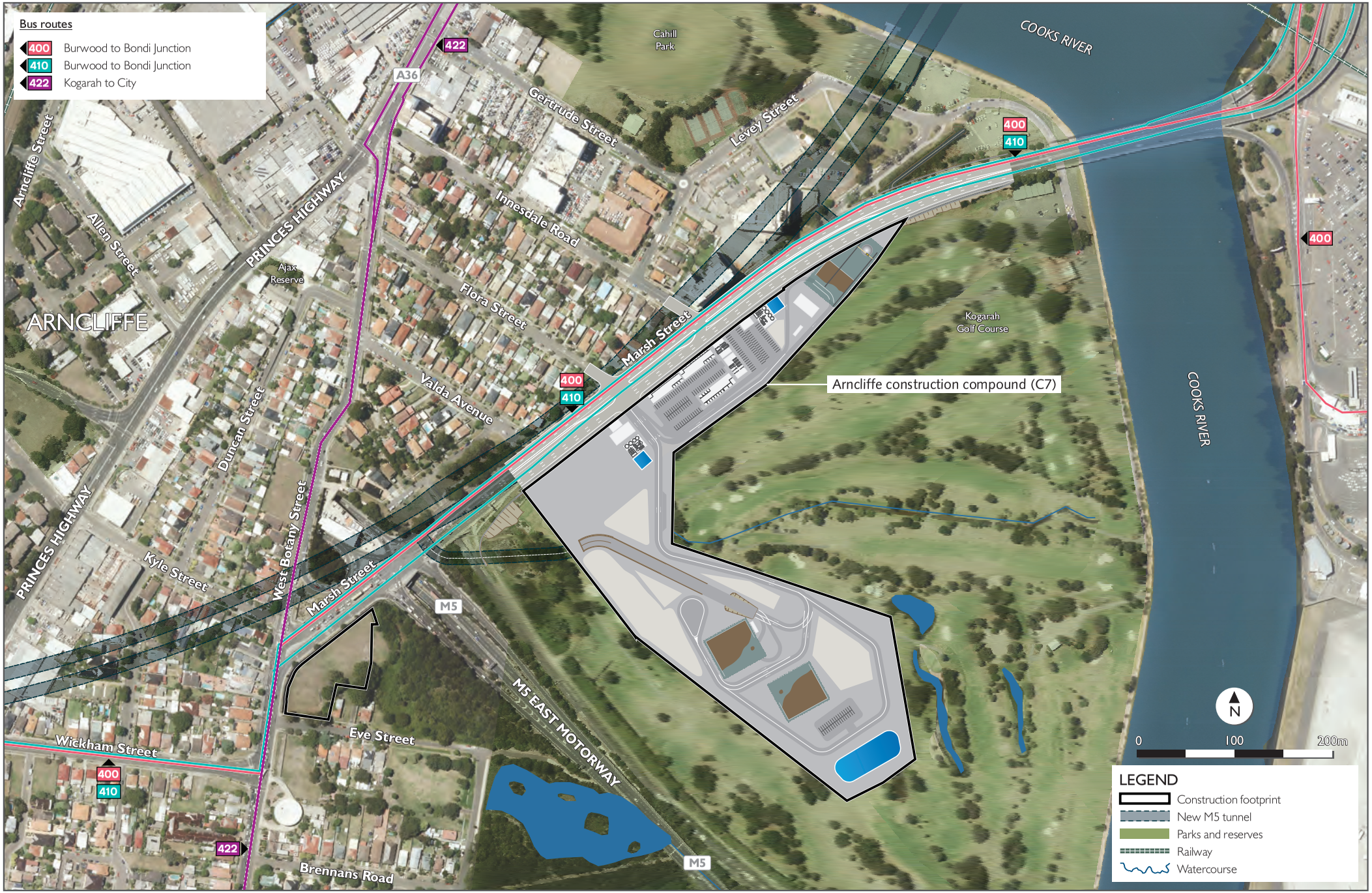

Figure 3-1 Bus routes around the construction site

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Figure 3-2 Cycle routes around the construction site

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4 Assessment of impacts

4.1 Construction

4.1.1 Access routes

Traffic generated by the construction of the Marsh Street ponds would access the site via Eve Street, as follows:

- Entering vehicles would turn left from Marsh Street into Eve Street
- Exiting vehicles would turn left onto Marsh Street from Eve Street.

4.1.2 Generated traffic

The volume of traffic generated during construction is expected to be small, with three light vehicles and two heavy vehicles expected to enter and exit the site during each peak hour.

4.1.3 Traffic impacts

As shown in **Table 4-1**, construction traffic would result in a small increase in mid-block traffic, minor changes in V/C ratios, and no change to mid-block Level of Service. The impacts on local road traffic operations would be minimal, with a change of one per cent or less. This change would fall within the daily variation in vehicle volume and performance. No further analysis of traffic impact has therefore been undertaken.

Table 4-1 Midblock performance (with construction)

Location	Direction	Mid-Block Capacity	Light Vehicles	Heavy Vehicles	V/C	V/C % change	LoS
AM Peak Hour							
West Botany Street (Marsh Street – Wickham Street)	NB	2400	2310	92	1.06	No change	F
	SB	3600	737	74	0.26	<1.0%	A
PM Peak Hour							
West Botany Street (Marsh Street – Wickham Street)	NB	2400	988	44	0.46	No change	C
	SB	3600	2732	51	0.79	<1.0%	D

4.1.4 Public transport impacts

As with the impact on general traffic, construction activities are likely to have minimal impact on public transport operations.

4.1.5 Active transport impacts

The Eve Street Cycleway follows a section of Eve Street to the east of the site. However, the volume of construction vehicles is low, and as such would present a minor risk to cyclists accessing this cycle route from West Botany Street.

A strategy for the maintenance of pedestrian and cyclist access throughout construction would be provided as part of the Construction Traffic Management and Safety Plan for the project (environmental management measure TT01, refer to Chapter 8 of the Submissions and Preferred Infrastructure report); which would be prepared during the detailed design stage. This would be particularly relevant for maintaining the accessibility of the Eve Street Cycleway.

4.2 Operation

The operation of the Marsh Street ponds would only involve minor maintenance activities such as pond flushing, inspections and species monitoring, and general property maintenance (eg mowing). These activities would generate small and infrequent traffic movements and would be unlikely to have an impact on the operational performance of vehicles travelling on nearby roads or intersections. An assessment of the operational impacts has not been undertaken. The access point to the site via Eve Street, would be similar to the current arrangement.

5 Conclusion and recommendations

With regard to traffic and transport impacts associated with the construction and operation of the Marsh Street ponds, it is found that the three light vehicles and two heavy vehicles expected to enter and exit the site in each of the AM peak and PM peak hours during the construction period would have a minimal impact on the performance of the local road network.

Based on the outcomes of this assessment, there would not be a significant change to the traffic and transport impacts as presented in the Technical working paper: Traffic and transport (AECOM, 2015). No additional mitigation measures are recommended over and above those contained in the technical working paper and Chapter 8 of the Submissions and Preferred Infrastructure report.

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New M5

Environmental Impact Statement

Marsh Street ponds – Noise and Vibration Impact Assessment

Appendix D

March 2016

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WESTCONNEX NEW M5

Appendix D – Marsh Street ponds – Noise and vibration impact assessment

MARCH 2016

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Roads and Maritime Services

WestConnex New M5

Marsh Street ponds – Noise and vibration impact assessment

March 2016

Prepared for

Roads and Maritime Services

Prepared by

AECOM Australia

Document controls

Title	New M5 Submissions and Preferred Infrastructure report Appendix D – Noise and vibration
	WestConnex New M5 Appendix D – Marsh Street ponds – Noise and vibration impact assessment
Approval and authorisation	
Prepared by:	AECOM Australia
Authorised by:	Caitlin Bennett Associate Director - Environment
	3 March 2016

Document status	Date
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1 Introduction

1.1 Background

The noise and vibration impacts during the construction and operation of the New M5 project have been assessed and presented in the Technical working paper: Noise and vibration (AECOM, 2015), which formed part of the environmental impact statement (EIS) for the project.

The Green and Golden Bell Frog Plan of Management, which was prepared for the project, identified the provision of additional habitat on a parcel of land to the east of the Marsh Street and West Botany Street intersection, Arncliffe (the site), referred to as the Marsh Street ponds. However, no design detail was available at time of the EIS preparation.

The design of the proposed Marsh Street ponds has now been progressed as part of the project and a review of the potential impacts associated with the construction and operation of the ponds has been undertaken.

1.2 Purpose of this report

This report provides an addendum to the Technical working paper: Noise and vibration and presents a summary of the noise and vibration impacts that would be generated during the construction of the Marsh Street ponds.

This report is to be read in conjunction with the Technical working paper: Noise and vibration which contains detailed descriptions and explanations on the assessment guidelines and methodologies used.

As the operation of the Marsh Street ponds would only involve minor and infrequent maintenance activities, an assessment of the operational impacts has not been undertaken.

The risk of vibration induced human discomfort, regenerated noise and structural damage is extremely low. The construction works would involve low vibration intensive equipment, which would not operate within close proximity to the nearest residential building or occupied structure. That is, works would occur within safe working distances. Therefore vibration impacts are not considered further in this assessment.

The construction works would only occur within standard construction working hours. As works would not occur in the night-time period, sleep disturbance has not been considered further in this assessment.

1.3 Guidelines

This technical report considers the following legislation, guidelines, policies and / or standards to inform the impact assessment of the project:

- *NSW Protection of the Environment Operations Act 1997* (POEO Act 1997)
- *Interim Construction Noise Guideline* (DECC, 2009)
- *NSW Road Noise Policy* (DECCW, 2011)
- *NSW Industrial Noise Policy* (EPA, 2000)
- NSW Industrial Noise Policy Application Notes (EPA, 2013)
- Australian Standard 1055: Part 1 – 1997 – Acoustics – Description and measurement of environmental noise, Part 1: General procedures
- Australian Standard 2436 – 2010 – Guide to noise control on construction, demolition and maintenance sites

1.4 Terminology

The acoustic terminology used in this report is explained in the glossary of terms and abbreviations in **Appendix A** of this report.

2 Design change – Marsh Street ponds

2.1 Description of change

The Green and Golden Bell Frog Plan of Management identified the provision of new additional habitat at Marsh Street (refer to Appendix S of the EIS) as part of a broader package of mitigation and management measures to support the long term survival of the local population by expanding and enhancing the habitats available for the species. This additional habitat is referred to as the Marsh Street ponds.

The Marsh Street ponds would be located on a parcel of land to the east of the Marsh Street and West Botany Street intersection (the site) (**Figure 2-1**). The site is owned by Roads and Maritime Services (Roads and Maritime).

The Marsh Street ponds would consist of:

- Three Green and Golden Bell Frog ponds, located along the western boundary of the site consisting of:
  - One pond of around 1.5 metres in depth, about 25 metres long, which has been designed to provide refuge habitat; and
  - Two ponds of around 0.8 metres in depth, about 20 metres long, which have been designed to provide suitable breeding habitat.
- Water supply systems, including a header tank (with capacity of around 200 kilolitres), pipes and a drainage swale to fill and drain the ponds
- A serviced work shed, around 10 square metres, to support maintenance and monitoring activities and to store equipment
- Perimeter fencing, designed to enable frog passage along the eastern and northern perimeter of the site, and to prevent frog passage along the southern and western perimeter
- Permanent vehicle access off Eve Street.

A concept design of the Marsh Street ponds is provided in **Figure 2-1**.

The larger and deeper pond has been designed as the refuge pond and would be the only pond that would permanently contain water. The two smaller ponds would vary considerably in depth during each season (by water management) and may even be allowed to become dry for short periods. A rock platform with fixing for a small outboard motor is to be provided in each pond, extending into open water for pond mixing.

The edges of clay lined ponds would be planted with aquatic macrophytes. Pond banks and areas between the ponds would be planted with suitable plant species to provide shelter, foraging and dispersal habitat for the Green and Golden Bell Frog. Sandstone rocks would also be placed at suitable locations within the site to provide refuge close to the ponds.

To the south and east of the three ponds, a drainage and habitat swale would be created. This swale would be capable of receiving water from two of the three ponds via a piped drainage outlet. Drainage from the larger pond (when required) would be undertaken by an external pump. The swale would be of a suitable size to allow for ponds to be periodically drained, while being able to withstand erosion. This swale would be planted with species suitable for shelter and foraging habitat.

The water source to the ponds, and suitability of the source for this purpose, would be confirmed during detailed design. Potential sources (in order of preference) include:

- Stormwater harvesting via connections to Rockdale City Council's stormwater system at Eve Street
- Potable water. A connection to the Sydney Water main could also be constructed to provide a supply, or in the case of stormwater harvesting, a backup supply to the ponds during dry periods and/or

- Treated groundwater from the permanent water treatment plant located at the Arncliffe motorway operations complex.

Water discharged from the site would eventually flow through land owned by Rockdale City Council; into an existing vegetated drain which formed part of the original Marsh Street wetland, which flows into the Eve Street wetland (a Sydney Water asset). Overflow water from the Eve Street wetland is discharged also via an open drain into Muddy Creek (near its junction with the Cooks River).

Consultation with Rockdale City Council would continue during detailed design. This would include consultation with Rockdale City Council to ensure that the conveyance of water through its land is appropriately managed.

Roads and Maritime would also consult with Sydney Water with respect to connections to the water main. Any works would be in accordance with Sydney Water's requirements.

The management protocols of Marsh Street ponds have been detailed in a Green and Golden Bell Frog Habitat Creation and Captive Breeding Plan (Eco Logical Australia, 2016a), which is provided in Appendix B of the Submissions and Preferred Infrastructure report. This plan details the management protocols for the site during construction and operation. This includes (but is not limited to):

- Dosing the ponds with salt (sodium chloride) to control Chytrid disease (Chytrid is a skin fungal disease that can wipe out frog populations)
- Control of pond water levels
- Drainage of individual ponds for vegetation management to promote dieback and regrowth of aquatic macrophytes, and plague minnow control to ensure that pond communities do not become diverse and unsuitable for the frogs
- Vegetation management for the removal of trees to ensure adequate access to sunlight.

The design of the ponds is subject to detailed design, but would be consistent with the requirements of the Green and Golden Bell Frog Habitat Creation and Captive Breeding Plan.

The Marsh Street ponds would be managed for conservation in perpetuity, such as through a biobanking agreement or through a community trust. The long term management framework would be determined in consultation with Rockdale City Council.

Figure 2-1 The Marsh Street ponds (indicative)

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2.2 Description of construction works

Construction would take around six months to complete, and is expected to be completed no later than the end of 2019 (refer to **Table 2-1**). Works would occur during standard construction hours (Monday to Friday 7am to 6pm, Saturday 8am to 1pm).

Table 2-1 Indicative construction program (Marsh Street ponds)

Construction activity	Indicative construction timeframe (month)					
	1	2	3	4	5	6
Site establishment						
Pond construction works						
Plantings, construction of supporting infrastructure and landscaping						
Demobilisation						

A construction compound would not be established at the site. Any required construction support would be from the Arncliffe construction compound. Amenities would be provided at the site (such as a temporary office and portable toilet).

Site access would be provided off Eve Street, with construction vehicles accessing the site via Eve Street / West Botany Road intersection and exiting via the same intersection, West Botany Street and Wickham Street. During the peak construction period, around 10 movements (or five vehicles) per hour would be generated.

The construction footprint for the site is depicted in **Figure 2-2**.

Opportunities to minimise vegetation clearance within the construction footprint would be explored during detailed design.

The key construction activities at the site would include:

- Site establishment including vegetation removal
- Bulk earthworks to form the three ponds and drainage network
- Stockpiling of materials and spoil
- Construction of the work shed, site access point and fencing, including a limited area of hardstand
- Utility connections, including stormwater, potable water (including installation of a header tank), sewer and electricity
- Landscaping and rehabilitation
- Demobilisation.

A 1.8 metre high hoarding would be provided along the Eve Street perimeter of the site. The existing road noise barriers along Marsh Street would not be impacted by the construction activity.

Excavated spoil, in excess of site requirements or spoil not suitable for re-use would be temporarily stockpiled on site prior to removal. Spoil would be managed in accordance with the Spoil Management Plan for the overall project.

The potential for encountering contaminated and acid sulfate soils during bulk earthworks would be confirmed during detailed design and management measures implemented to manage potential odour, soil and water quality impacts.

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Figure 2-2 The Marsh Street Ponds - Construction footprint

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2.2.1 Construction noise attenuation

Construction hoarding would be installed along the boundaries of the construction compound which face sensitive receivers. The construction hoarding would provide noise attenuation during the construction phase. Details of the hoarding location and height are provided in **Table 2-2**.

Table 2-2 Temporary construction noise attenuation structures

Construction compound	Temporary noise attenuation
Marsh Street ponds	1.8 metre high hoarding along Eve Street perimeter of the construction compound

Existing road noise barriers along Marsh Street and adjacent to the Marsh Street ponds site would be retained for the entirety of the construction period.

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3 Existing environment and receivers

3.1 Existing environment description

The noise environment is dominated by heavy traffic flows on Marsh Street, West Botany Street, Princes Highway and the M5 East Motorway. The M5 East Motorway portals are also located within close proximity to sensitive receivers. Sydney Airport is located to the east. Aircraft noise is a key source of noise for receivers within this area.

3.2 Noise sensitive receivers

Sensitive receivers within this area are predominantly residential in nature and lie along West Botany Street, the north western side of Marsh Street and on both sides of Eve Street and Brennans Road. These receivers generally comprise single and double storey individual houses. Kogarah Golf Course is located to the east of the Marsh Street interchange of the M5 East Motorway.

The study area surrounding the construction works has been divided into three distinct noise catchment areas (NCAs). These are:

- NCA 12 – Around 120 metres to the north of the Marsh Street ponds site
- NCA 13 – The area including, and immediately adjacent to the Marsh Street ponds site
- NCA 14 – Around 90 metres to the south of the Marsh Street ponds site.
- The NCAs are consistent with the Technical working paper: Noise and vibration. The noise environment at each of the sensitive receivers within a noise catchment area is considered to have a similar noise environment. The location of each NCA is provided graphically in **Appendix B** of this report.

3.3 Ambient noise monitoring

Ambient noise monitoring was undertaken at three locations to quantify the noise environment for surrounding receivers.

A noise logger measures the noise level over the sample period and then determines L_{A1}, L_{A10}, L_{A90}, L_{Amax} and L_{Aeq} levels of the noise environment. The L_{A1}, L_{A10} and $_{LA90}$ levels are the levels exceeded for one per cent, 10 per cent and 90 per cent of the sample period respectively. The L_{Amax} is indicative of maximum noise levels due to individual noise events. The L_{A90} is taken as the background noise level. The L_{Aeq} is the energy averaged noise level over a defined period.

The results of the noise monitoring have been processed in accordance with the procedures contained in the *NSW Industrial Noise Policy*. Weather data recorded during the noise monitoring survey periods was obtained from the Bureau of Meteorology weather station, located at Canterbury. This is consistent with the Technical working paper: Noise and vibration and was found to generally result in slightly lower noise levels, than if weather from the more wind affected Sydney Airport weather station was used. Measurement results which were affected by noise from extraneous wind and rain were omitted.

Details of each noise logging location and the noise monitoring equipment are provided in **Table 3-1** below. The noise logging naming is consistent with the Technical working paper: Noise and vibration.

Table 3-1 Noise logging locations

No.	Address	Measurement period
NL20	20 Marsh Street, Arncliffe	12 – 20 June 2015
NL21	6 Eve Street, Arncliffe	17 – 25 June 2015
NL22	25 Firmstone Garden, Arncliffe	12 – 24 June 2015

3.4 Unattended background noise monitoring results

The background noise monitoring results are provided in **Table 3-2**. These noise levels were used to define the appropriate construction noise management levels, consistent with the *Interim Construction Noise Guideline*.

The assessment background levels (ABL) were established by determining the lowest tenth-percentile level of the L_{A90} noise data acquired over each assessment period of interest. The background noise level or rating background levels (RBL) representing the day, evening and night-time assessment periods were based on the median of individual ABLs determined over the entire monitoring duration.

Table 3-2 also presents the ambient L_{Aeq} levels at each monitoring location. The L_{Aeq} level is the equivalent continuous sound level and has the same sound energy over the sample period as the actual noise environment with fluctuating sound levels.

The noise levels presented in **Table 3-2** indicate that the noise environment at the measurement locations are typical of urban noise environments that has through traffic with characteristically heavy and continuous traffic flows during peak periods.

Day time and evening background levels are high due to heavy and continuous traffic flows. The night time background levels tend to decrease as a result of reduced traffic flows.

Table 3-2 Ambient noise measurements

Noise logging location	Rating background level, dB(A)			Ambient L_{Aeq} noise level, dB(A)		
	Day (7am to 6pm) $L_{A90,15\ minute}$	Evening (6pm to 10pm) $L_{A90,15\ minute}$	Night (10pm to 7am) $L_{A90,15\ minute}$	Day (7am to 6pm) $L_{Aeq,15\ hour}$	Evening (6pm to 10pm) $L_{Aeq,4\ hour}$	Night (10pm to 7am) $L_{Aeq,9\ hour}$
NL20	55	56	45	61	62	59
NL21	49	48	42	54	55	50
NL22	47	48	39	55	54	50

4 Assessment criteria

4.1 Construction noise

The risk of adverse impact of construction noise on a community is determined by the extent of its emergence above the existing background noise level, the duration of the event and the characteristics of the noise.

The *Interim Construction Noise Guideline* is a NSW Government document that sets out ways to deal with the impacts of construction noise on residences and other sensitive land uses. It presents assessment approaches tailored to the scale of the construction project and identifies practices to minimise noise impacts. The *Interim Construction Noise Guideline* recommends that a quantitative assessment is carried out for all major construction proposals that are typically subject to the environmental impact assessment processes. A quantitative assessment, based on the likely construction scenarios, has been carried out for the project.

Predicted noise levels at nearby noise sensitive receivers (e.g. residences, schools, hospitals, places of worship, passive and active recreation areas) are compared to the levels provided in the *Interim Construction Noise Guideline*. Where an exceedance of the management levels is predicted the *Interim Construction Noise Guideline* advises that receivers can be considered 'noise affected' and the proponent should apply all feasible and reasonable work practices to minimise the noise impact. The proponent should also inform all potentially impacted residents of the nature of the works to be carried out, the expected noise level and duration, as well as contact details.

Where construction noise levels reach 75 dB(A) residential receivers can be considered as 'highly noise affected' and the proponent should, in consultation with the community, consider restricting hours to provide respite periods.

The *Interim Construction Noise Guideline* defines what is considered to be feasible and reasonable as follows:

- Feasible – A work practice or abatement measure is feasible if it is capable of being put into practice or of being engineered and is practical to build given project constraints such as safety and maintenance requirements.
- Reasonable – Selecting reasonable measures from those that are feasible involves making a judgment to determine whether the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the measure.

Work that is proposed outside of standard working hours, as defined in the *Interim Construction Noise Guideline*, generally requires strong justification.

4.1.1 Residential receiver criteria

Noise management levels for residential receivers are derived using the information in **Table 4-1**.

Table 4-1 Construction noise management levels - Residential receivers from the Interim Construction Noise Guideline

Time of day	Management level $L_{Aeq\ (15\ min)}$ [1]	How to apply
Recommended standard hours: - Monday to Friday 7am to 6pm - Saturday 8am to 1pm - No work on Sundays or public holidays	Noise affected RBL + 10 dB(A)	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq\ (15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: – Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences. – If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB(A)	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community. • For guidance on negotiating agreements see Section 7.2.2 of the ICNG.

Note 1: Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 metres above ground level. If the property boundary is more than 30 metres from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 metres of the residence. Noise levels may be higher at upper floors of the noise affected residence.

4.1.2 Specific noise catchment area criteria

The receivers surrounding the construction works has been divided into three distinct noise catchment areas (NCAs). The noise environment at each of the sensitive receivers within a noise catchment area is considered to have a similar noise environment to the unattended monitoring location within that NCA. As such each of these sensitive receivers is assigned the same background noise level and noise management level. **Table 4-2** provides details of the construction noise management levels and the number of residential receivers identified within each NCA.

Table 4-2 Noise catchment areas and construction noise management levels

NCA	Representative logger	Number of residential receivers	Period	Rating background level[1] (RBL)	Construction noise management levels (NML) [2,3]
NCA12	NL20	108	Day	55	65
			Evening	55[1]	60
			Night	45	50
NCA13	NL21	65	Day	49	59
			Evening	48	53
			Night	42	47
NCA14	NL22	85	Day	47	57
			Evening	47[1]	52
			Night	39	44

Note 1: Application notes to the Industrial Noise Policy indicate that the community generally expects a greater control of noise during the evening and night as compared to the day time. Therefore the rating background level for the evening is set to no more than that for the daytime and the night-time to no more than the evening.

Note 2: Day noise management levels = RBL + 10 dB(A)

Note 3: Evening / night noise management levels = RBL + 5 dB(A)

4.1.3 Non-residential receiver criteria

Noise management levels recommended by the *Interim Construction Noise Guideline* for other sensitive land uses, such as schools, hospitals or places of worship are shown in **Table 4-3**. Noise management levels for commercial and industrial premises are provided in **Table 4-4**.

Table 4-3 Construction noise management levels – Sensitive land uses other than residential

Land use	Construction noise management level, $L_{Aeq\ (15\ min)}$ (applies when properties are in use)
Classrooms at schools and other educational institutions	Internal noise level 45 dB(A)
Hospital wards and operating theatres	Internal noise level 45 dB(A)
Places of worship	Internal noise level 45 dB(A)
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level 65 dB(A)
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example, reading, meditation)	External noise level 60 dB(A)
Community centres	Depends on the intended use of the centre. Refer to the recommended "maximum" internal levels in AS2107 for specific uses.

Table 4-4 Construction noise management levels – Commercial and industrial land uses

Land use	Construction noise management level, $L_{aeq\ (15min)}$ (applies when properties are in use)
Industrial premises	External noise level 75 dB(A)
Offices, retail outlets	External noise level 70 dB(A)

4.1.4 Construction road traffic noise

The Interim Construction Noise Guideline refers to the *Environmental Criteria for Road Traffic Noise*, now superseded by the *NSW Road Noise Policy*, for the assessment of construction traffic on public roads. Noise criteria are assigned to sensitive receivers using Roads and Maritime's *Noise Criteria Guideline*. The *Noise Criteria Guideline* documents Roads and Maritime's approach to implementing the *NSW Road Noise Policy*.

To assess noise impacts from construction traffic or a temporary reroute due to a road closure or both, an initial screening test should be undertaken by evaluating whether existing road traffic noise levels will increase by more than 2dB(A). Where the predicted noise increase is 2 dB(A) or less, then no further assessment is required. However, where the predicted noise level increase is equal to or greater than 2 dB(A), and the predicted road traffic noise level exceeds the road category specific criterion then noise mitigation would be considered for those receivers affected.

Relative noise levels are assessed using increments of 0.1 dB, therefore, a noise increase of 2.1 dB(A) would quality for noise mitigation consideration in accordance with the Roads and Maritime's *Noise Mitigation Guideline*.

Table 4-5 presents the *NSW Road Noise Policy* road traffic noise criteria for road categories applicable for this assessment. The criteria are external noise levels and apply one metre from the external façade of the affected building.

Table 4-5 Road traffic noise criteria – Sub-arterial roads

Period	Parameter	Criterion
Arterial roads		
Day (7am – 10pm)	$L_{Aeq\ (15\ hour)}$	60 dB(A)
Night (10pm – 7am)	$L_{Aeq\ (9\ hour)}$	55 dB(A)

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5 Assessment of impacts

5.1 Construction noise

5.1.1 Construction equipment

The construction of the Marsh Street ponds would comprise seven stages. These stages are provided in **Section 6.3**. The construction activities would take place from 7am to 6pm, Monday to Friday and 8am to 1pm Saturday, with no work on Sunday or public holidays.

The seven construction stages have been simplified into two packages of works; vegetation clearing, and general construction activities. The equipment composition of these work packages have been shown in **Table 5-1**.

Table 5-1 also presents the sound power levels of the proposed construction equipment for the described works above. These sound power levels are typical values taken from data provided in the *Australian Standard 2436-2010, Guide to noise control on construction, demolition and maintenance sites* and the UK Department for Environment, Food and Rural Affairs (DEFRA) noise database and assume equipment is modern and in good working order. The range and types of equipment used may be subject to change and would be confirmed during the detailed design phase. The *Interim Construction Noise Guideline* advises that 5 dB should be added to predicted levels where "particularly annoying" activities are to be undertaken. No "particularly annoying" activities are proposed for these works.

For a worst-case assessment, all construction equipment within the work package has been assumed to operate simultaneously.

Table 5-1 Sound power levels for proposed construction equipment and scenarios for surface works

Activity	Equipment	SWL, dB(A)	SWL, dB(A)
		Per plant	Total for the activity
Vegetation clearing	Shredder	113	114
	Stump grinder	106	
General construction activities	Excavator (35 tonne)	103	113
	Dump truck	102	
	Compactor	108	
	Concrete pump	106	
	Concrete vibrator	97	
	Fencing power auger	103	
	Concrete Truck	106[1]	
	Hand tools	94	

Note 1: Sound power levels are time-weighted.

5.1.2 Construction noise modelling and prediction

Noise levels due to the construction activities have been predicted at nearby residences using SoundPLAN noise modelling software v7.3. The modelling used the CONCAWE algorithm and includes ground topography, buildings and structures and representative construction noise sources as detailed in **Table 5-1**. Free field point receivers at 1.5 metres high were assumed.

It can be expected that measured noise levels may be lower than predicted noise levels due to variations in instantaneous operating conditions, plant in operation during the measurement and also the location of the plant equipment. The acoustic shielding calculated in the model due to fixed building structures would also vary as the construction equipment moves around the site. Neutral weather conditions were assumed for all construction scenarios.

Existing barriers along Marsh Street would not be impacted by the construction of the Marsh Street ponds. These barriers have been included into the noise model. Additional construction hoarding would be installed along the Eve Street boundary of the construction compound. The construction hoarding has been included into the model as a 1.8 metre barrier.

5.1.3 Construction noise assessment

The noise modelling results are provided in **Table 5-2**. The table presents the noise management levels, the median construction noise level (typically the noise level two to three rows of houses behind the construction works) and the highest predicted construction noise levels for each noise catchment area. The tables also present the number of receivers where the construction noise levels are predicted to exceed the NML and the number of receivers predicted to be highly noise affected level for each noise catchment area. The predicted construction noise levels are also provided graphically in **Appendix C**.

No other sensitive receivers, such as places of worship, schools and child care centres are identified in the area. Therefore, no results have been presented for these receiver types.

It is important to consider that this assessment is representative of the worst case 15 minute period of construction activity and does not necessarily represent the noise impact at noise sensitive receivers for an extended period of time. Particularly noisy activities, such as shredding or stump grinding, are likely to persist for only a fraction of the overall six month construction period.

The *Interim Construction Noise Guideline* states that where a receiver is predicted to be affected by construction noise levels of greater than 75 dB(A), it is considered to be 'highly noise affected' and afforded additional consideration. The receivers where noise levels exceed 75 dB(A) can be identified on the noise contours provided in **Appendix C**. The potential for highly noise affected receivers would be confirmed during detailed construction planning. These receivers would receive additional consultation with regards to specific timing and impacts of construction works. Respite periods would also be considered for these receivers in accordance with the *Interim Construction Noise Guideline*.

The predictions indicate that noise levels at commercial and industrial receivers would generally remain compliant with the applicable noise management levels. This would be confirmed in more detail in the Construction Noise and Vibration Management Plan.

Table 5-2 Marsh Street ponds daytime construction noise results

NCA	L_{Aeq} Noise management level dB(A)	Predicted median L_{Aeq} noise level dB(A)	Predicted maximum L_{Aeq} noise level, dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers
Vegetation clearing						
NCA12	65	42	54	0	0	0
NCA13	59	52	78	19	14	1
NCA14	57	45	62	5	6	0
General construction activities						
NCA12	65	41	53	0	0	0
NCA13	59	51	77	18	13	1

NCA	L_{Aeq} Noise management level dB(A)	Predicted median L_{Aeq} noise level dB(A)	Predicted maximum L_{Aeq} noise level, dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers
NCA14	57	44	61	4	4	0

The results indicate that noise levels at all receivers within NCA 12 would comply with the NML in all construction scenarios. Some receivers within NCA 13 and NCA 14 would experience noise levels in exceedance of their respective NMLs during the vegetation clearing and general construction activities. For the entire construction period, only one receiver is predicted to be highly-affected. This receiver is within NCA 13, located on the same side of Eve Street as the Marsh Street ponds site.

Vegetation clearing, which induces slightly higher noise levels than other works, would only occur for a short period of time at the beginning of construction. For the remainder of the construction period, all equipment would be unlikely to operate simultaneously as has been assessed. As such, the results presented are conservative and would not occur for the entire six month construction period.

5.2 Cumulative noise assessment

5.2.1 Cumulative impacts from the project

Construction of the overall project is scheduled to start mid-2016, and it is likely that they would be overlap of construction activities at the Marsh Street pond site with other components of the project. The other project works that would occur near to the Marsh Street ponds would be located within the Arncliffe construction compound (C7).

Predicted noise levels due to construction works at the Arncliffe construction compound have been provided within the Technical working paper: Noise and vibration. Noise levels as a result of cumulative impact could increase by up to 3 dB(A) higher than the maximum noise level predicted for the Marsh Street ponds works or Arncliffe construction compound works. In addition an increase in the frequency of potential construction noise impact may occur.

Detailed construction scheduling is not yet complete for the New M5 Motorway, therefore it is not clear which works would occur concurrently with others. As noted above, the maximum noise level increase would be 3 dB(A) on the maximum noise level predicted for the individual construction works. It should be noted that an increase of this magnitude would be unlikely due to the following reasons:

- The construction noise assessment for each set of works has been completed on a worst case basis, assuming all equipment is operating simultaneously and are all positioned at the worst possible position within the construction footprint. If all equipment does not operate or if acoustic shielding or distance loss is provided the noise levels would be lower than presented in this assessment and in the Technical working paper.
- It is likely that one set of works would be the dominant source at any residential receiver and therefore the cumulative impact would be less than an increase of 3 dB(A). This is very likely as the Arncliffe construction compound and the Marsh Street ponds construction sites are separated by the M5 East Motorway. Therefore, residences along Eve Street and West Botany Street, south of Wickham Street, would be impacted more by the Marsh Street ponds and residences along Marsh Street would be impacted more by the Arncliffe construction compound.

Given that the potential increase due to cumulative impacts is a maximum of 3 dB(A), which is widely accepted as being ‘just perceptible’, and is more likely to be less than 3 dB(A), it is not considered beneficial to provide further analysis at this stage. In any case all feasible and reasonable noise mitigation measures would be implemented and an increase of up to 3 dB(A) is unlikely to modify these mitigation measures.

Should any receiver become 'highly noise affected' due to concurrent construction works, such receivers would be afforded additional consideration in accordance with the requirements of the *Interim Construction Noise Guideline*.

5.2.2 Cumulative impacts from other projects

Currently there are no major projects scheduled which are in the direct vicinity of the project that could result in increased noise impacts.

During construction, ongoing consultation would be undertaken with local communities regarding potential overlaps in the construction of the project and other newly approved projects. Additionally, consultation would be undertaken with the proponents of any other nearby projects to increase the overall awareness of project timeframes and any cumulative impacts.

5.3 Construction traffic noise

The volume of traffic that would be generated by vehicles associated with the construction is expected to be small, with three light vehicles and two heavy vehicles expected to enter and exit site during each peak hour (totalling 10 movements). Vehicles used would include heavy vehicles used to transport spoil and light vehicles associated with the construction workers.

For the purposes of the construction traffic impact assessment, the period of construction activity that generates the peak volume of heavy vehicles was assessed to represent the worst case scenario. This peak construction period assumes that two heavy vehicles and three light vehicles would be associated with the construction of the Marsh Street ponds during each peak hour (totalling 10 movements). Daytime movements in off-peak periods would be minimal and have negligible impacts on surrounding receivers. Therefore, only peak-hour periods have been assessed.

5.3.1 Peak Movements

Provided in **Table 5-3** and **Table 5-4** are summaries of the existing, forecasted additional traffic flow and the resultant noise increases for the AM and PM peak periods. These periods occur between 6:30am and 9:30am and between 3:30pm and 7:00pm respectively.

Table 5-3 Construction road traffic during AM peak hour

Route/Direction	Existing (hourly)		Additional (hourly)		Relative noise level increase, dB(A)
	Light	Heavy	Light	Heavy	
Arncliffe area					
West Botany Street (Marsh Street - Wickham Street)	3,050	168	6	4	0.0
West Botany Street (Wickham Street - Brennans Road)	1,183	59	6	4	0.1

Table 5-4 Construction road traffic during PM peak hour

Route/Direction	Existing (hourly)		Additional (hourly)		Relative noise level increase, dB(A)
	Light	Heavy	Light	Heavy	
Arncliffe area					
West Botany Street (Marsh Street - Wickham Street)	3,723	97	6	4	0.0

Route/Direction	Existing (hourly)		Additional (hourly)		Relative noise level increase, dB(A)
	Light	Heavy	Light	Heavy	
West Botany Street (Wickham Street - Brennans Road)	2,644	47	6	4	0.1

The predicted increases in road traffic noise for the AM and PM peak periods are expected to be less than 2 dB(A) and are therefore within the recommended construction traffic noise goal.

It should be noted that construction compound access would be provided off Eve Street, with construction vehicles entering the site by turning left from Marsh Street onto Eve Street and exiting the site onto Marsh Street from Eve Street.

Existing road traffic volumes along Eve Street and Wickham Street were not available. The traffic volume along Eve Street is likely to be considerably lower than the surrounding road network. The noise environment at residential receivers along Eve Street is currently controlled by traffic on the surrounding road network. The Marsh Street ponds – Transport and traffic impact assessment (Appendix C of the Submissions and Preferred Infrastructure Report)identifies that the additional traffic volumes generated would likely have minimal impact on the road traffic volumes for Wickham Street, with an estimated one percent or less change in volume. Therefore, an additional three light vehicles and two heavy vehicles, making ten movements in total would not cause appreciable noise increases at residential receivers along Eve Street and Wickham Street.

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6 Construction noise mitigation measures

This chapter of the report presents construction noise mitigation measures to be considered for implementation to minimise and manage construction noise impacts. Noise impacts would be managed through the implementation of the environmental management measures outlined in Chapter 8 (Revised environmental management measures) of the Submissions and Preferred Infrastructure report. These are reproduced in **Section 6.1** of this report.

The construction noise assessment presented in **Section 5.1** of this report detailed a number of exceedances of the noise management levels within this project. These were predicted as a result of two different construction work packages. A number of exceedances of the 'highly noise affected' criteria have also been predicted within the study area. As a result of these exceedances, the following generic and receiver specific mitigation measures have been identified.

6.1 Construction noise and vibration management plan

A Construction Noise and Vibration Management Plan (CNVMP) would be prepared for the project. Construction Noise and Vibration management considerations which are specific to the Marsh Street ponds site would be incorporated into the project Construction Noise and Vibration Management Plan. The Construction Noise and Vibration Management Plan would include the following:

- Identification of nearby residences and other sensitive land uses
- Description of approved hours of work
- Description and identification of all construction activities, including work areas, equipment and duration
- Description of what work practices (generic and specific) would be applied to minimise noise and vibration
- A complaints handling process
- Noise and vibration monitoring procedures
- Overview of community consultation required for identified high impact works
- The CNVMP should include consideration of construction noise fatigue.

Feasible and reasonable mitigation measures would be detailed within the CNVMP to manage predicted noise levels at sensitive receivers and areas where construction fatigue could occur. Consultation with the affected community would also occur prior to and during construction.

6.2 Community consultation and complaints handling

All residents impacted by noise from the proposed works which are expected to exceed the construction noise management levels (NML) should be consulted about the project prior to the commencement of the particular activity, with the highest consideration given to those that are predicted to be most affected as a result of the works.

The information provided to the residents should include:

- Programmed times and locations of construction work
- The hours of proposed works
- Construction noise and vibration impact predictions
- Construction noise and vibration mitigation measures being implemented on site.

Community consultation regarding construction noise and vibration would be detailed in the Community Involvement Plan for the construction of the project and would include a 24 hour hotline and complaints management process.

6.3 Construction Works

6.3.1 Work practices

Induction and training would be provided to relevant staff and sub-contractors outlining their responsibilities with regard to noise and vibration.

6.3.2 Construction hours and work scheduling

Particularly noisy activities such as the use of shredders and grinders should be scheduled where feasible and reasonable around times of high background noise to provide masking.

Deliveries would be carried out during standard construction hours where feasible and reasonable.

6.3.3 Respite

A protocol would be developed to identify the need for and provision of respite measures for residential receivers in accordance with the *Interim Construction Noise Guidelines*. Respite measures may include the restriction to the hours of construction activities resulting in impulsive or tonal noise (such as shredding or stump grinding), or other appropriate measures agreed between Roads and Maritime and residential receiver.

The protocol would form part of the Construction Noise and Vibration Management Plan.

6.3.4 Construction compound

The noise associated with the operation of the construction compound would primarily result from the operation of fixed and mobile plant and truck movements. Consideration would be given to the layout of the site in order to maximise distance and shielding to nearby receivers.

6.3.5 Plant and equipment selection and location

The selection of plant and equipment can have a significant impact on construction noise levels. Appropriate plant would be selected for each task to minimise the noise contributions.

Alternative works methods such as use of hydraulic or electric-controlled units in place of diesel units would be considered and implemented where feasible and reasonable. The use of alternative machines that perform the same function, such as rubber wheeler plant, would be considered in place of steel tracked plant.

Equipment would be regularly inspected and maintained to ensure it is in good working order.

Plant should be located on site with as much distance as possible between the plant and noise sensitive receivers. Noisy equipment would be orientated away from residential receivers where feasible and reasonable.

6.3.6 Noise barriers

The proposed construction hoarding locations can be found in **Table 2-2**. The proposed construction hoarding would attenuate noise between construction works and sensitive receivers.

Existing road noise barriers along Marsh Street would be retained for the entirety of the construction period.

6.3.7 Noise monitoring

Noise monitoring program would be implemented to assist in confirming and controlling the site specific potential for disturbance at particularly sensitive localities at the commencement of activities and periodically during the construction program as the works progress. The results would be reviewed to determine if additional mitigation measures are required. All measurements would be undertaken in accordance with Australian Standard 1055.1-1997 – *Acoustics – Description and measurement of environmental noise, Part 1: General procedures*.

A noise monitoring program would be presented in the Construction Noise and Vibration Management Plan.

6.4 Construction Traffic

The following measures would be implemented to reduce and manage noise and vibration impacts:

- Truck drivers would be advised of designated vehicle routes, parking locations, acceptable delivery hours or other relevant practices (i.e. minimising/restricting the use of engine compression brakes, and no extended periods of engine idling)
- Site access and egress points would be located away from residences and other sensitive land uses, where feasible and reasonable
- Deliveries and spoil removal would be planned to avoid queuing of trucks on or around the construction compound
- Construction sites would be arranged to limit the need for reversing associated with regular / repeatable movements (eg trucks transporting spoil) to minimise the use of reversing alarms
- Where feasible and reasonable, non-tonal reversing alarms would be used, taking into account the requirements of the Workplace Health and Safety legislation.

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7 Conclusion and recommendations

In relation to construction and vibration impacts associated with the construction and operation of the Marsh Street ponds, the proposed design change would cause some construction noise management level exceedances. One residential receiver would be 'highly noise affected'. This resident is situated on the same side of Eve Street, Arncliffe, as the construction footprint.

Two construction work packages were assessed for the Marsh Street ponds – vegetation clearing and general construction activities. Vegetation clearing, which induces slightly higher noise levels than other works, would only occur for a short period of time at the beginning of construction. For the remainder of the construction period, all equipment would not operate simultaneously as has been assessed. As such, the results presented are conservative and would not occur for the six month construction period.

Generally these receivers would not be affected by the noise and vibration impacts as presented in the Technical working paper: Noise and vibration would now experience construction noise impacts.

To manage the potential impacts, the mitigation and management measures outlined in **Chapter 6** of the assessment should be implemented. These mitigation and management measures are in-line with those provided within the Technical working paper: Noise and vibration.

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Appendix A Acoustic terminology

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The following is a brief description of acoustic terminology used in this report.

Term	Definition
Sound power level	The total sound emitted by a source
Sound pressure level	The amount of sound at a specified point
Decibel [dB]	The measurement unit of sound
A Weighted decibels [dB(A])	The A weighting is a frequency filter applied to measured noise levels to represent how humans hear sounds. The A-weighting filter emphasises frequencies in the speech range (between 1 kHz and 4 kHz) which the human ear is most sensitive to, and places less emphasis on low frequencies at which the human ear is not so sensitive. When an overall sound level is A-weighted it is expressed in units of dB(A).
Decibel scale	The decibel scale is logarithmic in order to produce a better representation of the response of the human ear. A 3 dB(A) increase in the sound pressure level corresponds to a doubling in the sound energy. A 10 dB(A) increase in the sound pressure level corresponds to a perceived doubling in volume. Examples of decibel levels of common sounds are as follows: 0 dB(A) Threshold of human hearing 30 dB(A) A quiet country park 40 dB(A) Whisper in a library 50 dB(A) Open office space 70 dB(A) Inside a car on a freeway 80 dB(A) Outboard motor 90 dB(A) Heavy truck pass-by 100 dB(A) Jack hammer / subway train 110 dB(A) Rock Concert 115 dB(A) Limit of sound permitted in industry 120 dB(A) 747 take off at 250 metres
Frequency [f]	The repetition rate of the cycle measured in Hertz (Hz). The frequency corresponds to the pitch of the sound. A high frequency corresponds to a high pitched sound and a low frequency to a low pitched sound.
Equivalent continuous sound level [L_{eq}]	The constant sound level which, when occurring over the same period of time, would result in the receiver experiencing the same amount of sound energy.
Insertion loss	Reduction in noise by inserting a barrier between the source and receiver
L_{max}	The maximum sound pressure level measured over the measurement period
L_{min}	The minimum sound pressure level measured over the measurement period
L_{10}	The sound pressure level exceeded for 10% of the measurement period. For 10% of the measurement period it was louder than the L_{10}.
L_{90}	The sound pressure level exceeded for 90% of the measurement period. For 90% of the measurement period it was louder than the L_{90}.
Ambient noise	The all-encompassing noise at a point composed of sound from all sources near and far.
Background noise	The underlying level of noise present in the ambient noise when extraneous noise (such as transient traffic and dogs barking) is removed. The L90 sound pressure level is used to quantify background noise.

Term	Definition
Traffic noise	The total noise resulting from road traffic. The L_{eq} sound pressure level is used to quantify traffic noise.
Day	**Construction noise** The period from 0700 to 1800 h Monday to Saturday and 0800 to 1800 h Sundays and Public Holidays. **Road traffic noise** The period from 0700 to 2200 h every day of the week.
Evening	**Construction noise** The period from 1800 to 2200 h Monday to Sunday and Public Holidays. **Road traffic noise** Not applicable.
Night	**Construction noise** The period from 2200 to 0700 h Monday to Saturday and 2200 to 0800 h Sundays and Public Holidays. **Road traffic noise** The period from 2200 to 0700 h every day of the week.
Assessment background level [ABL]	The overall background level for each day, evening and night period for each day of the noise monitoring.
Rating background level [RBL]	The overall background level for each day, evening and night period for the entire length of noise monitoring.

*Definitions of a number of terms have been adapted from Australian Standard AS1633:1985 “Acoustics – Glossary of terms and related symbols”, the EPA’s *Industrial Noise Policy* and *Road Noise Policy*.

Appendix B Noise catchment area

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AECOM

Legend

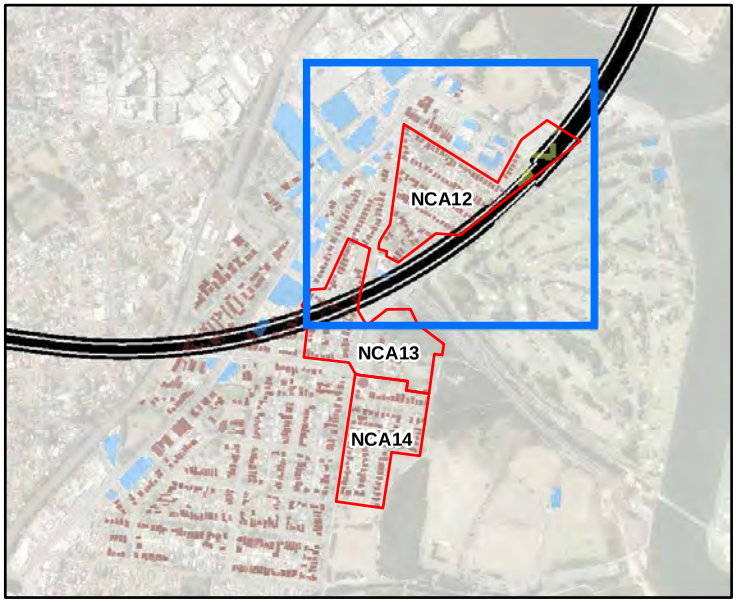
- Logger Locations
- Noise Catchment areas

Project Features

- Construction Compounds
- Tunnel
- Road Works

Building Usages

- Aged care
- Child Care
- Church
- Commercial
- Community Centre
- Empty Lot
- Fire Station
- Hotel
- Industrial
- Mixed Use
- Recreational
- Residential
- School
- Under Construction



WestConnex Stage 2

Noise Catchment Area - NCA 12

Source: SKM2014

0 50 100 200 m

N

NOV 2015

60327128

Fig. **12**

AECOM

Legend

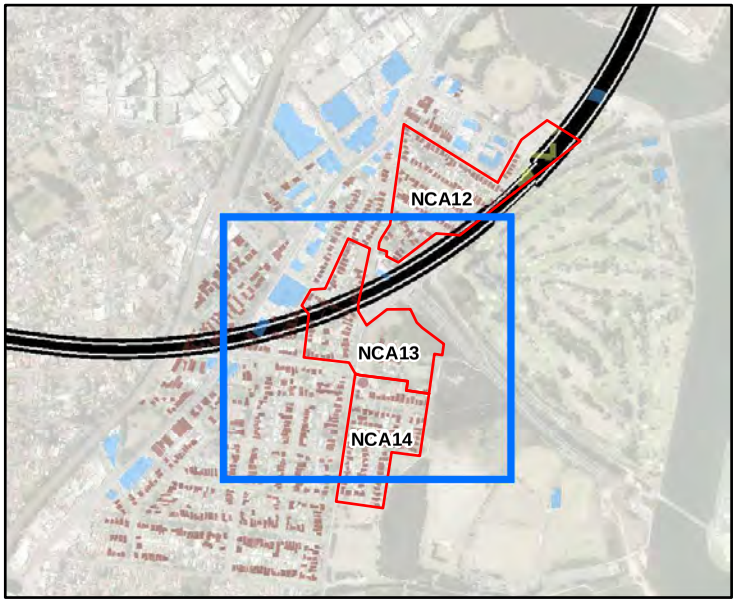
- Logger Locations
- Noise Catchment areas

Project Features

- Construction Compounds
- Tunnel
- Road Works

Building Usages

- Aged care
- Child Care
- Church
- Commercial
- Community Centre
- Empty Lot
- Fire Station
- Hotel
- Industrial
- Mixed Use
- Recreational
- Residential
- School
- Under Construction



WestConnex Stage 2

Noise Catchment Area - NCA 13

Source: SKM2014

0 50 100 200 m

N

NOV 2015

60327128

Fig. **13**

AECOM

Legend

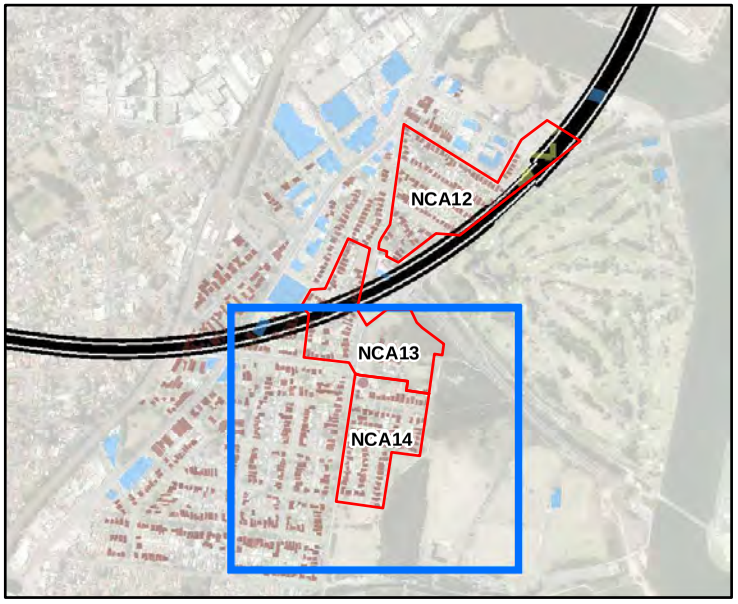
- Logger Locations
- Noise Catchment areas

Project Features

- Construction Compounds
- Tunnel
- Road Works

Building Usages

- Aged care
- Child Care
- Church
- Commercial
- Community Centre
- Empty Lot
- Fire Station
- Hotel
- Industrial
- Mixed Use
- Recreational
- Residential
- School
- Under Construction



WestConnex Stage 2

Noise Catchment Area - NCA 14

Source: SKM2014

0 50 100 200 m

N

NOV 2015

60327128

Fig. **14**

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Appendix C L_{Aeq} Noise Contours

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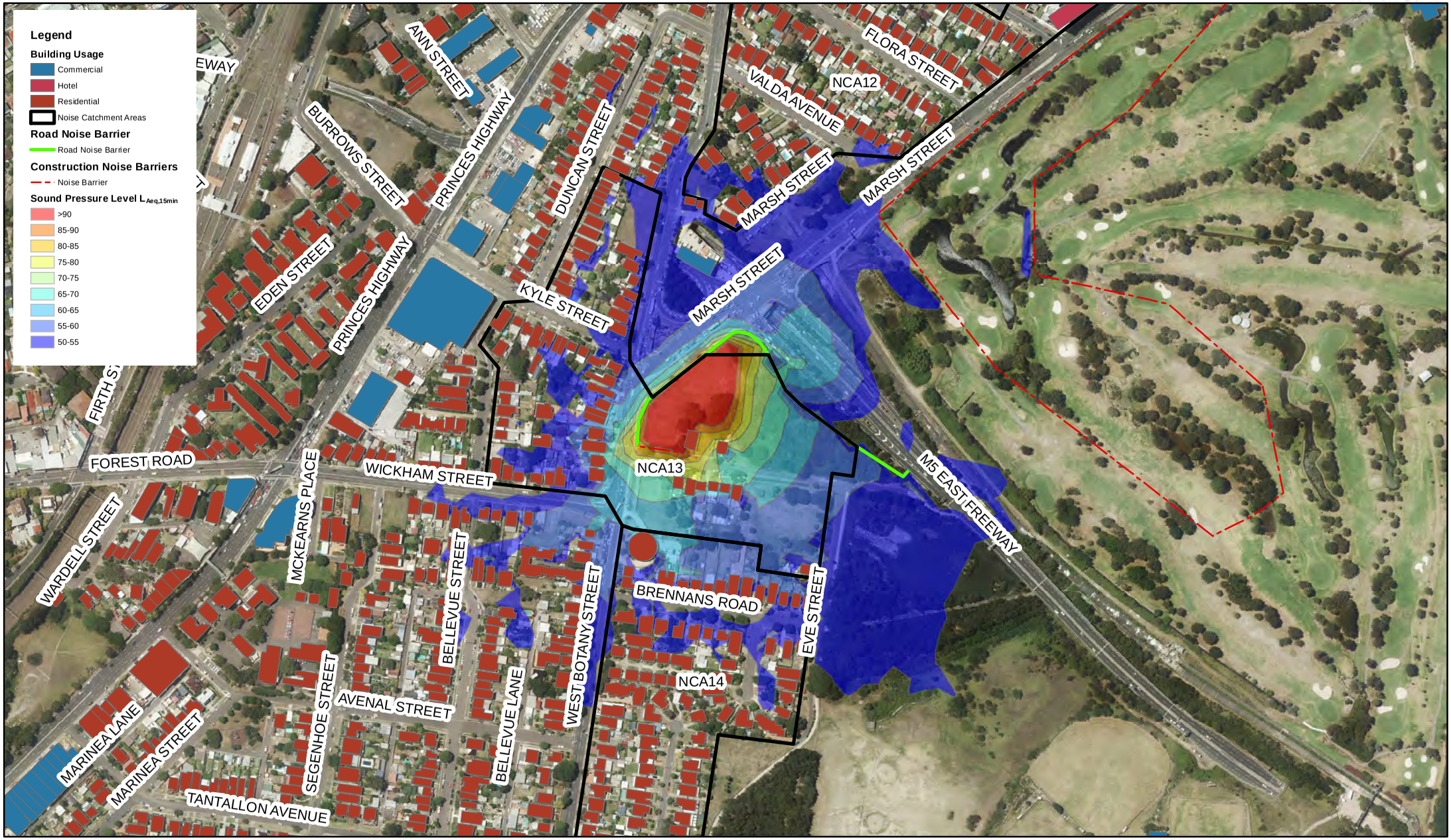

WestConnex Stage 2 - Construction Noise Impact Assessment
Vegetation clearing - Day

Source: SKM2014

FEB 2016

60327128

Time	Descriptor	Sound Pressure Level, L_{Aeq} dB(A)																													
		NCA1	NCA2	NCA3	NCA4	NCA5	NCA6	NCA7	NCA8	NCA9	NCA10	NCA11	NCA12	NCA13	NCA14	NCA15	NCA16	NCA17	NCA18	NCA19	NCA20	NCA21	NCA22	NCA23	NCA24	NCA25	NCA26	NCA27	NCA28	NCA29	NCA30
Day	Background	57	45	45	57	57	45	52	54	60	58	58	55	49	47	51	54	48	48	45	50	47	47	49	50	47	47	60	52	47	53
	NML	67	55	55	67	67	55	62	64	70	68	68	65	59	57	61	64	58	58	55	60	57	57	59	60	57	57	70	62	57	63
Evening	Background	51	43	43	51	51	43	50	45	54	56	52	55	48	47	51	54	48	48	45	49	46	46	49	50	47	47	58	51	47	52
	NML	56	48	48	56	56	48	55	50	59	61	57	60	53	52	56	59	53	53	50	54	51	51	54	55	52	52	63	56	52	57
Night	Background	40	32	32	40	40	32	44	40	43	49	42	45	42	39	43	40	43	43	43	40	40	40	42	42	41	41	46	39	41	44
	NML	45	37	37	45	45	37	49	45	48	54	47	50	47	44	48	45	48	48	48	45	45	45	47	47	46	46	51	44	46	49

0 25 50 100 m

N

Fig.

15_01

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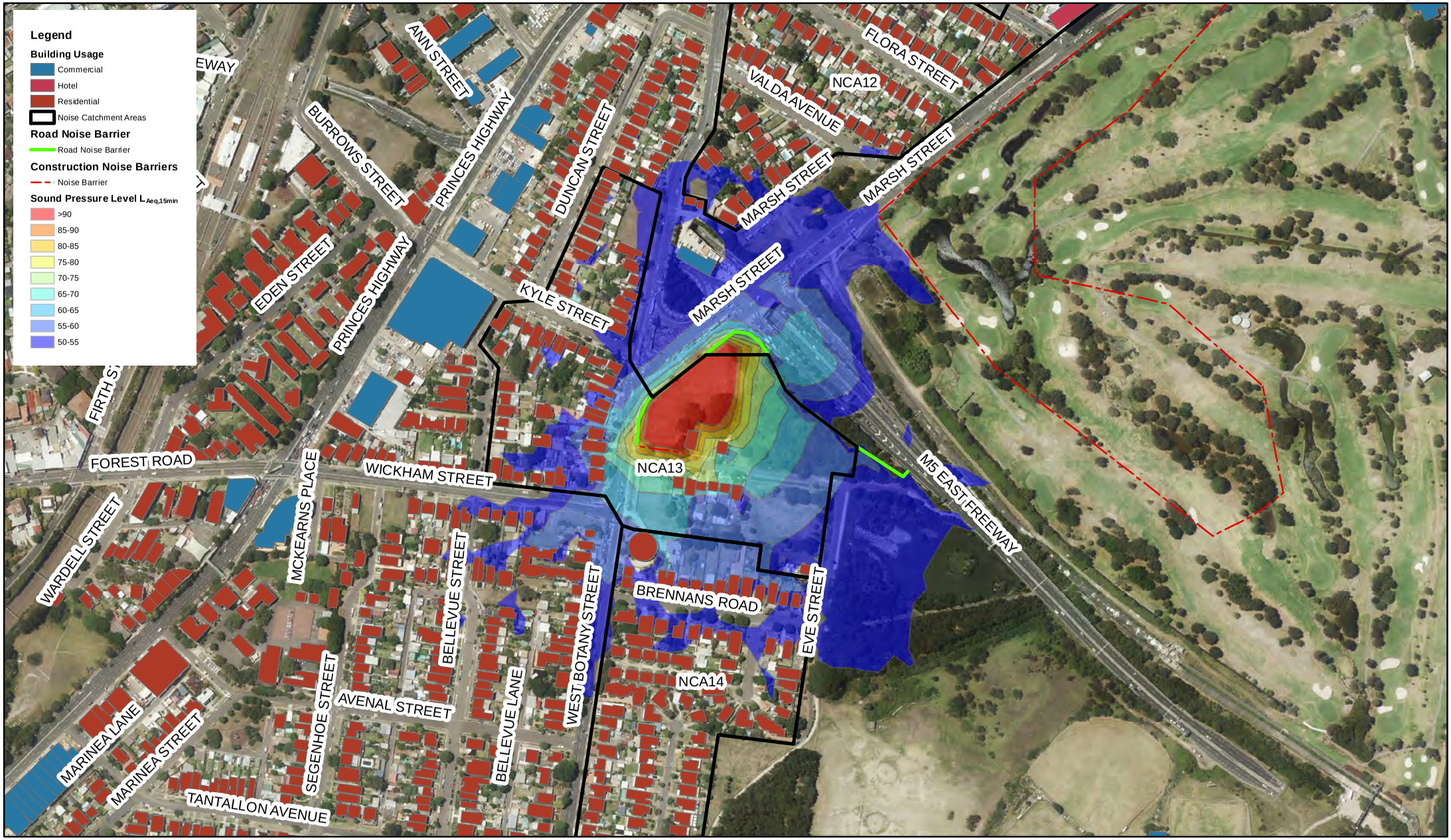

WestConnex Stage 2 - Construction Noise Impact Assessment
General construction activities - Day

FEB 2016
60327128

Source: SKM2014

Time	Descriptor	Sound Pressure Level, L_{Aeq} dB(A)																													
		NCA1	NCA2	NCA3	NCA4	NCA5	NCA6	NCA7	NCA8	NCA9	NCA10	NCA11	NCA12	NCA13	NCA14	NCA15	NCA16	NCA17	NCA18	NCA19	NCA20	NCA21	NCA22	NCA23	NCA24	NCA25	NCA26	NCA27	NCA28	NCA29	NCA30
Day	Background	57	45	45	57	57	45	52	54	60	58	58	55	49	47	51	54	48	48	45	50	47	47	49	50	47	47	60	52	47	53
	NML	67	55	55	67	67	55	62	64	70	68	68	65	59	57	61	64	58	58	55	60	57	57	59	60	57	57	70	62	57	63
Evening	Background	51	43	43	51	51	43	50	45	54	56	52	55	48	47	51	54	48	48	45	49	46	46	49	50	47	47	58	51	47	52
	NML	56	48	48	56	56	48	55	50	59	61	57	60	53	52	56	59	53	53	50	54	51	51	54	55	52	52	63	56	52	57
Night	Background	40	32	32	40	40	32	44	40	43	49	42	45	42	39	43	40	43	43	43	40	40	40	42	42	41	41	46	39	41	44
	NML	45	37	37	45	45	37	49	45	48	54	47	50	47	44	48	45	48	48	48	45	45	45	47	47	46	46	51	44	46	49

0 25 50 100 m

N

Fig.
15_02

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New M5

Environmental Impact Statement

Marsh Street Ponds – Surface Water and Flooding Impact Assessment

Appendix E

March 2016

WestConnex

WESTCONNEX NEW M5

Appendix E – Marsh Street ponds – Surface water and flooding impact assessment

MARCH 2016

This document cover is to be replaced with a Roads and Maritime Services approved document cover. Refer to Roads and Maritime Services Visual Identity Manual.

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Roads and Maritime Services

WestConnex New M5

Marsh Street ponds – Surface water and flooding impact assessment

March 2016

Prepared for

Roads and Maritime Services

Prepared by

AECOM Australia

Document controls

Title	New M5 Submissions and Preferred Infrastructure report Appendix F - Surface water and flooding
	WestConnex New M5 Marsh Street ponds – Surface water and flooding impact assessment
Approval and authorisation	
Prepared by:	AECOM Australia
Authorised by:	Caitlin Bennett Associate Director - Environment
	3 March 2016

Document status	Date
Final	3 March 2016

1 Introduction

1.1 Background

The surface water and flooding impacts during the construction and operation of the WestConnex New M5 project have been assessed and presented in the Technical working paper: Surface water (AECOM, 2015) and Technical working paper: Flooding (Lyall & Associates, 2015), which formed part of the Environmental Impact Statement (EIS) for the project.

The Green and Golden Bell Frog Plan of Management, which was prepared for the project, identified the provision of additional habitat on a parcel of land to the east of the Marsh Street and West Botany Street intersection, Arncliffe (the site), referred to as the Marsh Street ponds. However, no design detail was available at time of the EIS preparation.

The design of the proposed Marsh Street ponds has now been progressed as part of the project and a review of the potential impacts associated with the construction and operation of the ponds has been undertaken.

The inclusion of this additional habitat as part of the project requires additional assessment as it could generate additional surface water and flooding impacts during the construction and operation of the Marsh Street ponds.

1.2 Purpose of this report

This report provides an addendum to the Technical working paper: Surface water (AECOM, 2015) and presents a summary of the surface water and flooding impacts that could be generated during the construction and operation of the Marsh Street ponds.

This report is to be read in conjunction with the Technical working paper: Surface water (AECOM, 2015) and Technical Working Paper: Flooding (Lyall & Associates, 2015) which contains detailed descriptions and explanations on the assessment guidelines and methodologies used.

1.3 Methodology

For this study, the methodology adopted is consistent with the EIS. This chapter details the methodology applied in this assessment, which involved:

- Compilation of relevant information, including past flood studies and flood information, records and mapping of existing drainage infrastructure, and water quality and geomorphic characterisations of the area surrounding the site.
- Characterisation of the existing environment and potential surface water issues through review and analysis of existing information (desktop analysis).
- A field inspection to confirm the outcomes of the desktop analysis, and further refine the scope or relevant issues to be considered in the surface water impact assessment.
- Assessment of specific surface water issues, including flooding, surface water quality and geomorphology impacts during construction and operation, having regard to applicable policies and guidelines. MUSIC modelling has been undertaken to quantify the changes in flow entering the downstream environment of the Eve Street wetlands.

The assessment of flooding comprised a desktop study and site assessment to identify overland flow paths, the stormwater drainage network, and floodplain storage. The potential for works associated with the Marsh Street ponds project to impact flooding characteristics surrounding the site has been identified.

The assessment of surface water quality impacts from proposed works has involved collation and review of available data on stream condition, water quality and soils to define the existing environment within the catchments and watercourses (where available). The assessment of the project impacts on surface water runoff incorporates an assessment of the mitigation measures provided in the design.

The quality of surface water runoff during the construction phase is largely determined by sediment and erosion control measures, and requires an assessment of the erosion hazard of the site soils. This assessment is guided by *Managing Urban Stormwater: Soils and Construction* (The Blue Book) (Landcom, 2004) and construction environmental management plan (CEMP) requirements.

The surface water impacts on the geomorphology of the downstream flow paths were assessed for the construction and operation phases of the Marsh Street ponds. A review of the dominant soil landscapes found in the study area was undertaken. Geomorphological conditions were verified during a visual inspection as part of the field assessment.

This report only considers the issues that are relevant to the construction and operation of the Marsh Street ponds.

1.3.1 Field assessment

The objective of field inspections was to assess the current state of surface water features within the surface water study area. A judgement of their resilience was made to determine if the surface water environment is likely to be impacted by the Marsh Street ponds. Field assessment included inspection of features that could be impacted by changes to surface water flooding, hydrology or water quality.

A field inspection of the site and the surrounding environment was undertaken on 4 February 2016 by AECOM's Nick Bartho and Josh Atkinson. Some rainfall had occurred in the five days preceding the inspection, including 23 millimetres in 24 hours to 9:00 on 31st January 2016 (BoM Station No. 066037). This inspection included the channel through the Marsh Street wetland, the Eve Street wetland and the channel connecting the Eve Street wetland to the Cooks River. Dense vegetation restricted access to the waterways and channels at the time of the inspection.

2 Design change – Marsh Street ponds

2.1 Description of change

Operation

The Green and Golden Bell Frog Plan of Management identified the provision of new additional habitat at Marsh Street (refer to Appendix S of the EIS) as part of a broader package of mitigation and management measures to promote the long term survival of the local population by expanding and enhancing the habitats available for the species. This additional habitat is referred to as the Marsh Street ponds.

The Marsh Street ponds would be located on a parcel of land to the east of the Marsh Street and West Botany Street intersection (the site) (**Figure 2-1**). The site is owned by Roads and Maritime Services (Roads and Maritime).

The Marsh Street ponds would consist of:

- Three Green and Golden Bell Frog ponds, located along the western boundary of the site consisting of:
  - One pond of around 1.5 metres in depth, about 25 metres long, which has been designed to provide refuge habitat; and
  - Two ponds of around 0.8 metres in depth, about 20 metres long, which has been designed to provide suitable breeding habitat.
- Water supply systems, including a header tank (with capacity of around 200 kilolitres), pipes and a drainage swale to fill and drain the ponds
- A serviced work shed, around 10 square metres, to support maintenance and monitoring activities, and to store equipment
- Perimeter fencing, designed to enable frog passage along the eastern and northern perimeter of the site, and to prevent frog passage along the southern and western perimeter
- Permanent vehicle access off Eve Street.

A concept design of the Marsh Street ponds is provided in **Figure 2-1**.

The larger and deeper pond has been designed as the refuge pond and would be the only pond that would permanently contain water. The two smaller ponds would vary considerably in depth during each season (by water management) and may even be allowed to become dry for short periods. A rock platform with fixing for a small outboard motor is to be provided in each pond, extending into open water for pond mixing.

The edges of clay lined ponds would be planted with aquatic macrophytes. Pond banks and areas between the ponds would be planted with suitable plant species to provide shelter, foraging and dispersal habitat for the Green and Golden Bell Frog. Sandstone rocks would also be placed at suitable locations within the site to provide refuge close to the ponds.

To the south and east of the three ponds, a drainage and habitat swale would be created. This swale would be capable of receiving water from two of the three ponds via a piped drainage outlet. Drainage from the larger pond (when required) would be undertaken by an external pump. The swale would be of a suitable size to allow for ponds to be periodically drained, while being able to withstand any erosion. This swale would be planted with species suitable for shelter and foraging habitat.

The water source to the ponds, and suitability of the source for this purpose, would be confirmed during detailed design. Potential sources (in order of preference) include:

- Stormwater harvesting via connections to Rockdale City Council's stormwater system at Eve Street
- Potable water. A connection to the Sydney Water main could also be constructed to provide a supply, or in the case of stormwater harvesting, a backup supply to the ponds during dry periods and/or
- Treated groundwater from the permanent water treatment plant located at the Arncliffe motorway operations complex.

Water discharged from the site would eventually flow through land owned by Rockdale City Council; into an existing vegetated drain which formed part of the original Marsh Street wetland, which flows into the Eve Street wetland (a Sydney Water asset). Overflow water from the Eve Street wetlands is discharged also via an open drain into Muddy Creek (near its junction with the Cooks River).

Consultation with Rockdale City Council would continue during detailed design. This would include consultation with Rockdale City Council to ensure that the conveyance of water through its land is appropriately managed.

Roads and Maritime would also consult with Sydney Water with respect to connections to the water main. Any works would be in accordance with Sydney Water's requirements.

The management protocols of Marsh Street ponds have been detailed in a Green and Golden Bell Frog Habitat Creation and Captive Breeding Plan (Eco Logical Australia, 2016), which is provided in Appendix B of the New M5 Submissions and Preferred Infrastructure report. This plan details the management protocols for the site during construction and operation. This includes (but is not limited to):

- Dosing the ponds with salt (sodium chloride) to control Chytrid disease (Chytrid is a skin fungal disease that can wipe out frog populations)
- Control of pond water levels
- Drainage of individual ponds for vegetation management to promote dieback and regrowth of aquatic macrophytes, and plague minnow control to ensure that pond communities do not become diverse and unsuitable for the frogs
- Vegetation management for the removal of trees to ensure adequate access to sunlight.

The design of the ponds is subject to detailed design, but would be consistent with the requirements of the Green and Golden Bell Frog Habitat Creation and Captive Breeding Plan.

The Marsh Street ponds would be managed for conservation in perpetuity, such as through a biobanking agreement or through a community trust. The long term management framework would be determined in consultation with Rockdale City Council.

Figure 2-1 The Marsh Street ponds (indicative)

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Construction

Construction would take around six months to complete, and is expected to be completed no later than the end of 2019 (refer to **Table 2-1**). Works would occur during standard construction hours (Monday to Friday 7am to 6pm, Saturday 8am to 1pm).

Table 2-1 Indicative construction program (Marsh Street ponds)

Construction activity	Indicative construction timeframe (month)					
	1	2	3	4	5	6
Site establishment						
Pond construction works						
Plantings, construction of supporting infrastructure and landscaping						
Demobilisation						

A construction compound would not be established at the site. Any required construction support would be from the Arncliffe construction compound. Amenities would be provided at the site (such as a temporary office and portable toilet).

Site access would be provided off Eve Street, with construction vehicles accessing the site via Eve Street / West Botany Road intersection and exiting via the same intersection, West Botany Street and Wickham Street. During the peak construction period, around 10 movements (or five vehicles) per hour would be generated. The construction footprint for the site is depicted in **Figure 2-2**.

Opportunities to minimise vegetation clearance within the construction footprint would be explored during detailed design.

The key construction activities at the site would include:

- Site establishment including vegetation removal
- Bulk earthworks to form the three ponds and drainage network
- Stockpiling of materials and spoil
- Construction of the work shed, site access point and fencing, including a limited area of hardstand
- Utility connections, including stormwater, potable water (including installation of a header tank), sewer and electricity
- Landscaping and rehabilitation
- Demobilisation.

A 1.8 metre high hoarding would be provided along the Eve Street perimeter of the site. The existing road noise barriers along Marsh Street would not be impacted by the construction activity.

Excavated spoil, in excess of site requirements or spoil not suitable for re-use would be temporarily stockpiled on site prior to removal. Spoil would be managed in accordance with the Spoil Management Plan for the overall project.

The potential for encountering contaminated and acid sulfate soils during bulk earthworks would be confirmed during detailed design and management measures implemented to manage potential odour, soil and water quality impacts.

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Figure 2-2 The Marsh Street Ponds - Construction footprint

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3 Existing environment

The site of the proposed Marsh Street ponds is located on a 5,400 square metre parcel of land between Marsh Street, West Botany Street, the M5 East Motorway and Eve Street in Arncliffe, Sydney (the site). Historically the area has been a mixture of residential uses and market gardens.

At present the site is a grass reserve that drains towards a constructed vegetated channel through the Marsh Street wetland (on land owned by Rockdale City Council), which in turn drains to Eve Street wetland owned by Sydney Water, and onto the Cooks River. The construction of the Marsh Street Ponds has the potential to impact the rehabilitated section of channel in the Marsh Street wetlands as well as the Eve Street wetland.

3.1 Soil landscape

The *Soil Landscapes of the Sydney 1:100,000 Sheet 9130* (Department of Conservation and Land Management (now NSW Office of Environment and Heritage), 1989) indicates that the site is underlain by two soil landscape groupings; Gymea and Warriewood. The Gymea soil landscape covers the majority of the site.

The site drains to and may affect areas that are underlain by Warriewood or Disturbed Terrain soil landscapes. The site is also fringed by some Birrong soil landscape which may have remnant significance to the site. Comparison to 1943 aerial photographs shows that some of the landscapes may have been disturbed by previous works. The characteristics of the soil landscapes noted on site are described in **Table 3-1**.

Mapping of Acid Sulfate Soils (ASS) risk indicates that the site is not likely to contain ASS. For areas downstream of the site, such as the Eve Street wetland, there is a high probability that ASS are present.

Table 3-1 Soil landscapes found in the surface water study area

Soil Landscape Grouping	Soil Landscape	Characteristics	Erosional nature
Erosional	Gymea	• The majority of the site and associated works would be located within this landscape. • Occurs on undulating to rolling rises and low hills on Hawkesbury Sandstone. • Localised steep slopes. • High soil erosion hazard.	Severe sheet erosion occurs following bushfires which destroy or damage stabilising vegetative cover. Minor gully erosion can occur along unpaved areas.

Soil Landscape Grouping	Soil Landscape	Characteristics	Erosional nature
Swamp	Warriewood	• Occurs on level to gently undulating swales, depressions and infilled lagoons in Quaternary sands. • High water tables and localised flooding, highly permeable soils, compressible soils. • This landscape may have been disturbed by previous works near the M5 East Motorway. • Eve Street wetland noted in this landscape.	No appreciable erosion occurs where slopes are low and a vigorous ground cover is maintained.
Disturbed Terrain	Disturbed Terrain	• Terrain extensively disturbed by human activity, including complete disturbance, removal or burial of soil. Variable relief and slopes	Rocks revetments have been used to stabilise channels where there is the potential for erosion.

3.2 Catchments and watercourses

For the purposes of this assessment, five sub-catchments draining to the Eve Street wetland have been identified. The sub-catchments draining to the site, as well as to the Eve Street wetland, are shown in **Figure 3-1**, while the sub-catchment properties are discussed in **Table 3-2**.

The total catchment area draining to the Eve Street wetland is around 29.1 hectares, of which around 8.7 hectares would potentially be part of the stormwater harvesting catchment associated with the site.

Downstream of the site a further 6.9 hectares drains to the channel that connects the Eve Street wetland to the Cooks River. This area includes the existing M5 East Motorway. Downstream of the Eve Street wetland, the existing channel is dominated by tidal flows, and as such the hydrology of that reach has not been separately assessed.

Upstream of the site, in the developed portions of the catchment (sub-catchments E_02 and M_02), there is a formal drainage network consisting of roads and kerbs, inlet pits and pipes. Downstream of the site, in sub-catchments E_01, M_01 and S_01, drainage is via the Eve Street wetland and constructed channels.

The Marsh Street wetland comprises a drainage channel through a highly disturbed and vegetated but weedy environment. During the site inspection on the 4 February 2016, standing water was noted in the channel through the Marsh Street wetland, indicating impeded drainage between the channel and the Eve Street wetland, which are downstream.

Figure 3-1 Sub-catchments upstream of the Marsh Street ponds and the Eve Street wetland

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Table 3-2 Identified sub-catchments draining to the Eve Street wetland

Catchment name	Sub-catchment area (hectares)	Impervious fraction (%)	Current catchment landuse	Downstream catchment
E_01	12.1	20	Residential, maintained playing fields, wetlands.	n/a – flows to Cooks River via the channel
E_02	8.7	70	Residential, some commercial along the western portion of the catchment including motor vehicle workshops.	E_01 (Eve Street wetland)
M_01	1.5	15	Rehabilitated spoil, grass, some roads and abandoned houses	E_01 (Eve Street wetland)
M_02	6.3	70	Residential, some commercial along the western portion of the catchment including motor vehicle workshops.	M_01 (Marsh Street wetland)
S_01	0.5	0	Grass with a few trees	M_01 (Un-named channel)

3.3 Catchment landuse

The catchments upstream of the site, including the catchments that may be used for stormwater harvesting, are predominantly residential; although some commercial land uses, such as automotive workshops, are present within the catchment. Descriptions of the landuse in each of the identified sub-catchments are outlined in **Table 3-2**.

Upstream of the site (sub-catchments E_02 and M_02) is predominantly residential; however, there are now commercial areas on the western boundary, nearest the Princes Highway. These commercial areas include activities such as motor vehicle workshops and dealerships, offices, and warehousing.

Downstream of the site, in sub-catchments E_01, M_01 and S_01, there is a mixture of open fields, wetlands and residential. Portions of this area have been set aside as groomed sports fields, and have associated facilities.

3.4 Geomorphology

The site is located on the lower slopes of a hill that slopes upwards to the west towards the Princes Highway. As such, it is raised above the swampy areas associated with the Warriewood soil landscapes downstream, and is part of the erosional landscape associated with the Gymea soil landscapes.

The site does not contain significant morphological features such as a creek. Water from the site currently flows overland to a constructed channel through the Marsh Street wetland to the east of the site. Aerial photographs from 1943 show that both the site, the Marsh Street wetland and surrounding areas were used as market gardens with some residential dwellings, and with no discernible drainage channels. The present channels through the wetlands have therefore been constructed sometime more recently. Some asphalt pavement was noted on the site during the site inspection, consistent with the previous uses of the site.

A large mound was noted on the north-eastern portion of the Marsh Street wetlands nearest the existing M5 East Motorway during the site inspection on 4 February 2016. This mound was also noted in topographic data available for the wetlands, and is consistent with placement of fill on the wetlands from earlier construction activity.

The Eve Street wetland, while consistent with the Warriewood soil landscape noted in the area, is not visible in earlier aerial photographs from 1943 when the area was also used as market gardens. The present wetlands were constructed by Sydney Water sometime more recently.

3.5 Hydrology and flooding

The site is above the 100 year Average Recurrence Interval (ARI) flood level and is not likely to be affected by local catchment flooding for all events up to and including the 100 year ARI.

There is no upstream catchment that drains through the site at present. Kerb and gutter drainage is found along Marsh Street and West Botany Street. This collects water flowing along the road network upstream of the site, and directs it towards drainage pits that are part of the Eve Street catchment drainage network, or the Marsh Street catchment drainage network.

Sub-catchment E_02 drains through a pipe that runs under the north side of Eve Street. During major rainfall events where the capacity of the stormwater system is exceeded, this catchment drains to the Eve Street wetland via an overland flow path along Eve Street.

Likewise, the catchment that drains to Marsh Street (sub-catchment M_02) is contained in the underground stormwater system for minor storm events, and flows overland along the road network in major storm events. Both the underground drainage network and the overland flow paths drain to the channel to the east of the site before entering the Eve Street wetland.

3.6 Surface water quality

No water quality monitoring data for the Eve Street wetland or its tributaries was available at the time of writing. During the site inspection on the 4 February 2016, standing water in the channel through the Marsh Street wetlands had a notable opaque grey colour. Water quality data was not available for the site or the downstream environment at the time of writing. Nearby data was not directly relevant to the site.

The Eve Street wetland is a hypersaline environment, with tidal exchange with the Cooks River regulated by a weir. The weir has a crest elevation of 0.67 metres above Australian Height Datum (AHD) (BHBB M5 East Joint Venture, 2002). The weir allows only tidal flow from some high tides from the Cooks River to enter the wetland (NSW Department of Environment 1998).

The conditions in the wetland are the result of a dynamic equilibrium that has formed between tidal exchanges with the Cooks River, stormwater inflows form the identified catchment and evaporation. As the evaporation is greater than the freshwater inflows from the catchment, and the exchange with Cooks River is restricted, salinity in the wetlands often exceeds that of the Cooks River (Arthur White *pers. comm.*). The Eve Street wetlands were remediated in 2008 to remove silt that was impeding tidal flushing and fish passage (SMH 2008).

4 Assessment of impacts

4.1 Construction

The following construction activities have the potential to impact surface water:

- Clearing of vegetation, removal of existing pavement, excavation and stockpiling of spoil prior to reuse or removal from site. These activities could expose underlying soils that could cause erosion, landform instability, sedimentation and reduction in water quality.
- Construction of the ponds and the drainage swale, during which time the exposed soils may be highly susceptible to erosion and flow paths may be obstructed or diverted.
- Potential spills or leaks of fuels and/ or oils can come from maintenance or re-fuelling of construction plant and equipment or vehicle / truck incidents.
- Rinse water from plant washing may contain polluting contaminants.
- Temporary construction activities located within flood risk areas, potentially resulting in altered flood storage or conveyance.
- Water used in construction of the Marsh Street ponds, for activities such as dewatering and dust suppression, has the potential to generate polluted runoff.

The receiving environments where surface water could be impacted include the Marsh Street wetland, the Eve Street wetland and the Cooks River.

4.1.1 Water extraction and use

It is expected that water extraction will be required for a range of activities including:

- Surface works such as compaction , dust suppression and washdown
- Site facilities
- Commissioning of the ponds.

Most of the water used would be sourced from the Sydney Water potable supply network during construction.. The water requirements associated with the construction of the Marsh Street ponds are expected to be minor.

During establishment the ponds would require regular watering to support the growth of plants. Aquatic plants need about twice the volume of water that terrestrial vegetation requires during establishment.

4.1.2 Regional flooding and drainage

The construction footprint is outside the Cooks River flood extents for events up to and including the 100 year ARI. These flooding extents are based on the Technical working paper: Flooding (Lyall & Associates, 2015). As such, construction is not expected to have an impact in mainstream Cooks River flooding.

Since the site is also located outside the local drainage corridors, flooding during the construction activities associated with the Marsh Street ponds are unlikely to impact areas within and near the construction site.

Some minor works, such as the construction of a stabilised connection to the existing channel, are expected to take place within the drainage corridor. Some minor works, such as the construction of a stabilised connection to the existing channel, are expected to take place within the drainage corridor subject to further discussions with Rockdale City Council. These works would need to consider flood risks during these activities.

4.1.3 Localised flooding and drainage

As the site does not contain existing drainage infrastructure, and is outside the existing creeks and local drainage paths, impacts on local drainage are unlikely. However, all construction works would have the potential to impact local overland flows and existing minor drainage paths due to activities that take place off the site, such as the arrival or departure of vehicles associated with the works. Debris and sediment can also be washed off site by rainfall events. Specific causes of these impacts could include:

- Disruption of existing drainage networks during decommissioning, upgrade or replacement of drainage pits and pipes, for example, associated with the construction of the water harvesting system
- Interruption of overland flow paths by installation of temporary site access facilities (driveway and stabilised access)
- Blocking of drainage assets caused by deposition of eroded sediments within the drainage network.

These would require consideration during future detailed design and construction planning, along with the typical mitigation measures described in **Chapter 8** (Revised environmental management measures) of the Submissions and Preferred Infrastructure report.

4.1.4 Maintenance of natural flow variability

There may be a need for dewatering during the earthworks for pond construction as rainwater may potentially fill the partially completed ponds (subject to EPL conditions). This water would need to be pumped into the channel or the existing stormwater drainage network. Such dewatering activities would be of short duration due to the limited extent of works. Water from dewatering may have a greater sediment concentration than water from the undisturbed site. The erosion and sedimentation management plan would contain measures to manage the sediment associated with the pump out water. Further, the limited extent of works means that volumes would be small relative to the extent of groundwater that would be expressed in the downstream channel. Therefore, dewatering is unlikely to have an impact on flow variability that would be detrimental to the receiving environments.

Water may be required for dust suppression but the volumes required for these activities are expected to be small and not expected to generate runoff.

4.1.5 Water quality

Potential impacts on surface water quality during construction of the Marsh Street ponds are considered manageable with the application of standard mitigation measures.

Exposed soils may be eroded by wind or rain, and the eroded soils may lead to water quality issues such as sedimentation in the receiving waters downstream. Drainage works, such as the drainage swale also have the potential to concentrate flows, which may exacerbate erosion. Soils transported into local waterways can impact water quality through increased turbidity, lowered dissolved oxygen levels, and increased nutrients (nitrogen and phosphorus). The sedimentation may smother aquatic ecosystems and increases in nutrients may contribute to eutrophication.

Erosion and sediment loads would gradually diminish with completion of construction activities as the disturbed areas are stabilised and the vegetation of batters start to establish and hold the soils in place. The risk of erosion during construction would be minimised by bringing the ponds online only after the landscape has established. This ensures that the ponds would only be exposed to flows from external catchments after the landscape is fully stabilised.

During construction the impacts would be managed by minimising the erosion of disturbed earthworks areas and to contain any sediment runoff on-site. A preliminary erosion and sedimentation assessment was undertaken for the Marsh Street ponds in accordance with the *Erosion and Sedimentation Risk Assessment Procedure – Appendix 1a &1b for Concept Designs* (RTA, 2004). This identified the Marsh Street ponds works to be high risk, with reference to:

- Slopes in parts of the surface water study area with greater than ten percent grade.
- An R factor (rainfall erosivity) of 3,000-3,500 for this area of Sydney.

As this presents a high erosion hazard, an Erosion and Sedimentation Management Plan would need to be prepared as outlined in *Erosion and Sedimentation Risk Assessment Procedure* (RTA, 2008).

Disturbance of contaminated soils or Acid Sulfate Soils (ASS) could affect water quality by liberating acids, however ASS are unlikely to be found on the site. Should ASS be encountered during construction, then recommended mitigation and management measures for ASS are provided in **Chapter 8** (Revised environmental management measures) of the Submissions and Preferred Infrastructure report.

4.2 Operation

Operation of the Marsh Street ponds has the potential to result in impacts to surface water from the following activities:

- Impact to water quality of receiving watercourses due to the discharge of water from the ponds, including the periodic salt water flush. This discharge would flow into the channel at Marsh Street wetlands, and then the Eve Street wetland prior to flowing to the Cooks River.
- Impact to the geomorphology of receiving watercourses resulting from changes in the frequency of flows, and velocity of flows.
- Flow entering the existing watercourses at a new location from the proposed ponds or swale.

4.2.1 Water extraction / use

Water would be extracted from either the Rockdale City Council stormwater line along Eve Street, or from the Sydney Water potable water supply. Water extracted from the stormwater system would flow back into the Eve Street wetland via the proposed ponds, and hence use of this water source at the site is not expected to have a significant impact on the long term water balance of the downstream wetlands.

The Sydney Water potable water supply is expected to only be used when insufficient stormwater is available, and is therefore only expected to result in a minor increase in fresh water inflows to the downstream environment, and principally during dry periods.

4.2.2 Flooding and drainage

Mainstream flooding of the Cooks River and associated waterways has been assessed in the Technical Working Paper: Flooding (Lyall & Associates, 2015). As the site is outside to the expected Cooks River flood extents, the ponds are not expected to have an impact on Cooks River flooding.

As the site is outside of the local drainage corridors, it is not expected to have an impact on catchment drainage. Where a connection to the existing drainage is required, for example to construct the stormwater harvesting pit or the connection from the pond drainage swale, appropriate design can minimise the impacts by ensuring that the flow capacity is not compromised.

4.2.3 Maintenance of natural flow variability

During the operation, less than 30 percent of the catchment drainage to the Eve Street wetland would be available for stormwater harvesting, and only a fraction of the runoff from this catchment would be used in the ponds. As such, the cycles of stormwater and tidal flushing would only be altered in a minor way as the majority of the identified sub-catchments draining to the Eve Street wetlands would not be available for capture by the stormwater harvesting system.

To quantify the changes in flow to the Eve Street wetland that could result from stormwater harvesting to supply water to the ponds, MUSIC software, which is commonly used to assess urban runoff and associated pollutants, has been used to develop a model of the flows drainage to the Eve Street wetlands. This model is based on the catchments identified in **Section 3.2**. This model was used to calculate the impact of evaporation and evapotranspiration within the Marsh Street ponds on the total volume of runoff to the channel and the Eve Street wetland.

These calculations indicated that the net change in flow volumes to the channel in the Marsh Street wetlands would be a reduction of by less than 0.7 percent, and that flows to the Eve Street wetland would be reduced by less than 0.5 percent as a result of diverting stormwater to the Marsh Street ponds. Such a small reduction in flows is unlikely to have a measureable impact on these receiving environments, since this change is much less than the natural variability in flows that these environments are subjected to.

4.2.4 Water quality

Operation of the Marsh Street ponds has the potential to result in impacts to surface water as a result of the diversion of untreated stormwater through the ponds. Runoff from this catchment would typically contain pollutants such nutrients, oils and greases, petrochemicals and heavy metals, which result from atmospheric deposition, vehicle leaks, operational wear, road wear or spills of materials on the road.

As stormwater passes through the ponds, pollutants are likely to be removed from the water column by the treatment processes that are an inherent part of vegetated ponds, namely:

- Fine particle settling and entrapment;
- Chemical adsorption to sediments and organic matter; and
- Biological uptake and transformation.

Runoff from sub-catchments E_02 would be directed to the ponds. Preliminary MUSIC modelling indicates that the Marsh Street ponds would improve the quality of the water passing through the ponds resulting in a net removal of pollutants of between six and 19 per cent depending on the pollutant (refer **Table 4-1)**. Gross pollutants such as leaves and litter would also be retained by the ponds.

Table 4-1 Pollutant removal from the Marsh Street ponds

Pollutant	Source Pollutants	Residual Pollutants	% Removal
Total Suspended Solids (kg/yr)	26,700	21,600	19
Total Phosphorus (kg/yr)	44.6	39.9	10.5
Total Nitrogen (kg/yr)	330.0	310.0	6.3
Gross Pollutants (kg/yr)	3,720.0	2,330.0	37.2

This pollutant removal represents a net benefit to the downstream environments.

The ponds would be periodically dosed with salt for the control of the Chytrid fungus (about six monthly intervals). After dosing, salinity levels would be temporarily as high as 3,000 milligrams per litre, thereafter dropping at a rate proportional with the amount of dilution created by catchment runoff. The discharge of saline water from the ponds in not expected to impact the receiving environments for the following reasons:

- Saline incursions are a natural part of wetlands in the near-coastal environment, and most of the native species of these communities are tolerant of short-term brackish conditions.
- The highest concentrations of salts are expected to be 3,000 milligrams per litre. The Marsh Street ponds themselves are not expected to be impacted by this salinity. At present saline dosing is carried out in the existing frog ponds associated with the M5 East Motorway. These ponds discharge to ponds on the Kogarah Golf Course, which in turn drains to the Cooks River. There are no apparent detrimental impacts to the aquatic macrophytes or frog populations associated with this dosing. Water discharged from the ponds would be diluted by catchment runoff prior to any discharge so that discharges to the receiving environments would be of a lower salt concentration.
- The key receiving environment of is the Eve Street wetland, which is a hyper saline environment.

4.2.5 Geomorphology

During operation the Marsh Street ponds has the potential to impact the geomorphology of receiving watercourses in the surface water study area. Impacts on watercourses could result from the discharge of drainage at new locations, for example, at the end of the swale, or as a result of increased discharges.

During detailed design, Roads and Maritime will consult with Rockdale City Council concerning the construction of appropriately designed connections to the existing watercourses through the Marsh Street wetlands to manage the risk or erosion in the operational phase, consistent with the measures provided in the **Chapter 8** (Revised environmental management measures) of the Submissions and Preferred Infrastructure report.

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5 Conclusion and recommendations

Flooding impacts associated with the construction and operation of the Marsh Street ponds are unlikely because the proposed design change is located outside of the Cooks River floodplain, and, with the exception of the required connections, outside the existing drainage paths. The operation of the stormwater harvesting system is not expected to alter the frequency, volume or water quality of the inflows to the Eve Street wetland to a measurable extent.

The risk of erosion during construction would be minimised by bringing the ponds online only after the landscape has established,. During detailed design, Roads and Maritime will consult with Rockdale City Council concerning the construction of appropriately designed connections to the existing watercourses through the Marsh Street wetlands to manage the risk or erosion in the operational phase, consistent with the measures provided in the Chapter 8 (Revised environmental management measures) of the Submissions and Preferred Infrastructure report.

There is the potential for some geomorphological impacts and water quality impacts as a result of sediment runoff during construction, however these impacts are consistent with those identified previously in the Technical working paper: Surface water (AECOM, 2015) and Technical working paper: Flooding (Lyall & Associates, 2015).

Based on the outcomes of this assessment, there would not be a significant change to the surface water impacts as presented in the Technical Working Paper: Surface water (AECOM, 2015) and Technical working paper: Flooding (Lyall & Associates, 2015).

No further mitigation and management measures are proposed in addition to those provided in the technical working papers and Chapter 8 (Revised environmental management measures) of the Submissions and Preferred Infrastructure report.

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New M5

Environmental Impact Statement

Marsh Street Ponds – Biodiversity Impact Assessment

Appendix F

March 2016

WestConnex

WestConnex: New M5

Marsh Street ponds – Biodiversity impact assessment

Prepared for
AECOM

March 2016

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DOCUMENT TRACKING

Item	Detail
Project Name	Construction of Green and Golden Bell Frog Habitat Ponds, Marsh Street – Flora and Fauna
Project Number	16WOL-3510
Project Manager	Meredith Henderson (02) 4201 2209 Suite 204 Level 2 62 Moore Street, Austinmer, NSW 2515.
Prepared by	Matthew Dowle, Stacey Wilson
Reviewed by	Meredith Henderson
Approved by	Mark Adams
Status	FINAL
Version Number	1
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Abbreviations

Abbreviation	Description
CMA	Catchment Management Authority
DotE	Commonwealth Department of the Environment
EIS	Environmental Impact Statement
ELA	Eco Logical Australia Pty Ltd
EPBC Act	*Environmental Protection and Biodiversity Conservation Act 1999*
FM Act	*Fisheries Management Act 1994*
LGA	Local Government Area
MNES	Matters of Environmental Significance
OEH	NSW Office of Environment and Heritage
PCT	Plant Community Type
Roads and Maritime	NSW Roads and Maritime Services
RTA	NSW Roads and Traffic Authority
TSC Act	*Threatened Species Conservation Act 1995*
VIS	NSW Vegetation Information System Classification Database
WoNS	Weeds of National Significance

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1 Introduction

This report has been prepared to describe and assess the ecological impact of the Marsh Street ponds which have undergone further design development since the exhibition of the environmental impact statement (EIS) for the New M5 project (the project). As outlined in Chapter 5 of the EIS, the project description is based on the preferred design and will be refined during detailed design. Accordingly, this report addresses the proposed additional habitat creation for Green and Golden Bell Frog at Arncliffe.

1.1 Marsh Street ponds

The Green and Golden Bell Frog Plan of Management identified the provision of new additional habitat at Marsh Street (refer to Appendix S of the EIS) as part of a broader package of mitigation and management measures to support the long term survival of the local population by expanding and enhancing the habitats available for the species. This additional habitat is referred to as the Marsh Street ponds.

The Marsh Street ponds would be located on a parcel of land to the east of the Marsh Street and West Botany Street intersection (the site) (**Figure 1**). The site is owned by NSW Roads and Maritime Services (Roads and Maritime).

The Marsh Street ponds would consist of:

- Three Green and Golden Bell Frog ponds, located along the western boundary of the site consisting of:
  - One pond of around 1.5 metres in depth, about 25 metres long, which has been designed to provide refuge habitat; and
  - Two ponds of around 0.8 metres in depth, which have been designed to provide suitable breeding habitat.
- Water supply systems, including a header tank (with capacity of around 200 kilolitres), pipes and a drainage swale to fill and drain the ponds
- A serviced work shed, around 10 square metres, to support maintenance and monitoring activities, and to store equipment
- Perimeter fencing, designed to enable frog passage along the eastern and northern perimeter of the site, to limit predators and unauthorised access, and to prevent frog passage along the southern and western perimeter
- Permanent vehicle access off Eve Street.

A concept design and detailed construction activities for the Marsh Street ponds is provided in the preferred infrastructure report.

1.2 Purpose of document

This report details the ecological values at the site proposed for the Marsh Street ponds, and considers the impacts to flora and fauna from the proposed works in relation to current environmental planning legislation.

1.3 Key terms

The following terminology has been used:

Subject site: means the area directly affected by the proposal.

Study area: means the area impacted by the proposed works (**Figure 1**). The area surveyed during the site inspection.

Locality: is the five kilometre radius around the subject site or, the same meaning as ascribed to local population of a species or local occurrence of an ecological community.

Figure 1: The Marsh Street ponds study area

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2 Methods

2.1 Data audit and literature review

A desktop literature review was undertaken to identify the threatened species, populations and ecological communities that could potentially occur within the study area. The following documentation, databases and mapping was reviewed:

- Office of Environment and Heritage (OEH) Atlas of NSW Wildlife. Search of data supplied 1 February 2016, five kilometre search radius (OEH 2016a).
- Department of the Environment (DotE) Online search (1 February 2016) for Matters of National Environmental Significance (MNES) with five kilometre buffer around the study area (DotE 2016a).
- Threatened aquatic species listed under the FM Act, NSW Department of Primary Industries, search results for listings by region (Sydney Metro CMA, 2016).
- Sydney Metropolitan Catchment Management Authority Vegetation Mapping (OEH 2013).
- WestConnex New M5 EIS: Technical Working Paper Biodiversity Assessment Report (ELA 2015).
- Relevant information on the proposed design and construction of the ponds.
- Management Plan for Green and Golden Bell Frog at Arncliffe (White 1998).
- Draft Recovery Plan for the Green and Golden Bell Frog (NSW DEC 2005).
- Plan of Management: Green and Golden Bell Frog Key Population of the Lower Cooks River (NSW DECC 2008).
- NSW Environmental Impact Assessment Guidelines for the Green and Golden Bell Frog (*Litoria aurea*) (NSW NPWS 2003).
- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Significant impact guidelines for the vulnerable Green and Golden Bell Frog (*Litoria aurea*) (Commonwealth of Australia 2009).

Aerial photography (Bing Maps and Google Earth) of the study area and surrounds were also used to investigate the extent of vegetation cover and landscape features. In addition, relevant GIS datasets (soil, geology, drainage) were reviewed to guide the field survey.

Species from the NSW Atlas searches, *Fisheries Management Act 1994* (FM Act) and searches for EPBC Act MNES were combined to produce a list of threatened species that may occur within the study area ("subject species"). Assessments for the likelihood of occurrence were made both prior to field survey and following field survey. Potential impacts to species that were considered potential, likely or known to occur area further assessed in this report.

2.2 Field survey

The site inspection for the flora and fauna assessment report was conducted by Dr Matthew Dowle and Stacey Wilson on 4 February 2016. The site inspection was conducted to:

- Determine if any native vegetation communities were present on the subject site
- Determine if any vegetation present corresponds to any listed threatened ecological community
- Determine if there was any fauna habitat present, in particular any habitat for Green and Golden Bell Frogs
- Determine if there were any other biodiversity values that may be adversely impacted by the proposed works.

The observations from the site inspection were used to inform the impact assessment (**Chapter 4**). The site inspection also included observations of the vegetation to the east of the study area.

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3 Existing environment

Information pertaining to the existing environment of the locality and broader landscape is detailed in the WestConnex New M5 EIS (Biodiversity Assessment Report).

The study area is located within the local government area of the City of Rockdale. It is situated one kilometre east of Cooks River, 2.5 kilometres south of Rockdale Bicentennial Park and 1.5 kilometres north-west of Wolli Creek.

The study area is bordered by Marsh Street to the north, West Botany Street to the west, Eve Street to the south, and existing houses and mapped vegetation to the east.

3.1 Field survey results

No indigenous native vegetation communities or threatened ecological communities listed under the *Threatened Species Conservation Act 1995* (TSC) or EPBC Act were recorded in the study area.

No threatened flora or fauna were observed in the study area. However, the site could provide potential Green and Golden Bell Frog dispersal or foraging habitat. A flora species list from the site inspection is provided in **Appendix A**.

3.1.1 Vegetation communities

The vegetation communities on site were managed, landscaped or exotic vegetation. None of these vegetation types corresponded with any plant community type (PCT) listed in the NSW Vegetation Information System Classification database (VIS). Descriptions of the vegetation communities are described below and their extents provided in **Figure 4** and **Table 1**.

Table 1: Vegetation within the study area

Vegetation*	Condition	Area (ha)
Exotic grassland (managed)	Disturbed	**0.421**
Urban native and exotic cover	Disturbed	**0.095**
	Total	**0.516**

Exotic grassland

The open area of the study area is dominated by a managed exotic grassland. Dominant species included *Paspalum dilatatum* (Paspalum), *Cynodon dactylon* (Couch), *Setaria* sp. (Pigeon Grass), *Plantago lanceolata* (Plantain), *Hypochaeris radicata* (Catsear) and *Stenotaphrum secundatum* (Buffalo Grass) (**Figure 2**).

Native diversity and ecological values were considered negligible. A number of common and noxious weeds were observed on the edge of the grassland boundaries.

Urban native and exotic cover

This vegetation community was observed on the southern and eastern boundary of the study area and consisted of a number of exotic and non-indigenous native tree species (**Figure 3**), including *Cinnamomum camphora* (Camphor Laurel), *Eucalyptus* spp. (planted) and *Pinus* sp. (Pine). These trees are associated with the adjacent houses and Eve Street nature strip. There was no reproductive material available to identify the *Eucalyptus* to species level.

A number of noxious weeds were present within the understorey of this community, including *Lantana camara* (Lantana), *Cestrum parqui* (Green Cestrum) and *Asparagus aethiopicus* (Asparagus Fern).

Figure 2: Exotic grassland adjacent to Marsh Street

Figure 3: Urban exotic and native vegetation in mid ground

3.1.2 Flora

A total of 42 flora species were identified within the study area, of which only four were native species and 38 were exotic species. A flora species list is available in **Appendix A**.

Threatened flora

No threatened flora species were identified during field surveys or have previously been recorded within the study area. Due to the current condition of the vegetation and disturbance, there is limited potential that threatened flora species would be persist within the study area.

One species that is listed as threatened under the TSC Act was found just outside the study area. This species, *Eucalyptus nicholii* (Narrow-leaved Black Peppermint), has a natural range in the northern tablelands of NSW. The specimen observed would have been planted and would not be affected by the proposed works.

Noxious Weeds

Four exotic species recorded within the study area are declared as noxious under the *Noxious Weeds Act 1993* in Rockdale Local Government Area (LGA). Three species are listed as a Weed of National Significance (WoNS) (**Table 2**). Noxious weeds require careful management to prevent spread into adjacent areas. Two other species of noxious weeds were recorded adjacent to the eastern boundary of the study area; *Celtis sinensis* (Chinese Celtis) and *Ligustrum lucidum* (Large-leaved Privet) (**Appendix A**).

Table 2: Noxious and WoNS species recorded within the study area

Scientific name	Common name	NSW Class	WoNS
Asparagus aethiopicus	Asparagus Fern	Class 4	Yes
Asparagus plumosus	Climbing Asparagus Fern	Class 4	Yes
Cestrum parqui	Green Cestrum	Class 3	No
Lantana camara	Lantana	Class 3	Yes

3.1.3 Fauna and habitat

Threatened fauna

No threatened fauna were identified during the site inspection or have previously been recorded within the study area. Due to land management practices (mowing) and the disturbed condition of the vegetation and habitat, there is limited potential that native fauna species outside of common, disturbance tolerant species would be present within the study area. Only common and urban tolerant fauna have been observed at this site (A. White pers comm 2016) and include *Rattus rattus* (Black Rats), *Vulpes vulpes* (European Red Fox) and various native skinks.

It was noted that limited marginal foraging or dispersal habitat may be present for Green and Golden Bell Frog, but the likelihood of this species being present at this site is low, despite the proximity to the key population. This species was historically recorded at the Marsh Street Wetlands, which is adjacent to the study area. However, recent records are limited to the Kogarah Golf Course and the RTA breeding ponds on the eastern side of the M5 East Motorway.

Figure 4: Ecological values of the study area

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4 Assessment of impacts

4.1.1 Biodiversity values

The biodiversity values of the study area were negligible, due to the dominance of exotic species, cleared land and current management practices (mowing). No threatened ecological communities, threatened flora or fauna were recorded as being present in the study area.

Old records for the Green and Golden Bell Frog occur within close proximity to the study area (within 100 metres and at the Marsh Street Wetlands). It was considered that there could be potential foraging or dispersal habitat for this species. However, following the site inspection, it is highly unlikely that the Green and Golden Bell Frog would currently persist in the study area and/or depend on any habitat within the study area. The site is highly disturbed and there is a distinct lack of cover or connection to the existing population and known habitat sites on the eastern side of the M5 East Motorway.

Potential Green and Golden Bell Frog foraging and dispersal habitat have been described as follows (extracted from the Management Plan for the Green and Golden Bell Frog Lower Cooks River Key Populations, DECC 2008).

- *Foraging habitat*: Typically includes grassed areas (native or exotic), tussock vegetation and emergent sedges and reeds bordering water features. Examples in the study area may include the open exotic grasslands.
- *Dispersal habitat*: typically includes wet areas such as creek lines, drains, stormwater canals, connecting vegetation, and other easements and depressions. In the study area, the exotic grassland provides potential movement habitat as it is in close proximity to the drainage channel connecting to the Marsh Street Wetlands. However, the regular management and lack of covered protection between the known habitats on the eastern side of the M5 East Motorway and the Marsh Street Wetlands is a restricting factor.

4.1.2 Impacts

The provision of the Marsh Street ponds (**Figure 5**) forms part of the mitigation and management measures for the project to provide for greater long term security of the local Green and Golden Bell Frog population by expanding and enhancing the habitats available for the species.

The ponds would be constructed across the entirety of the study area. The paucity of biodiversity values was a feature of the study area. Therefore, the construction impacts of the Marsh Street ponds to biodiversity values of the study area was considered to be negligible and no new adverse impacts are considered to be introduced to the project.

Furthermore, the construction of the Marsh Street ponds would provide future habitat (including breeding habitat) for the Green and Golden Bell Frog population, increasing the habitat available in the locality. The provision of additional habitat was recommended in the EIS, with the Plan of Management for the species supporting the need for additional habitat.

Thus, the Marsh Street ponds would be considered to have an overall positive impact to the Green and Golden Bell Frog.

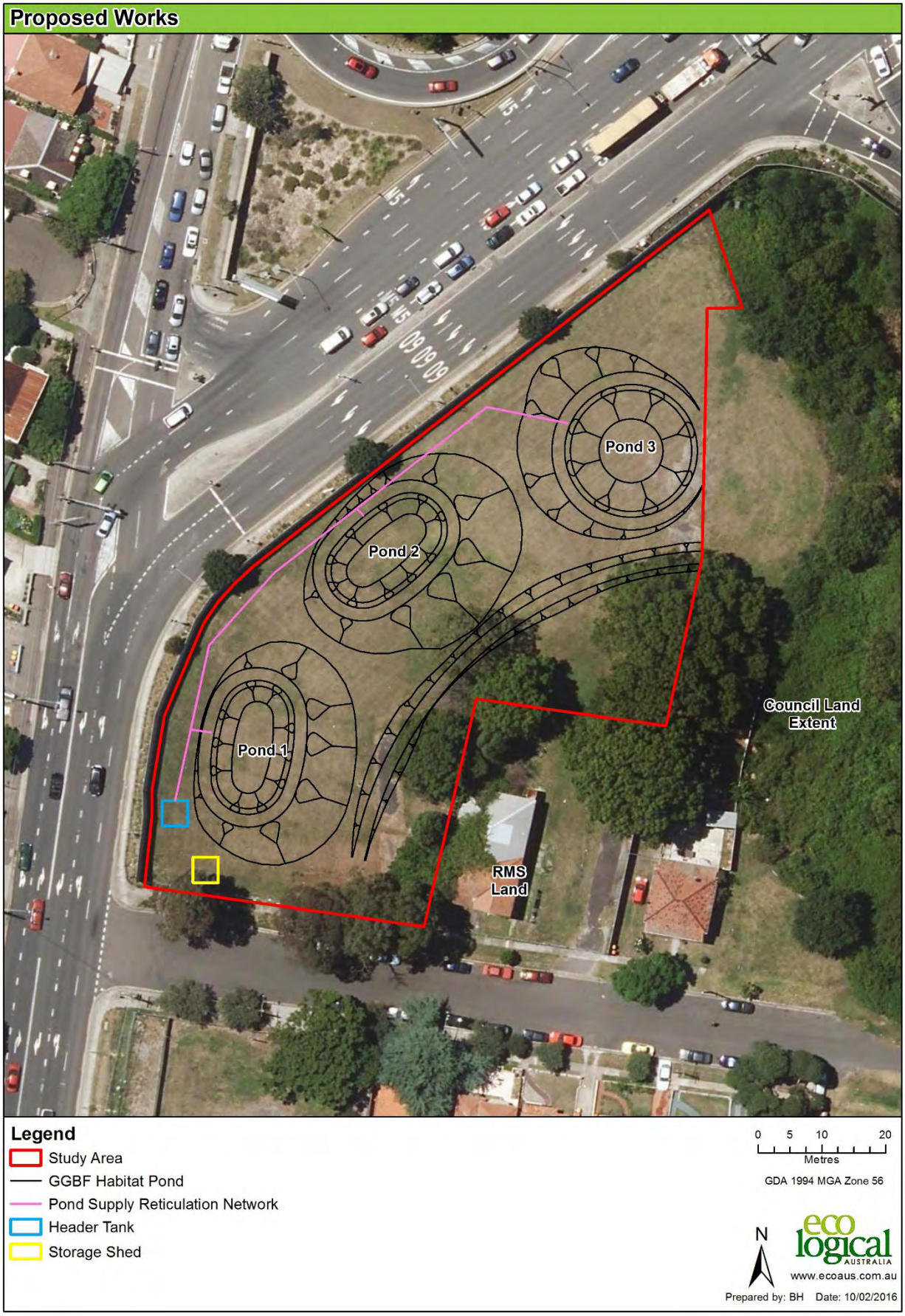

Figure 5: Proposed Marsh Street ponds – concept design (indicative)

5 Discussion

The Green and Golden Bell Frog Plan of Management identified the provision of new additional habitat at Marsh Street (refer to Appendix S of the EIS) as part of a broader package of mitigation and management measures to provide for greater security of the local population by expanding and enhancing the habitats available for the species.

The mitigation measures were recommended in the project EIS for impacts to current Green and Golden Bell Frog habitat at the Kogarah Golf Course, with the development of a supporting Plan of Management.

The Marsh Street ponds would be located on a parcel of land (owned by Roads and Maritime) to the east of the Marsh Street and West Botany Street intersection. The biodiversity values of this site were found to be extremely low, due to the dominance of exotic species, cleared land and current management practices. No threatened ecological communities, threatened flora or fauna were considered to be present at the site.

Thus, the Marsh Street ponds are considered to introduce negligible new adverse ecological impacts to those presented in the EIS. This is because no native vegetation communities, threatened ecological communities, threatened species or their habitats would be impacted by the proposed pond construction. The existing vegetation in the study area that would be cleared, does not correspond with any PCT.

The construction of the ponds would be considered to provide a positive outcome for the local Green and Golden Bell Frog population. These works would be in addition to the offset requirements for this species.

The Marsh Street ponds would be managed for conservation in perpetuity, such as through a biobanking agreement or through a community trust. The long term management framework would be determined in consultation with Rockdale City Council.

The management protocols of the frog ponds would include (but not limited to) bi-annual saline flushing of the pond system for chytrid control, control of pond water levels, as well annual drainage of individual ponds for vegetation management and plague minnow control. These measures are consistent with leading practice management of Green and Golden Bell Frog habitat.

Furthermore, the ponds are to provide suitable habitat for release of individuals from the captive breeding program, which is to be implemented with a suitably qualified and experienced animal husbandry organisation. This captive breeding program is an insurance for the species and a supplementary mitigation measure outlined in the EIS.

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Appendix A – Species list

The table identifies the flora species recorded within the study area from the field survey.

Species Name	**Common Name**	**Noxious**
Native Species		
Acacia longifolia	Long leaved Wattle	
Eucalyptus nicholii (planted – outside study area)	Narrow-leaved Peppermint	
Eucalyptus sp (planted).	Eucalypt	
Gamochaeta sp.		
Exotic Species		
**Asparagus aethiopicus*	Asparagus Fern	Class 4; WoNS
**Asparagus plumosus*	Climbing Asparagus Fern	Class 4; WoNS
**Bidens pilosa*	Cobblers Peg	
**Bromus* sp.	Brome	
**Carpobrotus* sp.	Pig Face	
**Celtis sinensis* (outside study area)	Chinese Celtis	Class 4
**Cestrum parqui*	Green Cestrum	Class 3
**Chamaesyce* sp.		
**Chloris gayana*	Rhodes Grass	
**Cinnamomum camphora*	Camphor Laurel	
**Conyza bonariensis*	Fuzzweed	
**Coriandrum sativum*	Coriandra	
**Cotoneaster* sp.	Cotoneaster	
**Cynodon dactylon*	Common Couch	
**Cyperus eragrostis*	Umbrella Sedge	
**Ehrharta erecta*	Panic Veldtgrass	
**Eragrostis tenuifolia*	Elastic Grass	
**Foeniculum vulgare*	Fennel	
**Hypochaeris radicata*	Catsear	
**Ipomoea indica* (outside study area)	Blue Morning Glory	
**Lantana camara*	Lantana	Class 3; WoNS
**Ligustrum lucidum* (outside study area)	Large-leaved Privet	Class 4
**Malus* sp.		
**Malva* sp.	Mallow	
**Medicago* sp.		
**Oxalis* spp.		
**Panicum maximum.*	Guinea Grass	
**Paspalum dilatatum*	Paspalum	
**Pennisetum clandestinum*	Kikuyu	
**Pinus* sp.	Pine	
**Plantago lanceolata*	Ribwort	
**Setaria gracilis*	Pigeon Grass	

Species Name	**Common Name**	**Noxious**
**Sporobolus africanus*	Parramatta Grass	
**Stenotaphrum secundatum*	Buffalo Grass	

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AS/NZS 4801:2001 Occupational Health and Safety Management

ISO 9001 Quality Management

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New M5

Environmental Impact Statement

Marsh Street Ponds – AHIMS Search results

Appendix G

March 2016

WestConnex

AHIMS Web Services (AWS)
Search Result

Purchase Order/Reference : 2

Date: 16 February 2016

Attention: Alice Thurgood

Email: alice.thurgood@aecom.com

Dear Sir or Madam:

AHIMS Web Service search for the following area at Lat, Long From : -33.9394, 151.1509 - Lat, Long To :

-33.9377, 151.1536 with a Buffer of 200 meters, conducted by Alice Thurgood on 16 February 2016.

The context area of your search is shown in the map below. Please note that the map does not accurately display the exact boundaries of the search as defined in the paragraph above. The map is to be used for general reference purposes only.

A search of the Office of the Environment and Heritage AHIMS Web Services (Aboriginal Heritage Information Management System) has shown that:

0	**Aboriginal sites are recorded in or near the above location.**
0	**Aboriginal places have been declared in or near the above location. ***

If your search shows Aboriginal sites or places what should you do?

- You must do an extensive search if AHIMS has shown that there are Aboriginal sites or places recorded in the search area.
- If you are checking AHIMS as a part of your due diligence, refer to the next steps of the Due Diligence Code of practice.
- You can get further information about Aboriginal places by looking at the gazettal notice that declared it. Aboriginal places gazetted after 2001 are available on the NSW Government Gazette (http://www.nsw.gov.au/gazette) website. Gazettal notices published prior to 2001 can be obtained from Office of Environment and Heritage's Aboriginal Heritage Information Unit upon request

Important information about your AHIMS search

- The information derived from the AHIMS search is only to be used for the purpose for which it was requested. It is not be made available to the public.
- AHIMS records information about Aboriginal sites that have been provided to Office of Environment and Heritage and Aboriginal places that have been declared by the Minister;
- Information recorded on AHIMS may vary in its accuracy and may not be up to date .Location details are recorded as grid references and it is important to note that there may be errors or omissions in these recordings,
- Some parts of New South Wales have not been investigated in detail and there may be fewer records of Aboriginal sites in those areas. These areas may contain Aboriginal sites which are not recorded on AHIMS.
- Aboriginal objects are protected under the National Parks and Wildlife Act 1974 even if they are not recorded as a site on AHIMS.
- This search can form part of your due diligence and remains valid for 12 months.

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