

Annual Environmental Management Report 2014

Prepared for:
Newcastle Coal Infrastructure Group

Prepared by:
ENVIRON Australia Pty Ltd

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Prepared by:		**Authorised by:**	
Name:	K Greenfield	Name:	F Robinson
Title:	Environmental Scientist	Title:	Manager Hunter
Phone:	02 49 625 444	Phone:	02 49 625 444
Email:	kgreenfield@environcorp.com	Email:	frobinson@environcorp.com

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Acronyms and Abbreviations

AEMR	Annual Environmental Monitoring Report
AI	Ash Island
BH	Borehole
CEMP	Construction Environmental Management Plan
CET	Coal Export Terminal
CHEMP	Compensatory Habitat Environmental Monitoring Program
CSWMP	Construction Surface Water Management Plan
EES	Environmental and Earth Sciences
ESCP	Erosion and Sediment Control Plan
GGBF	Green and Golden Bell Frog
KI	Kooragang Island
KIWEF	Kooragang Island Waste Emplacement Facility
Mtpa	Megatonne per annum
NCIG	Newcastle Coal Infrastructure Group
OEMP	Operational Environmental Management Plan
OWMP	Operational Water Management Plan

1 Introduction

This Annual Environmental Management Report (AEMR) has been prepared for the Newcastle Coal Infrastructure Group (NCIG) Coal Export Terminal project (the Project) in accordance with the conditions of the approved Construction Environmental Management Plan (CEMP) and Operation Environmental Management Plan (OEMP) (Sections 5.2 and 7.2 respectively). The CEMP was prepared in accordance with Condition 7.2 and the OEMP was prepared in accordance with Condition 7.5, both within Schedule 2 of the Project Approval (06_0009) which was granted on 13 April 2007.

This is the sixth AEMR prepared for the NCIG Project and it covers the period April 2013 to March 2014 (i.e. a 12 month period), which includes the fourth year of terminal operation and Stage 2F construction of the Project, including commencement of the Rail Flyover construction.

The AEMR reviews the performance of the Project against the requirements of the Project Approval and provides an overview of environmental management actions and summarises monitoring results over the 12 month reporting period. The AEMR will be distributed to relevant government agencies and stakeholders, and copies provided to other interested parties, if requested.

1.1 Approvals, leases, licences and permits

The Project is being undertaken under the approvals, leases, licences and permits presented in Table 1.

Table 1 Project Approval, Leases, Licences and Permits

Instrument	Relevant Authority	Date Granted	Duration of Approval
Project Approval (06_0009)	Department of Planning and Infrastructure	13 April 2007	5 years unless substantially commenced
Modification of Minister's Approval MP06_0009	Department of Planning and Infrastructure	27 November 2007	N/A (conditions appended to the Project Approval)
Modification of Minister's Approval MP06_0009 MOD2	Department of Planning and Infrastructure	13 May 2013	N/A (conditions appended to the Project Approval)
Project Lease	State Property Authority	22 January 2008	35 years
Environmental Protection Licence (EPL) (No. 12693)	NSW Environment Protection Authority	26 October 2007	Until the Licence is surrendered or revoked. The Licence is subject to review every 5 years.
Environment Protection and Biodiversity Conservation Act 1999	Department of the Environment and Heritage	11 October 2007	Perpetuity
Maritime Services Act 1935 s13JE	NSW Roads and Maritime Services	02 October 2007	Perpetuity
Environmental Representative	Department of Planning and Infrastructure	03 October 2007	Perpetuity
Project Ecologist	Department of Planning	02 May 2007 &	Perpetuity

Table 1 Project Approval, Leases, Licences and Permits

Instrument	Relevant Authority	Date Granted	Duration of Approval
	and Infrastructure	25 October 2007	

1.2 Management plans and monitoring programmes

In accordance with the Project Approval, the Project is currently being undertaken under a number of environmental management plans and monitoring programmes, including:

Construction Management Plans and Protocols

- Stage 2F Construction Environmental Management Plan
- Stage 2F Construction Noise Management Plan
- Stage 2F Construction Surface Water Management Plan
- Stage 2F Construction Traffic Management Plan
- Stage 2F Acid Sulphate Soils Management Plan
- Stage 2F (incl. Flyover) Construction Environmental Management Plan
- Stage 2F (incl. Flyover) Construction Noise Management Plan
- Stage 2F (incl. Flyover) Construction Surface Water Management Plan
- Stage 2F (incl. Flyover) Construction Traffic Management Plan
- Stage 2F (incl. Flyover) Acid Sulphate Soils Management Plan
- Stage 2F (incl. Flyover) Construction Aboriginal Heritage Management Plan
- Vegetation Clearance Protocol

Operations Management Plans

- Operation Environmental Management Plan
- Operation Dust Management Plan
- Operation Noise Management Plan
- Operation Spontaneous Combustion Management Plan
- Operation Water Management Plan

Stage 2 F and Fly Over Management Plans

Other Management Plans and Programs

- Site Water Management Plan

- Green and Golden Bell Frog Management Plan
- Compensatory Habitat and Ecological Monitoring Program
- Coordinated Works Program
- Compliance Tracking Program
- Coordinated Environmental Monitoring and Management Protocol (with PWCS)

Monitoring Programs

- Environmental Monitoring Program (contained within the CEMP and OEMP)
- Green and Golden Bell Frog Monitoring Program
- Avifauna Monitoring Program

1.3 Project Contacts

Contact Details for the Project are provided below:

Chief Executive Officer
Aaron Johansen
Phone: (02) 4920 3954
Email: ajohansen@ncig.com.au

Manager – Projects
Lex Gleeson
Phone: (02) 4920 3916
Email: lgleeson@ncig.com.au

Manager – HSEC
(Environmental Representative)
Nathan Juchau
Phone: (02) 4920 3965
Email: njuchau@ncig.com.au

1.4 Project Background

The Newcastle Coal Infrastructure Group (NCIG) Coal Export Terminal (CET) (the Project) is located on Kooragang Island in Newcastle, New South Wales (NSW) (Figure 1). The Project includes the construction and operation of a CET up to 66 million tonnes per annum (Mtpa), including associated rail and coal handling infrastructure and wharf/ship loading facilities on the south arm of the Hunter River.

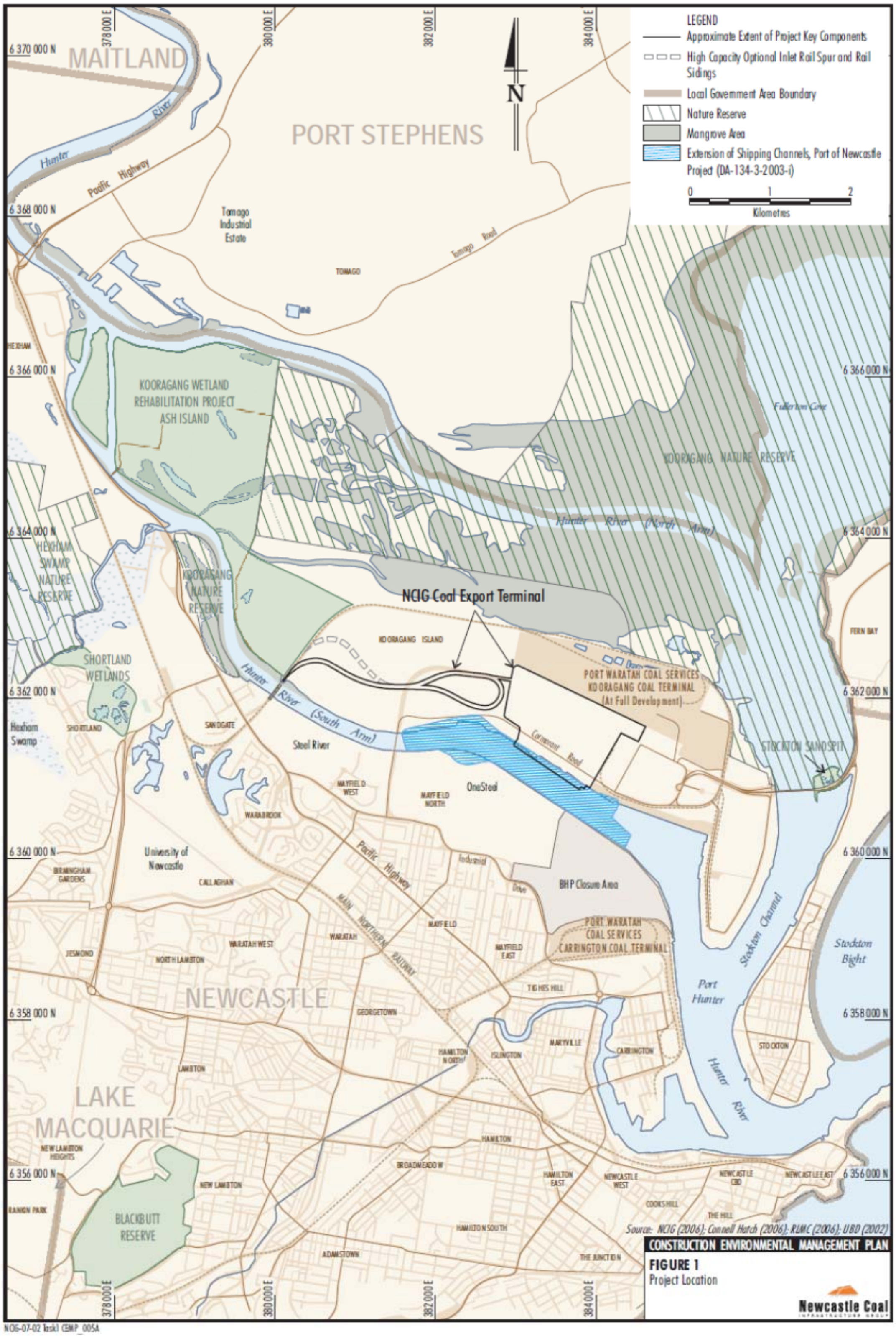


Figure 1: Project location

NCIG is the proponent of the Project and is a consortium of the following five companies:

- Banpu Public Company Limited;
- Hunter Valley Energy Coal Limited;
- Peabody Energy Corporation;
- Yankuang Group; and
- Whitehaven Coal Mining Pty Ltd.

NCIG was formed in response to a call for Expressions of Interest for the development of land on Kooragang Island by the NSW State Government in 2004. The outcome of this process was that in 2006 NCIG was awarded the right to develop the parcel of land that is now the Project site. Project Approval (06_0009) was granted in April 2007 and construction of Stage 1 of the coal export terminal (30 Mtpa) commenced in April 2008. Stage 1 of construction is completed and was subsequently handed to NCIG for operation in July 2010. Stage 2AA construction commenced in the first half of 2010, with mechanical completion achieved in June 2012. Stage 2F construction commenced in June 2012 and was completed in June 2013.

The Project general arrangement is shown on Figure 2. The general arrangement is based on the planned maximum coal throughput of 66 Mtpa. The main activities associated with the construction of the Project include:

- re-use of dredged materials from the south arm of the Hunter River as preload and engineering fill for construction of the coal storage area, rail corridor and wharf facilities (*NB/ NCIG did not conduct dredging operations during the reporting period*);
- construction of a coal storage area including coal stockpiles, conveyors, transfer points and combined stacker/reclaimers;
- construction of wharf facilities, ship loaders, conveyors and buffer bins;
- foundation preparation, formation construction and capping of a rail corridor traversing the existing Kooragang Island Waste Emplacement Facility (KIWEF) for the development of the rail spurs, rail sidings and rail loops;
- construction of rail spurs, rail sidings and rail loops, rail overpass, train unloading stations and connecting conveyors;
- development of water management infrastructure including site drainage works, stormwater settlement ponds, primary and secondary settling ponds, site water pond, water tanks and stockpile spray system;
- installation of electricity reticulation and control systems;

- development of access roads and internal roads;
- construction of administration and workshop buildings; and
- other associated minor infrastructure, plant, equipment and activities.

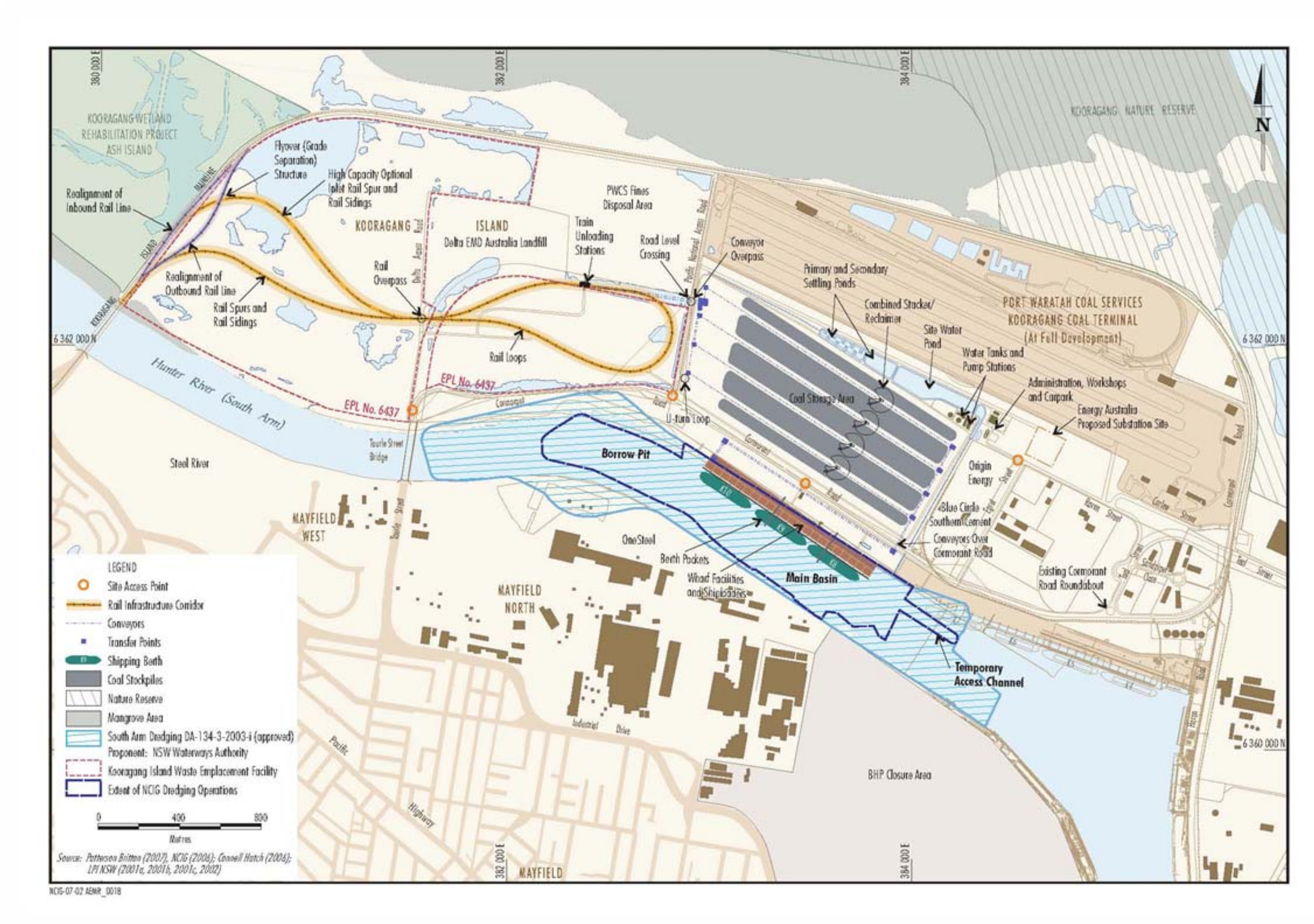


Figure 2: Project Layout

2 Overview of Activities

2.1 Operation

April 2013 to March 2014 reporting period included a continuation of Stage 1 and Stage 2AA operations, and commissioning and commencment of Stage 2F operations. This means that all mechanical equipment within the approved project were operational during the period, namely Dump Stations 1 and 2, Stacker/Reclaimers 1, 2,3 and 4 and Ship loaders 1 and 2, along with associated inbound and outbound conveyor systems. Commissioning completed on Milestones achieved in this reporting period include:

- September 2013 – 1000th vessel loaded
- September 2013 – Stage 2F Official Opening, opened by the NSW Premier
- February 2014 – 100MT of coal loaded since commencement of operations
- 21 March 2014 – best loading day (250,000 tonnes).

Figure 3: Construction of new Raw Water Tank.

Figure 4: Completion of Northern Haulage Road.

Figure 5: Completion of Northern Haulage Road and minor earthworks.

Figure 6: Completion of new Wharf Security Area.

Figure 7: Commencment of Rail Flyover construction, including site compound.

Figure 8: Commencment of Rail Flyover Embankment (western end).

Figure 9: Construction of Western Deviation (Rail Flyover).

Figure 10: Continuation of Rail Flyover Embankment Construction.

Figure 11: Rail Flyover Construction (flyover and western deviation).

Figure 12: Landscaping and construction of irrigation

Figure 13: Construction of new Stores Building

2.2 Construction

Construction activities during this reporting period were associated with the completion of Stage 2F, and commencement of the Rail Flyover construction. Construction activities and operational activities are shown in Figures 3 to 20. The milestones and specific activities associated with construction included:

- June 2013 – Completion of Stage 2F construction
- September 2013 – Commencment of Rail Flyover Construction
- January 2014 – Commencment of new Stores Building construction

Figure 14: NCIG Dust Suppression System in operation.

Figure 15: First coal delivered over Stacker Reclaimer 4.

Figure 16: First train delivery stacked to Stacker Reclaimer 4.

Figure 17: First coal on Conveyor 11.

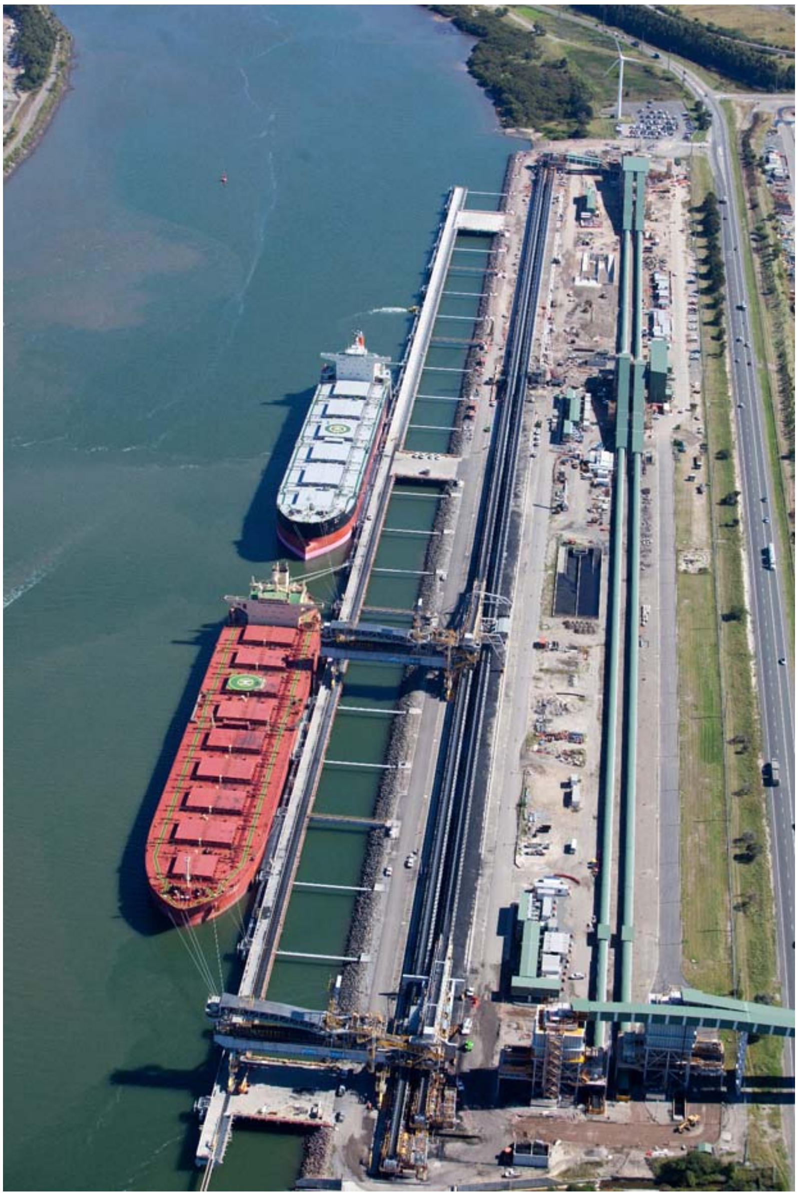


Figure 18: NCIG Wharf, two ships at berth.

Figure 19: NCIG Stockyard, Stacker Reclaimer 4 in foreground, Stack Reclaimer 1 in background.

Figure 20: Ship Loader 1, in park-up position.

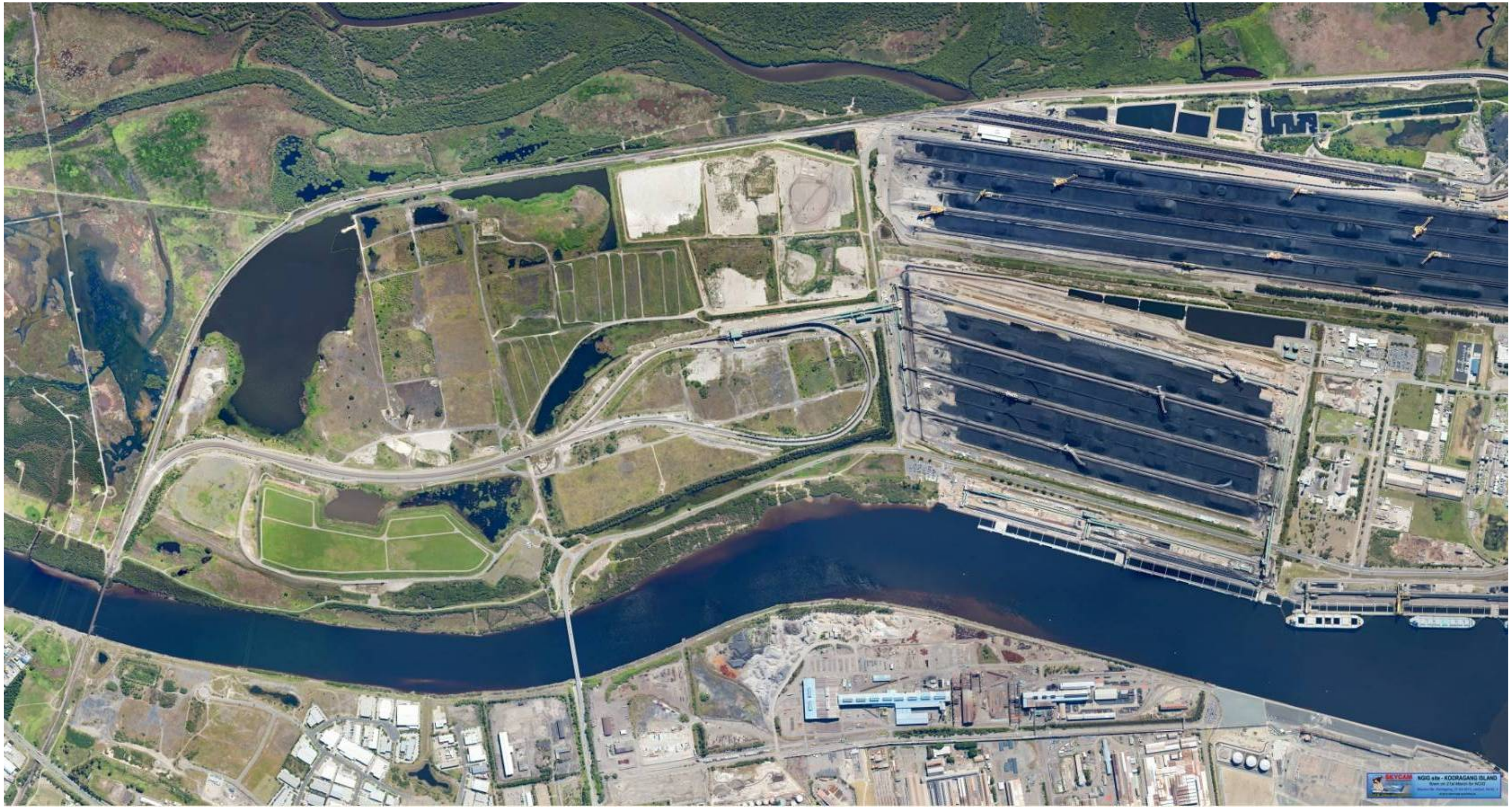


Figure 21: March 2013 Aerial Photograph of Project

Figure 22: March 2014 Aerial Photograph of Project

3 Environmental Management and Performance

3.1 Meteorology

3.1.1 Environmental Management

In accordance with Condition 2.8, Schedule 2 of the Project Approval (06_0009), an on-site automated meteorological monitoring station was operated during the reporting period to monitor weather conditions representative of the site. This station was installed on the NCIG site (see Figure 24) in accordance with the requirements of the CEMP.

The automated meteorological monitoring station allows parameters such as wind direction to be used in the control of stockyard sprays. This includes activation of sprays based on evaporation of surface moisture from the coal stockpiles and deactivation of sprays under wind conditions where sprays would otherwise be ineffective in reaching coal stockpiles.

3.1.2 Environmental Performance

Table 2 outlines the monitoring locations, meteorological parameters recorded and frequency of monitoring for the Project in accordance with the CEMP.

Table 2 Summary of the Meteorological Monitoring Program

Monitoring Parameter	Monitoring Sites	Frequency	Criteria
• Temperature • Relative humidity • Net solar radiation • Rainfall • Wind speed and direction • Sigma theta (rate of change of wind direction).	Project automated meteorological station [1].	Continuously monitored and the data averaged over 15 minute periods.	N/A

1 The location of the monitoring sites is shown on Figure 24.

3.1.3 Monitoring summary

The meteorological monitoring results for the reporting period are summarised below. Monthly statistical information for rainfall is detailed in Table 3.

Table 3 Rainfall statistics by month

Month	Total rainfall (mm)	Daily average (mm)	Daily minimum (mm)	Daily maximum (mm)
April 2013	107	3.5	0.0	34.8
May 2013	69.8	2.25	0.0	49.2
June 2013	131.4	4.9	0.0	31.0
July 2013	33.2	1.07	0.0	14.8
August 2013	8.2	0.27	0.0	4.6

Table 3 Rainfall statistics by month

Month	Total rainfall (mm)	Daily average (mm)	Daily minimum (mm)	Daily maximum (mm)
September 2013	24.2	0.8	0.0	9.6
October 2013	47.7	1.5	0.0	26.9
November 2013	265.2	8.84	0.0	98.2
December 2013	17.3	0.55	0.0	9.4
January 2014	8.6	0.27	0.0	2.8
February 2014	151.6	5.4	0.0	67.4
March 2014	82.0	2.6	0.0	32.4
Annual	946.2			

The monthly statistical information for each of the meteorological monitoring parameters is detailed in Appendix A.

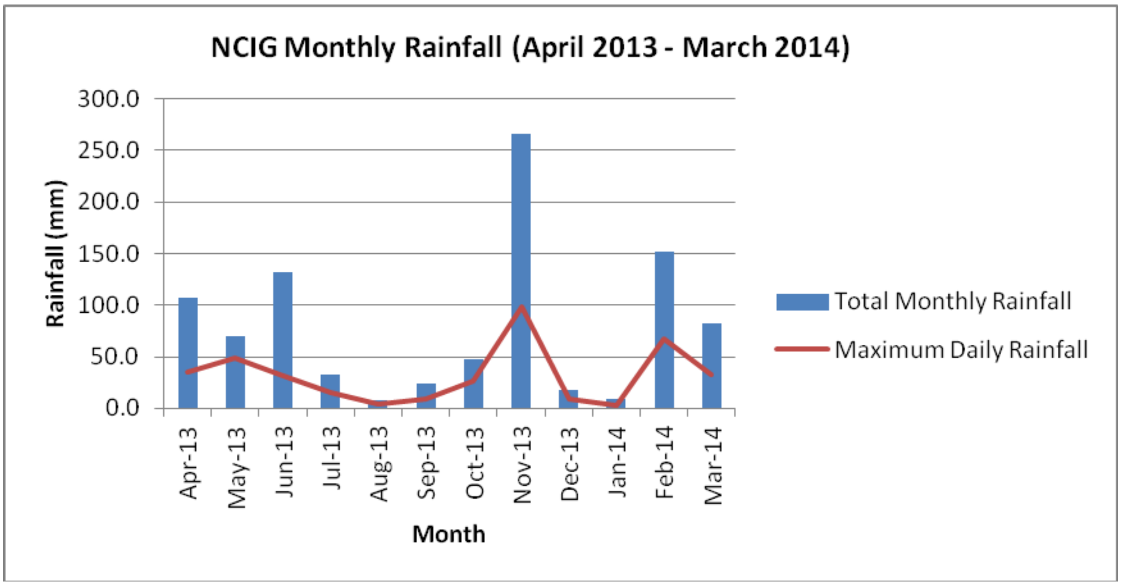


Figure 23: Total and maximum daily rainfall by month

The monthly and daily rainfall recorded at the project site is shown in Figure 23. A total of 946.2 mm of rain was received on the site during the reporting period with the highest rainfall recorded in November 2013. Low rainfall was recorded during April 2013 and the December 2013 to January 2014 period.

Figure 24: Environmental Monitoring Sites - Meteorology

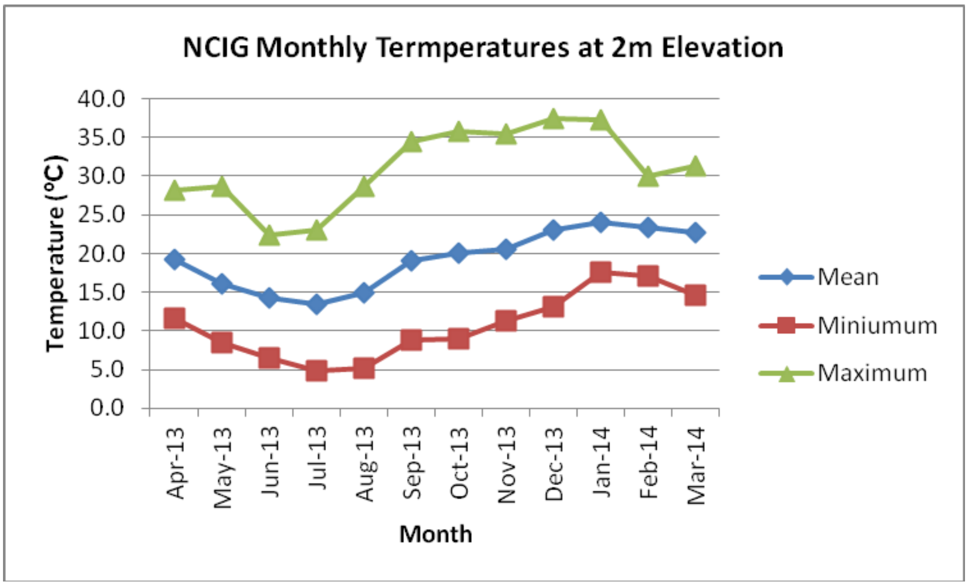


Figure 25: Temperature by month

Figure 25 illustrates the variation in average temperature during the reporting period. These variations from the winter to summer seasons are the expected seasonal normal variations. Figure 24 illustrates seasonal wind conditions.

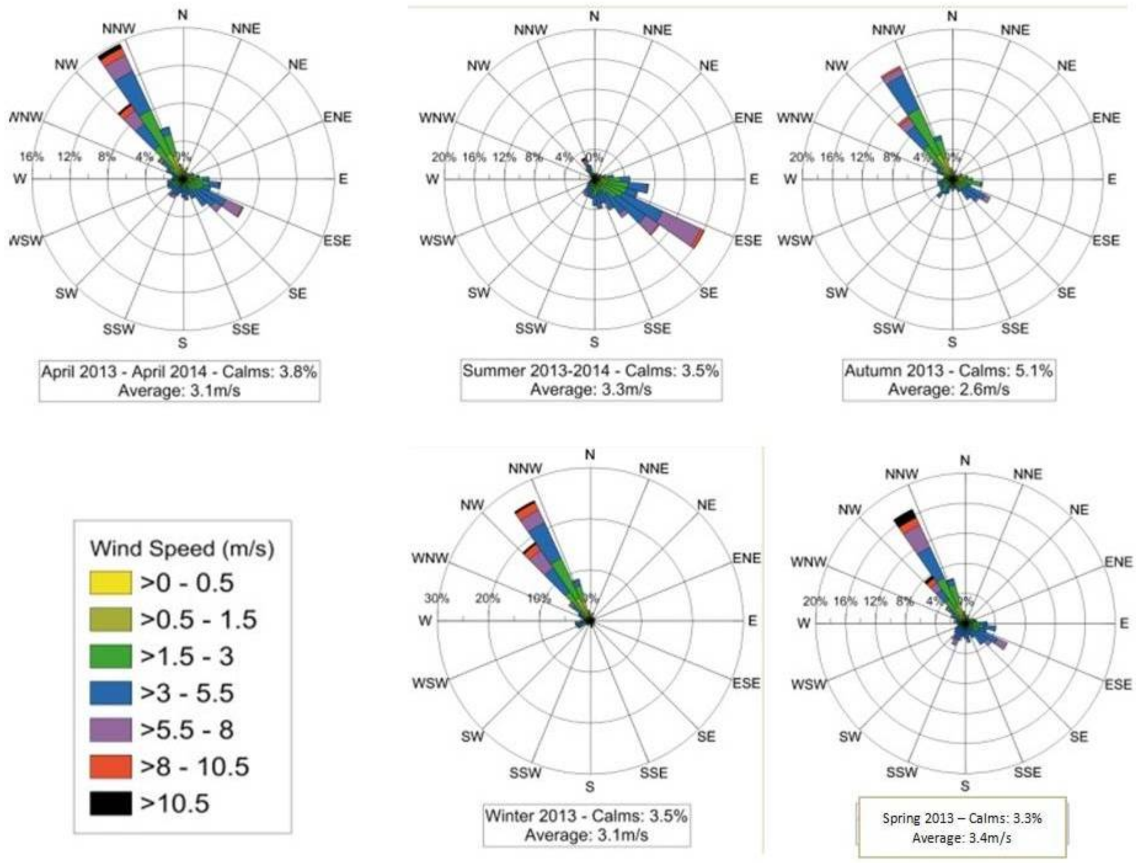


Figure 26: Seasonal Wind Conditions

3.1.4 Reportable incidents

No environmental incidents or complaints relating to meteorological conditions were made during the reporting period.

3.1.5 Further Improvements

No major improvements are anticipated for the meteorological system. Notwithstanding, elements of the existing meteorological station will be maintained as necessary.

3.2 Air Quality

3.2.1 Environmental Management

In accordance with Conditions 2.2 and 2.4, Schedule 2 of the Project Approval (06_0009) NCIG designed and constructed the Project in a manner that minimises or prevents the emission of visible dust beyond the boundary of the site (including windblown and traffic generated dust).

In accordance with Condition 2.5, Schedule 2 of the Project Approval (06_0009) dust emissions are being controlled on all internal roads, trafficable areas and manoeuvring areas by sealing, or otherwise treating surfaces to minimise the potential for dust generation.

In accordance with Condition 2.1, Schedule 2 of the Project Approval (06_0009) NCIG did not permit any offensive odour, as defined under section 129 of the *Protection of the Environment Operations Act, 1997*, to be emitted beyond the boundary of the Project site.

3.2.2 Environmental Performance

Table 4 outlines the monitoring locations, air quality parameters recorded, frequency of monitoring and air quality criteria for the Project in accordance with the CEMP.

Table 4 Summary of the Air Quality Monitoring Programme

Monitoring Parameter	Monitoring Sites	Frequency	Criteria
Dust deposition[2].	DG1, DG2, DG3, DG4, DG5 and DG6[1].	Monthly during the first three months of construction, then quarterly.	• 4 g/m^2/month.
Total Suspended Particulates (TSP).	HVAS1, HVAS2, HVAS3, HVAS4.	6-daily.	• 90µg/m[3] (NHMRC annual average)
Particulate Matter <10 microns (PM10).	HVAS1, HVAS2, HVAS3, HVAS4.	6-daily.	• 50µg/m3 (OEH 24hr daily limit, NEPM 24hr daily limit – allows for 5 exceedences in a year) • 30µg/m³(OEH annual average).

1 The location of monitoring sites is shown on Figure 24.

2 Dust deposition was analysed in accordance with AS/NZS 3580.10.1-2003 *Methods for Sampling and Analysis of Ambient Air – Determination of Particulate Matter – Deposited Matter – Gravimetric Method.*

3 TSP was analysed in accordance with AS/NZS 3580.9.3-2003 *Methods for Sampling and Analysis of Ambient Air – Determination of suspended particulate matter – Total suspended particulate matter (TSP) – high volume sampler gravimetric method.*

4 PM10 was analysed in accordance with AS/NZS 3580.9.6-2003 *Methods for Sampling and Analysis of Ambient Air – Determination of suspended particulate matter – PM10 high volume sampler with size selective inlet – Gravimetric method.*

The depositional dust monitoring (insoluble solids) results for the reporting period are displayed in Figure 27 and Figure 28 below.

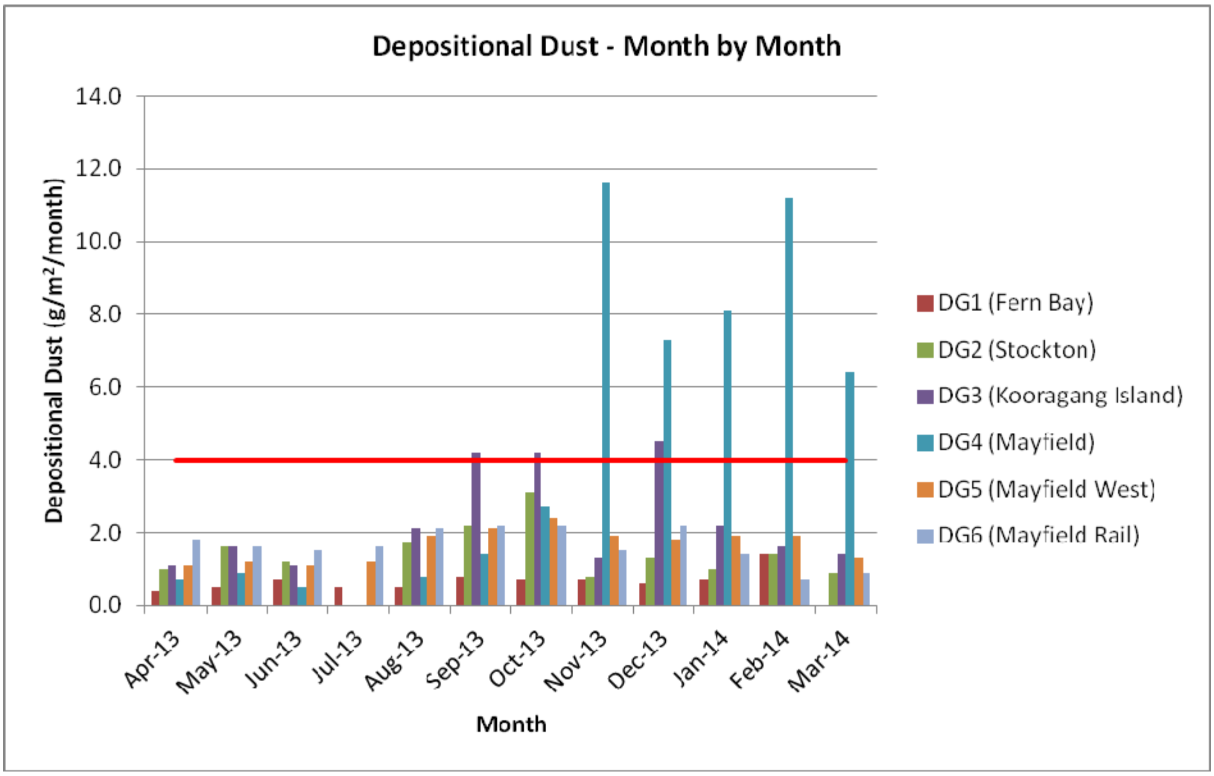


Figure 27: Monthly Depositional Dust

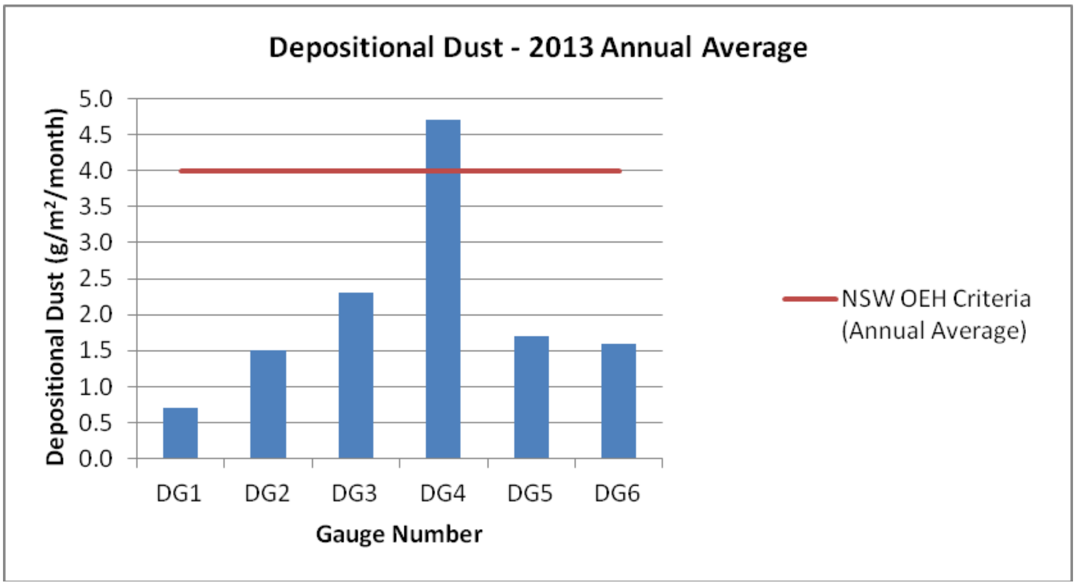


Figure 28: Annual Average Depositional Dust

Average depositional dust results were below the monthly criteria of 4 grams per square metre per month at all depositional dust gauge locations aside from DG4 located at Mayfield (Figure 28).

Figure 27 shows that individual monthly samples from DG4 exceeded the 4g/m^2/month criteria between November 2013 and April 2014.

The exceedences at DG4 in Mayfield would not be sourced from NCIG. Construction of a residential housing development, including cut to fill, commenced on a property immediately adjacent to the location of the dust gauge in November 2013. The ash content, which is an indication of the mineral content of the dust (primarily soil or rock particles) increased from 1.9g/m^2 in October 2013 to 8.7g/m^2 in November 2013, correlating with the commencement of construction in Mayfield. The ash content has remained elevated since this time and construction is on-going.

Air quality monitoring results from High Volume Air Sampling (HVAS), as they relate to both Total Suspended Particulate (TSP) and Particulate Matter with an equivalent aerodynamic diameter less than 10 Microns (PM_{10}), are displayed in Figure 29 and Figure 30.

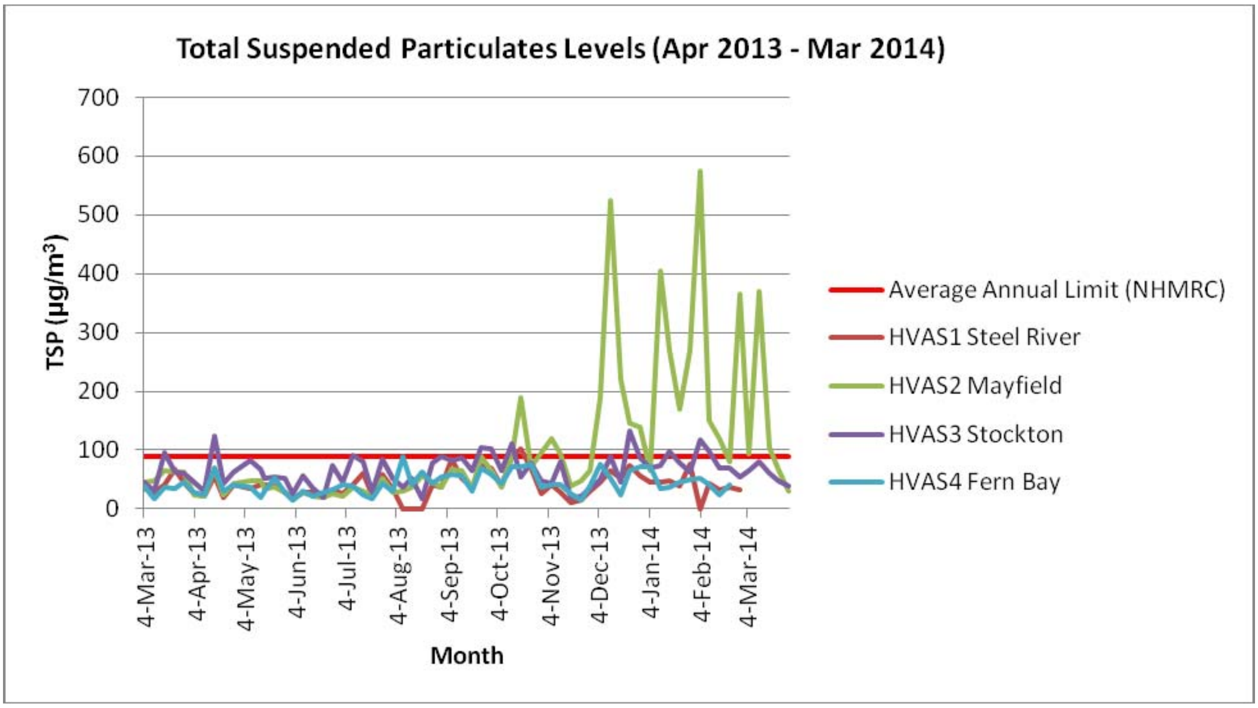


Figure 29: Total Suspended Particulates (TSP)

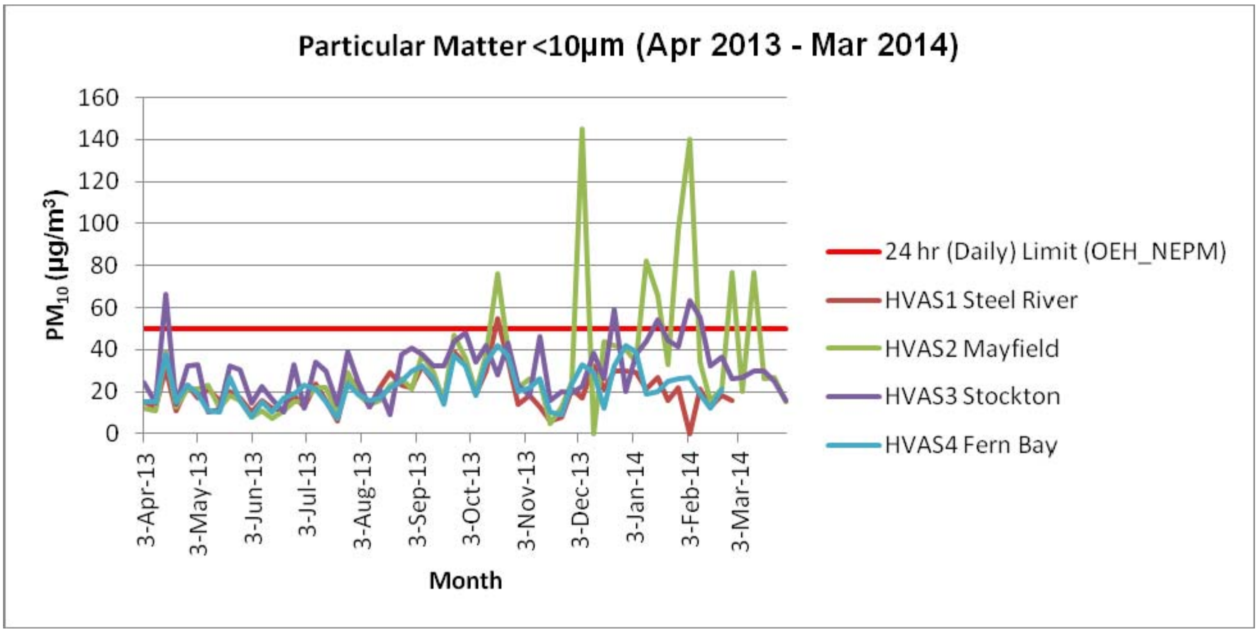


Figure 30: Particulate matter <10µm (PM10)

The annual average TSP concentrations for three of the four monitoring locations were below the NHMRC Annual Average Limit of 90µg/m^3, as shown in Table 6. Average TSP concentrations at HVAS2 in Mayfield exceeded the limit of 90µg/m^3 due to the commencement of construction at the adjacent property in Mayfield.

Daily concentrations of PM_{10} were also below their respective guideline of 50µg/m^3 (OEH and NEPM), with the exception of HVAS2 in Mayfield between October 2013 and March 2014 and HVAS3 in Stockton on the following dates: 15 April 2013, 23 December 2013, 16 January 2014, 3 February 2014 and 9 February 2014. Meteorological conditions were reviewed on these days to assess the likelihood that NCIG had contributed to these elevated levels as shown in Table 5 below.

For the Mayfield monitoring station, the elevated PM10 events are considered to be associated with the commencement of construction at the adjacent residential property in Mayfield.

For the Stockton monitoring station, a nor westerly wind direction at elevated wind speeds above 5m/s gives rise to a high risk of particulate emissions sourced from the Kooragang Island vicinity. The nor westerly wind conditions do not necessarily mean that the source of elevated particulates at the Stockton monitoring station is the NCIG CET as there are several potential sources of particulates in the upwind direction from the monitoring station. In addition, dust suppressant sprays are activated at NCIG in high wind erosion risk conditions. Daily PM_{10} events greater than 50µg/m^3 guideline value at Stockton are discussed further in Table 5.

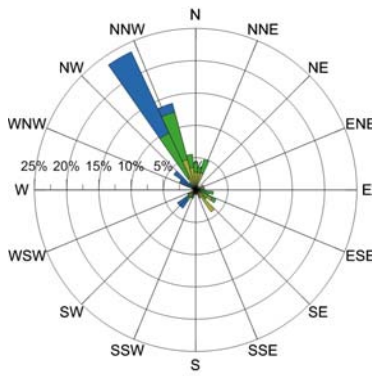
Table 5 Daily PM_{10} events greater than 50µg/m^3 guideline value at Stockton.		
Event	**Wind patterns**	**Comments**
15-Apr-13 66 µg/m^3 at Stockton	15 April 2013 - Calms: 2.1% Average: 2.2m/s	NCIG is to the northwest of the Stockton monitor. Prevailing winds on this day were from the northwest. There was no rainfall on this day or the preceeding day. Wind speeds ranged from 0.3 to 5.5 m/s. Measured PM_{10} concentrations at Beresfield (upwind of Kooragang Island) on the day were 35.6 µg/m^3. The 24-hour average PM_{10} concentration measured by the BAM on NCIG's eastern boundary was 69 µg/m^3. Therefore: - Activities at NCIG may have contributed to the exceedance as NCIG's on-site BAM monitoring result showed a 24-hour average PM_{10} concentration of 69 µg/m^3. The monitor on the eastern boundary is impacted by localized dust from an adjacent conveyor head and is not a good indicator of ambient dust on the eastern boundary. This monitor was relocated closer to the NCIG boundary in June 2014. - Activities on Kooragang Island may have contributed to the exceedance of the 50 µg/m^3 criterion on this day. The specific source(s) could not be identified. - Modelling in the Environmental Assessment suggested that the maximum 24-hour average PM_{10} concentration at Stockton, due to NCIG activities, would be up to around 5 µg/m^3. Outcome: Compliance

Table 5 Daily PM_{10} events greater than 50µg/m^3 guideline value at Stockton.

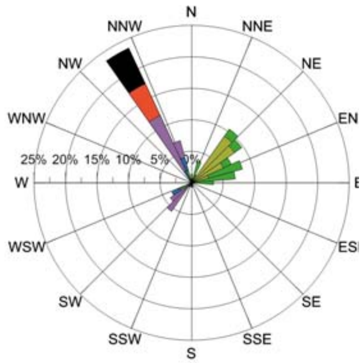
Event	Wind patterns	Comments
23-Dec-13 59 µg/m^3 at Stockton	 23 December 2013 - Calms: 0.7% Average: 3.9m/s	NCIG is to the northwest of the Stockton monitor. Prevailing winds on this day were mainly from the northwest. There was no rainfall on this day or the preceding day. Wind speeds ranged from 0.9 to 12.5 m/s. Measured PM_{10} concentrations at Beresfield (upwind of Kooragang Island on the day were 34 µg/m^3 (EPA, 2013). The 24-hour average PM_{10} concentration measured by the BAM on NCIG's eastern boundary was 216 µg/m^3. Therefore: - Activities at NCIG may have contributed to the exceedence as NCIG's on-site BAM monitoring result showed a 24-hour average PM_{10} concentration of 216 µg/m^3. The monitor on the eastern boundary is impacted by localized dust from an adjacent conveyor head and is not a good indicator of ambient dust on the eastern boundary. This monitor was relocated closer to the NCIG boundary in June 2014. - Activities on Kooragang Island may have contributed to the exceedance of the 50 µg/m^3 criterion on this day. The specific source(s) could not be identified. - Modelling in the Environmental Assessment suggested that the maximum 24-hour average PM_{10} concentration at Stockton, due to NCIG activities, would be up to around 5 µg/m^3. Outcome: Compliance

Table 5 Daily PM_{10} events greater than $50 µg/m^3$ guideline value at Stockton.

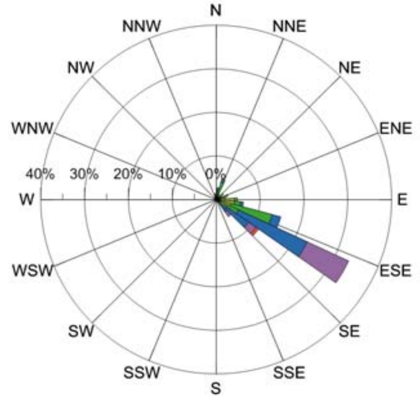
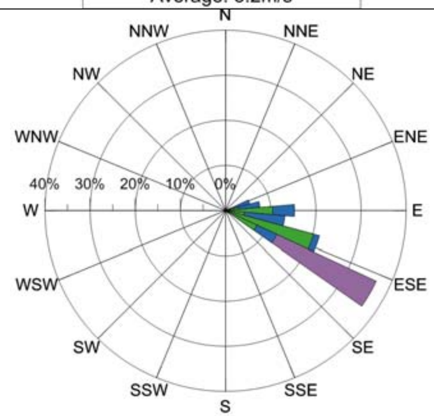
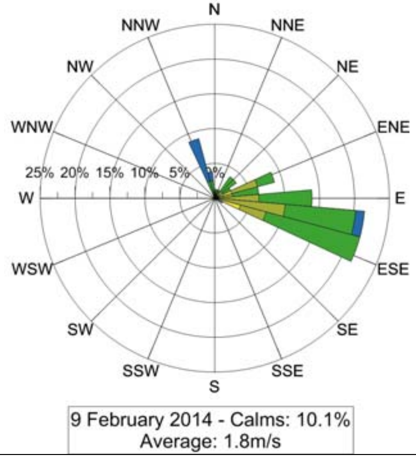
Event	Wind patterns	Comments
16 - Jan -14 54 µg/m3 at Stockton	 16 January 2014 - Calms: 9.7% Average: 3.2m/s	NCIG is to the northwest of the Stockton air quality monitor. Prevailing winds on this day were from the south east. Therefore: - Activities at NCIG were unlikely to have contributed to the measured result at Stockton on this day. Outcome: Compliance
3-Feb-14 63.5 µg/m3 at Stockton	 3 February 2014 - Calms: 0.0% Average: 4.0m/s	NCIG is to the northwest of the Stockton air quality monitor. Prevailing winds on this day were from the south east. Therefore: - Activities at NCIG were unlikely to have contributed to the measured result at Stockton on this day. Outcome: Compliance

Table 5 Daily PM_{10} events greater than 50µg/m³ guideline value at Stockton.		
Event	**Wind patterns**	**Comments**
9-Feb-14 55 µg/m3 at Stockton		NCIG is to the northwest of the Stockton air quality monitor. Prevailing winds on this day were from the east south east. Therefore: - Activities at NCIG were unlikely to have contributed to the measured result at Stockton on this day. Outcome: Compliance

The OEH Annual Average Goal of 30µg/m^3 (formerly NSW DEC, 2005) for PM_{10} was exceeded at monitoring stations HVAS2 and HVAS3 as shown in Table 6 below.

Table 6 Annual Average TSP and PM_{10} Concentrations (µg/m^3)

Annual Average Jan 2012 – Dec 2012	HVAS1 Steel River	HVAS2 Mayfield	HVAS3 Stockton	HVAS4 Fern Bay
TSP annual average criteria (NSW DEC, 2005)	90			
TSP	43.2	101.3	64.4	42.7
PM_{10} annual average criteria (NSW DEC, 2005)	30			
PM_{10}	20.8	32.4	30.4	22.0

Dust from coal handling operations was managed primarily through suitable design of plant and machinery, including enclosures and housed areas at the dump station, conveyors, transfer houses, the buffer bin and feeders throughout the site. Additional measures include operation of dust suppression and moisture addition sprays at transfer points positioned both in transfer houses and on the machines (i.e. Stacker/Reclaimers and the Ship loader). Dust suppression spray guns have also been positioned along the stockyard berms directly adjacent the coal stockpiles. These operate on an automatic sequence, which takes into account varying weather conditions and evaporation rates of water from stockpiles. The onsite weather station is also connected to the system. This system is managed in accordance with the Operations Dust Management Plan (ODMP), including programming logic known as an Integrated Dust Management System

In accordance with Condition 3.2 e) of Project Approval (06_0009), NCIG utilises real-time monitoring data to inform environmental management decisions associated with the project. This is done through interaction with real-time Environmental Beta Attenuation Monitors (EBAMs), which measure PM_{10}. These are located at the boundaries of the stockyard and are used to assist the management of operation to ensure compliance with project obligations (Note – since the end of the reporting period, the EBAMs have been replaced with Beta Attenuation Monitors, which are more reliable and consistent measurement. These measure Total Suspended Particulates (TSP). In addition, the Eastern Monitor has been relocated away from the adjacent conveyor head to avoid impacts of point source localised dust which is likely to fall out within the NCIG boundary).

The dust control measures implemented during construction of the Project include the following:

- demarcation and minimisation of ground disturbance areas;

- paving of appropriate internal roads;
- watering of exposed ground disturbance areas with high traffic use using water trucks to minimise the generation of dust;
- surface binder sealing of unsealed surfaces that are not traffic thoroughfares;
- establishment of grass pasture on disturbed areas as soon as possible;
- confining vehicle movements to designated access routes;
- limiting the speed of vehicles on unpaved roads; and
- limiting ground disturbance activities during identified windy conditions.

All stockpiled construction materials were also managed to minimise wind-blown dispersal of the materials in accordance with Condition 2.45 of Project Approval (06_0009) by limiting the height of the stockpiles and watering of the stockpiles during windy conditions.

3.2.3 Reportable Incidents

There were no air quality incidents during the reporting period.

Complaints regarding air quality received during the reporting period (see Section 3.13) were responded to in accordance with the Complaints Response Procedure.

3.2.4 Further Improvements

Further enhancement of NCIG's Integrated Dust Management System were made in the 2013/14 reporting period. These improvements included further implementation of a dust risk classification system and refinement of programming logic, particularly in regards to water addition on the conveyor system and coal stockpiles. Further changes will be a part of the ongoing continuous environmental improvement programs at NCIG.

3.3 Water Quality

3.3.1 Environmental Management

In accordance with Condition 7.6 c), Schedule 2 of the Project Approval (06_0009), an Operations Water Management Plan (OWMP) was developed which defines the surface water, stormwater and groundwater controls on the NCIG Project site during operation. The Plan includes specific measures designed to avoid sediment-laden, coal-laden or hydrocarbon-impacted surface water from entering Deep Pond, wetland areas or the Hunter River. The Plan also includes a monitoring programme of surface water utilised on and around the Site. The plan identifies water management infrastructure and water requirements for activities such as dust suppression and plant washdown. A site water balance is included, which accounts for water captured on site through rainfall and volumes of water that may be required from the local potable water system.

In accordance with Condition 7.3b), Schedule 2 of Project Approval (06_0009), a Construction Surface Water Management Plan (CSWMP) was developed which defines how surface water and stormwater is managed on the NCIG CET site during construction. The

Plan includes the definition of appropriately-sized stormwater controls, in accordance with *Managing Urban Stormwater: Soils and Construction* (Landcom, 2004). The Plan also includes specific measures designed to avoid sediment-laden stormwater from entering Deep Pond, wetland areas or the Hunter River, and a monitoring programme for stormwater leaving the Site. This plan was updated in June 2013 to include information relating to the construction of the flyover.

Additional groundwater monitoring requirements were introduced during the reporting period for the construction of the fly over. Environmental Earth Sciences (EES) developed a Groundwater Management Plan in September 2013 to satisfy Conditions 2.45A and 2.45B of the Modification of the Minister's Approval MP06_0009. This plan includes groundwater monitoring and the monitoring of surface water at Deep Pond and Swan Pond on a quarterly basis.

The CSWMP and OWMP identify that surface water runoff from disturbance areas during construction and operation of the Project could potentially contain sediments, soluble salts, fuels, oils, grease and other contaminants, in particular coal residue. The potential surface water quality impacts that relate to these contaminants from each area of the Project site are summarised in Table 7.

Table 7 Potential surface water quality impacts

Project Site	Potential Impact Scenario	Potential Contaminant
Rail Infrastructure Corridor	Uncontrolled drainage of sediment laden runoff to downstream waterbodies within the Kooragang Island Waste Emplacement Facility (KIWEF) during construction of rail embankments.	Sediments, soluble salts, heavy metals, organic contaminants, fuels, oils and grease.
	Uncontrolled drainage of runoff from access roads and construction areas to downstream waterbodies within the KIWEF.	
	Uncontrolled drainage of runoff from exposed soils within the existing KIWEF to downstream waterbodies.	
	Potential erosion and sedimentation resulting from runoff from the rail corridor and associated drainage system.	
	Release/spill into downstream waterbodies.	Coal, diesel, lubricants and hydrocarbons.
Coal Storage Area	Uncontrolled drainage to downstream waterbodies during construction of the coal storage	Sediments, soluble salts, heavy metals, organic contaminants, fuels,

Table 7 Potential surface water quality impacts

Project Site	Potential Impact Scenario	Potential Contaminant
	area.	oils, lubricants and low pH water.
	Uncontrolled drainage of runoff from access roads and construction areas to downstream waterbodies.	
	Spillage/overflow of site water to downstream waterbodies.	
	Release/spill into downstream waterbodies due to rupture of fuel tank (diesel/petrol).	Sediments, coal, diesel, lubricants and hydrocarbons.
Wharf Facilities and Ship loader Area	Uncontrolled drainage of sediment laden runoff to the south arm of the Hunter River during construction of the berths and wharf structure, excavation on or near the banks of the South Arm of the Hunter River and during piling operations.	Sediments, soluble salts, fuels, oils and grease.
	Uncontrolled drainage of runoff to the south arm of the Hunter River from access roads and wharf construction areas including excavation on or near the banks of the South Arm of the of the Hunter River.	
	Release/spill into South Arm of the Hunter River.	Sediments, coal, diesel, lubricants, hydrocarbons.

This identification of surface water flows was utilised to develop the monitoring programme defined in both the CSWMP and the OWMP which aim to ensure adjacent water bodies are not impacted by NCIG construction activities. The CSWMP and OWMP were approved by the Department of Planning (now NSW Planning and Infrastructure) as part of the Construction Environmental Management Plan (CEMP) and Operations Environmental Management Plan (OEMP) respectively.

The surface water management strategies, as detailed in both the CSWMP and OEMP, are:

- the separation of surface water runoff generated from within the active CET and Project construction areas from that generated from surrounding areas;
- containment and reuse of water onsite;
- the implementation of adequate water management controls to minimise the potential for impacts to off-site water resources such as adjacent wetland areas, Deep Pond and the Hunter River (Figure 21).

The management of erosion and sedimentation is outlined is Section 3.4

3.3.2 Environmental Performance

Table 8 outlines the monitoring locations, frequency of monitoring and monitoring parameters for the Project in accordance with the CEMP, OEMP and OWMP. These monitoring elements form the Surface Water Monitoring Program for the Project.

Table 8 Surface Water Monitoring Program

Monitoring Locations	Frequency	Parameters
Primary and secondary settling ponds, overflow pond.	Monthly	• pH; • Electrical conductivity (EC); • Turbidity; • Temperature.
	During period of heavy rainfall (i.e. more than 20 mm of rainfall in a 24 hour period).	• Water level.
Surface water monitoring sites.[1]	Monthly	• pH; • EC; • Turbidity; • Temperature.
Drainage, erosion and sediment control infrastructure.	Monthly	• Structural stability and effectiveness in controlling sediment migration.
Collection sumps	Weekly	• Level of collected sediment.
Deep Pond and Swan Pond	Quarterly	• TRH, BTEX; • PAHs, incl. Naphthalene; • Dissolved heavy metals (Al, As, Br, Cr, Cu, Fe, Mn, Pb, Zn); • Biochemical Oxygen Demand.

1 The location of monitoring sites is shown in Figure 29

A site drainage network was established to capture site runoff. The topography grades to the north and west of the Project site and the existing flow path for surface runoff was incorporated into the completed site surface profile.

The drainage network that was established for dredging activities was incorporated into the design of the permanent water management infrastructure on the site. This design involves stormwater draining from east to west in the coal stockpile area at which point it collects in an open drain and is directed to the north-west of the site (see Figure 31). Additional subsurface drainage was constructed as part of Stages 2AA and 2F, specifically beneath the extended stockpile area. Surface water captured in the construction area of the stockyard is redirected both to the east and west. Both operations and construction surface water is then captured in primary settling ponds across the north of the site where fines are allowed to settle. This water cascades from the primary ponds into a secondary settlement pond prior to collection in the clearwater pond where it is then pumped to water storage tanks and is then available for reuse on the site. This water resource is to be utilised primarily for dust suppression purposes across the site, but also wash-down and belt cleaning activities.

Within the design of the drainage network, stormwater from the wharf and rail areas of the site are also directed into the stockyard water management system. Stormwater collected on the wharf is accumulated in an on-site pond and then pumped across Cormorant Road. Stormwater captured in the vicinity of the train unloading station is also pumped to the stockyard, with both sources eventually made available for reuse after treatment in the northern settlement ponds. This includes additional controls constructed as part of Dump Station 2. The existing surface water management controls in the rail loop and sidings allowed for the increased catchment capacity from Stages 2AA and 2F rail construction. Subsurface drainage from beneath Coal Stockpile Pads 4 and 5, and associated collection sumps were constructed as part of the Stage 2F construction works. Surface water drainage controls were also constructed at K10 wharf and the extension of the portside facility.

Sampling of surface water ponds was also undertaken during the reporting period in accordance with the CSWMP and OWMP. The location of the sampling undertaken is illustrated in Figure 31 with the water quality results recorded detailed in Appendix B.

Values for pH on site were slightly higher than the previous reporting period with a range of 7.7 to 8.6, although this is considered to be a healthy range and within historical range. The offsite water resources (7.7 to 9.3) were more variable than onsite sampling locations, although this is also considered to be a healthy range and within the historical range. Electrical conductivity (EC) was generally low onsite, with higher values reported at Swan Pond off-site. Dissolved Oxygen (DO), while being seasonally variable, was comparable between sites. Turbidity values were variable across all sites, which is likely due to discrete weather events (i.e. rainfall) and the settlement process within onsite ponds.

3.3.3 Reportable Incidents

No environmental incidents or complaints were reported relating to water quality management were made during the reporting period.

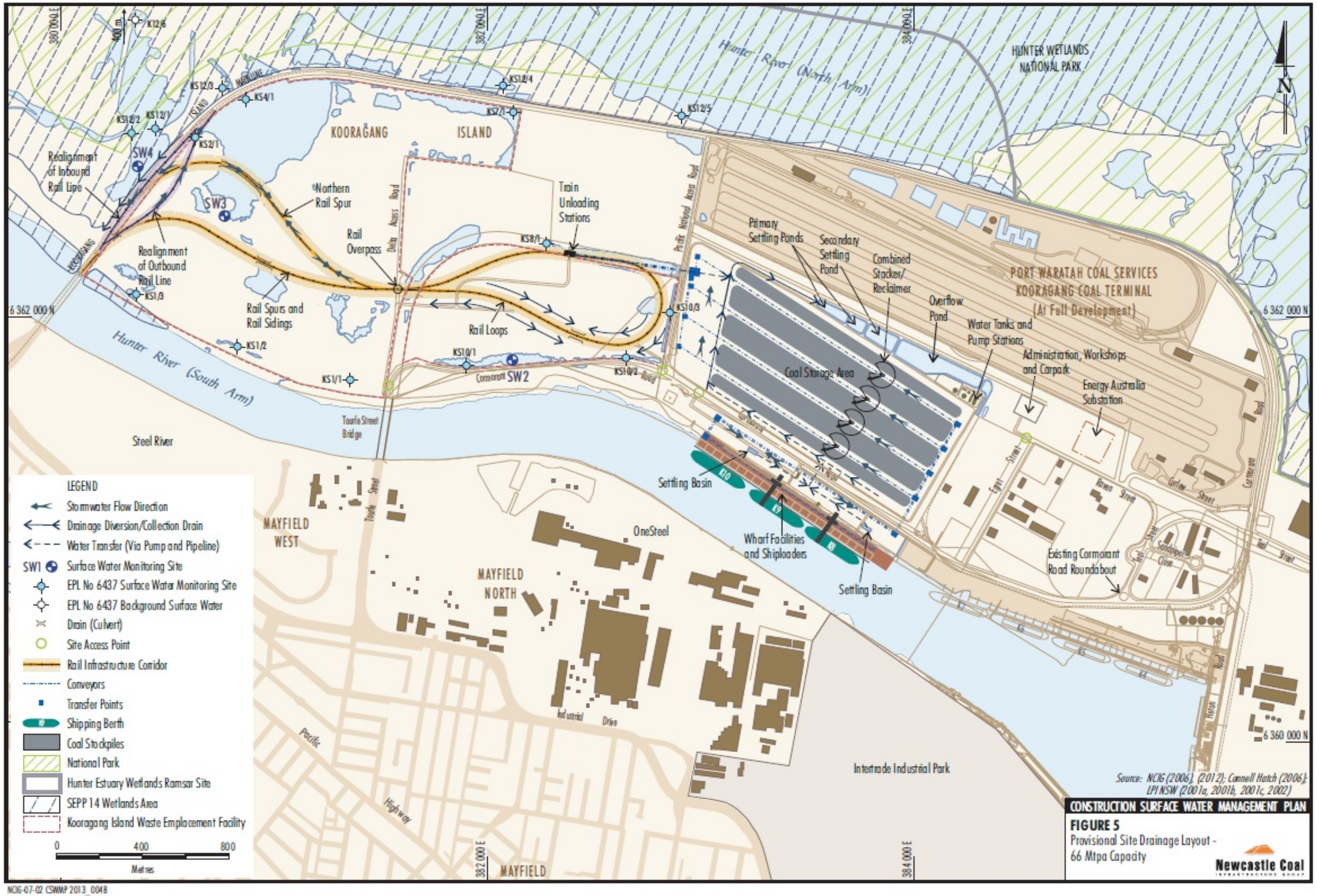


Figure 31: Permanent site drainage layout

3.3.4 Further Improvements

Additional surface water controls will be completed as part of the flyover construction, particularly the separation offsite clean water from onsite water.

3.4 Erosion and Sediment Control

3.4.1 Environmental Management

In accordance with Condition 2.43, Schedule 2 of the Project Approval (06_0009) NCIG took all reasonable measures to prevent soil erosion and the discharge of sediments and pollutants from the site during construction activities.

In accordance with Condition 2.42, Schedule 2 of the Project Approval (06_0009) NCIG has designed and constructed surface water and stormwater management infrastructure on the site to accommodate a 1 in 100 annual recurrence interval (ARI) rainfall event.

All erosion, sediment and pollution control infrastructure is being maintained on the Project site at or above design capacity during construction of the Project and will continue to be until such time as all ground disturbed by the works has been stabilised and rehabilitated so that it no longer acts as a source of sediment, in accordance with Condition 2.44, Schedule 2 of Project Approval (06_0009).

All stockpiled construction materials have been managed to minimise erosion or dispersal of the materials in accordance with Condition 2.45 of Project Approval (06_0009). All fill/preload material brought to the Project site is managed in a manner that minimises erosion and dispersal of those materials to the downstream waters (e.g. south arm of the Hunter River).

In accordance with Condition 2.49, Schedule 2 of the Project Approval (06_0009), all stormwater and surface water management infrastructure associated with the operation of the Project is lined with a low-permeability material to minimise potential leakage. Stormwater is reused onsite for beneficial purposes such as the wetting of coal to reduce dust emissions from the Site.

All grey wastewaters from the site are directed to sewer in accordance with a Trade Waste Licence, approved through Hunter Water Corporation, in accordance with Condition 2.51, Schedule 2 of Project Approval (06_0009).

Erosion and sediment control measures and general surface water management measures for the Project are documented in the approved Construction Surface Water Management Plan (CSWMP) and the Operations Water Management Plan (OWMP).

3.4.2 Environmental Performance

Table 9 outlines the monitoring locations, erosion and sediment control parameters recorded, frequency of monitoring and criteria for the Project in accordance with the CEMP.

Table 9 Summary of the Erosion and Sediment Control Monitoring Program

Monitoring Parameter	Monitoring Sites	Frequency	Criteria
Structural stability and effectiveness in controlling sediment migration.	Drainage, erosion and sediment control infrastructure.	Monthly and following significant rainfall events (i.e. greater than 20 mm in 24 hours)	N/A.

The management of erosion and sedimentation for the NCIG Project is detailed by the Erosion and Sediment Control Plan (ESCP). The ESCP is a document that is continually modified to account for project areas and activities of identified risk of erosion and sedimentation. Activities that have the potential to cause or increase soil erosion at the Project have been identified and are primarily due to exposure of soils during construction activities.

The general erosion and sediment control principles adopted take into account the general recommendations for site drainage works presented in Managing Urban Stormwater: Soils and Construction – Volume 1 (Landcom, 2004) which underpin the goal of protecting adjacent wetland areas, Deep Pond and the Hunter River. These principles involve:

- Minimising surface disturbance and restricting access to undisturbed areas.
- separation of runoff from disturbed and undisturbed areas where practicable.
- Construction of surface drains to facilitate the efficient transport of surface runoff or utilisation of existing stormwater systems.
- Construction of the site drainage network including perimeter bunds, internal bunds, primary settling ponds and hydraulically controlled discharge structures.
- Construction of primary and secondary settling ponds, site water pond and sediment dams to contain runoff up to specified design criterion.
- Installation of a silt curtain in the south arm of the Hunter River local to the disturbance area during construction of the shipping berth batters, wharf structure and during piling operations (in the River) that may create excessive material disturbance.
- Installation of silt curtains in Swan Pond and Deep Pond during construction of the Rail Flyover to contain mobilised sediments generated from ground disturbance.

In ensuring the erosion and sediment control principles are adhered to, development activities on the Project have been typically undertaken in the following order:

- Construction of sediment fences (down slope of disturbance areas) where required.
- Installation of silt curtains in identified water bodies, including the Hunter River, where required.

General construction works are only commenced once erosion and sediment control measures are in place.

- Construction of drainage diversions (typically upslope of disturbance areas) – these were only constructed where they significantly reduced the runoff catchment of disturbance areas and connected to the site drainage network where practicable.
- Construction of the primary and secondary settling ponds and a clearwater pond.
- Construction of collection drains (down slope of disturbance areas) where required to convey runoff to the site drainage network (including primary and secondary settling ponds and a site water pond).

Erosion and Sediment Control Plans (ESCP), detailing specific erosion and sediment control measures, are developed in a progressive manner prior to the development of each Project component requiring land disturbance. This is undertaken through a risk assessment process associated with the individual task proposed and are modified as required to ensure that the goal of protecting water bodies from erosion and sedimentation is achieved.

Temporary erosion and sediment controls (e.g. silt fences and sediment control structures) are installed prior to the commencement of construction activities on the Project site. Routine (i.e. monthly) inspections of sediment control structures, as well as inspections following significant rainfall events (e.g. 20 millimetres (mm) or more in a 24 hour period), are conducted by NCIG personnel. During these inspections, sediment control structures were inspected for capacity, structural integrity and effectiveness. Any deficiencies identified by these inspections are assessed, prioritised and rectified in the appropriate timeframe.

A network of permanent stormwater structures has been constructed to manage runoff around the site. All long-term site water management structures are lined with low permeability materials (e.g. compacted clay) to minimise the potential for leakage. Water management structures are designed with sufficient capacity for a 1 in 100 year average recurrence interval (ARI) rainfall event.

3.4.3 Reportable Incidents

No environmental incidents or complaints relating to erosion or sediment control were made during the reporting period.

3.4.4 Further Improvements

No scheduled improvement to erosion and sediment control is required for the next period as the construction of the permanent surface water management infrastructure on the terminal site was completed during this reporting period. Ongoing amendments to construction erosion and sediment control on the flyover site will be made as necessary to accommodate the change in work areas.

3.5 Groundwater

3.5.1 Environmental Management

Groundwater monitoring requirements were changed during the 2011 monitoring period as specified in EPL 12693. Monitoring Points GW2, GW3 and GW4 were removed from the licence and replaced with K9/3N, K9/3S, K11/1S and K11/1 (as shown in Figure 31), referred to as Monitoring Points 20, 21, 22 and 23 in the EPL. The reason for this change was to detect potential migration of contaminants of concern which may be mobilised as a result of settlement from the NCIG constructed rail embankments. The source of contamination is the former Kooragang Island Waste Emplacement Facility (KIWEF), which lies beneath the NCIG rail loop. Contaminants of concern include mainly hydrocarbons and some inorganic compounds. A series of Groundwater Trigger Values are established in the EPL, which activate further monitoring at additional locations and a notification process if exceeded. Monitoring of GW1 remains a requirement.

Additional groundwater monitoring requirements were introduced during the reporting period for the construction of the flyover. Environmental Earth Sciences (EES) developed a Groundwater Management Plan in Spetember 2013 to satisfy Conditions 2.45A and 2.45B of the Modification of the Minister’s Approval MP06_0009. This plan includes the monitoring of bores BH19s/BH19d, BH21s/BH21d and BH23s/BH23d on a quarterly basis. It is noted that BH19s and BH19d were sampled in October 2013 but were found to be damaged in the next sampling round in January 2014 and wells BH20s and BH20d were substituted for the damaged wells.

3.5.2 Environmental Performance

Table 10 outlines the monitoring locations, groundwater monitoring parameters recorded, frequency of monitoring and groundwater criteria for the Project in accordance with Section M2.3 of EPL 12693 and Conditions 2.45A and 2.45B of the Modification of the Minister’s Approval MP06_0009.

Table 10 Summary of the Groundwater Monitoring Program

Monitoring Parameter	Monitoring Sites	Frequency	Criteria
Al, Ammonia, Benzene, Co, Conductivity, Cu, Cyanide (Free), Cyanide (Total), Ethyl Benzene, Fe, m+p-Xylene, Mg, Mn, Ni, o-Xylene, pH, Phenol, K, Na, Toluene, Total PAH, TPH C6-9, TPH C10-36, Zn.	GW1 (Monitoring Point 1)	6 monthly	Refer EPL 12693
Ammonia, Benzene, Conductivity, Cyanide (Free), Cyanide (Total), Ethyl Benzene, m+p-Xylene, o-Xylene, pH, Phenol, Toluene, Total PAH, TPH C6-9, TPH C10-36.	K9/3S, K9/3N, K11/1S, K11/1 (Monitoring Points 20-23)	6 monthly	Refer EPL 12693
Al, Ammonia, Benzene, Co, Conductivity, Cu, Cyanide (Free), Cyanide (Total), Ethyl Benzene, Fe, m+p-Xylene, Mn, Ni, o-Xylene, pH, Phenol, K, Na, Toluene, Total PAH, TPH C6-9, TPH C10-36, Zn.	K11/3E, K11/3W, K11/2E, K11/2W, K9/4E, K9/4W, K9/2E, K9/2W, K10/4W, DM10 (Monitoring Points 24-33)	Only if Trigger Criteria is exceeded at Monitoring Points 20, 21, 22 or 23 and is confirmed through second monitoring round.	Refer EPL 12693
TRH (fraction C6-C40), BTEX, naphthalene, dissolved heavy metals(Al, As, Br, Cr, Cu, Fe, Mn, Ni, Pb, Zn), Biochemical Oxygen Demand (BOD)	BH19s/BH19d, BH21s/BH21d, BH23s/BH23d	3 monthly	Refer EES (2013) GMP

[1] The location of monitoring sites is shown on Figure 31

The Project site includes a relatively shallow groundwater table in areas of fill from previous landuse activities. Consequently, any interception of the groundwater table during Project construction activities or effect on the groundwater system as a result of Project operations is being managed. NCIG has incorporated into the design of the Project a comprehensive suite of construction methods and design systems. In response to groundwater conditions encountered on the project site the following groundwater management contingency measures were adopted for specific Project elements:

- piled foundations together with diaphragm sub-surface perimeter walls and jet-grouted base for construction of the train unloading stations base and adjacent conveyors were constructed to minimise groundwater inflow or connection (this was constructed in the tunnel beneath Dump Station 2 as part of Stage 2AA during the previous reporting period);

- a low permeability capping layer was incorporated into the rail embankment formation to minimise infiltration; and

- groundwater bores were established to monitor groundwater levels, and water quality around the perimeter of the coal storage area and along the rail infrastructure corridor.

A summary of the groundwater monitoring results recorded during the reporting period is provided in Appendix D and Table 11.

An assessment of the monitoring records found the following:

- that the Trigger Values For Further Investigation (as outlined in Section E1.1 of EPL 13693) were not exceeded at any of the required monitoring locations;

- that exceedences of criteria outlined in the CEMP and OWMP (ANZECC (2000) trigger level for the protection of 95% of marine water species) occurred at Monitoring Points 1, 20, 21, 22 and 23, typically for manganese, copper and zinc;

- that exceedences of the criteria outlined in the EES (2013) GWMP (ANZECC (2000) trigger level for the protection of 90% of marine and/ or fresh water species) occurred at the six shallow and deep monitoring points for a range of heavy metals, including zinc, aluminium, iron, chromium, lead, nickel and manganese.

Table 11 Summary of the Groundwater Monitoring Results April 2013- March 2014

Monitoring Sites	Dates of Sampling	Exceedances of EPL Requirements?	Exceedences of CEMP/ OWMP	Exceedences of EES (2013) GWMP	Comments
GW1 (Monitoring Point 1)	13/6/13, 2/12/13	N/A	Cu, Mn, Zn	N/A	Site-specific trigger values are currently being re-evaluated
K9/3N (Monitoring Point 20)	13/6/13, 2/12/13	No	Mn	N/A	
K9/3S (Monitoring Point 21)	13/6/13, 2/12/13	No	Cu, Mn, Zn	N/A	
K11/1 (Monitoring Point 22)	13/6/13, 2/7/13 (re-test), 2/12/13	No	Cu, Mn, Zn, TPH C10-C14	N/A	TPH was re-tested on 2/7/13, result <LOR
K11/1S (Monitoring Point 23)	13/6/13, 2/12/13	No	Mn	N/A	Site-specific trigger values are currently being re-evaluated
K11/3E, K11/3W, K11/2E, K11/2W, K9/4E, K9/4W, K9/2E, K9/2W, K10/4W, DM10 (Monitoring Points 24-33).	Not required	N/A	N/A	N/A	Not required to be sampled as no exceedances of Trigger Values for Further Investigations (Section E1.1 of EPL 13693).
BH19S	6/10/13	N/A	N/A	Zn	12-monthly review currently being conducted of the Flyover GW monitoring results, in accordance with the GWMP requirements.
BH19D	6/10/13	N/A	N/A	Fe, Zn	12-monthly review currently being conducted of the Flyover GW monitoring results, in accordance with the GWMP requirements.
BH21S	6/10/13, 16/1/14	N/A	N/A	Al, Cr, Pb, Ni, Mn, Fe, Zn	12-monthly review currently being conducted of the Flyover GW monitoring results, in accordance with the GWMP requirements.
BH21D	6/10/13, 16/1/14	N/A	N/A	Al	12-monthly review currently being conducted of the Flyover

Table 11 Summary of the Groundwater Monitoring Results April 2013- March 2014

Monitoring Sites	Dates of Sampling	Exceedances of EPL Requirements?	Exceedences of CEMP/ OWMP	Exceedences of EES (2013) GWMP	Comments
					GW monitoring results, in accordance with the GWMP requirements.
BH23S	6/10/13, 16/1/14	N/A	N/A	Zn	12-monthly review currently being conducted of the Flyover GW monitoring results, in accordance with the GWMP requirements.
BH23D	6/10/13, 16/1/14	N/A	N/A	Zn	12-monthly review currently being conducted of the Flyover GW monitoring results, in accordance with the GWMP requirements.

3.5.3 Reportable Incidents

No environmental incidents or complaints relating to groundwater quality conditions were made during the reporting period.

3.5.4 Further Improvements

As mentioned above, site-specific trigger values are currently being developed for groundwater, to replace the ANZECC criteria for the protection of 95% of marine species, which is currently adopted in the CEMP and OWMP. This recognises that the ANZECC criteria are not the most relevant criteria to the geographical area and in this circumstance are considered to be overly conservative.

NCIG also proposes to conduct a review of all groundwater monitoring (both on the NCIG operational site and the flyover construction site) in the future. The objective will be to rationalise and consolidate the groundwater monitoring program, taking into account the likely stabilisation of potential contaminant migration and contaminants of concern.

3.6 Land Contamination

3.6.1 Environmental Management

In accordance with Condition 2.53, Schedule 2 of the Project Approval (06_0009) NCIG engaged an appropriately qualified person to audit construction of the rail infrastructure over land used as part of the Kooragang Island Waste Emplacement Facility (KIWEF) against the commitments contained in the NCIG Project Environmental Assessment and supporting documents.

Prior to any excavation on the Project, a comprehensive surface and sub-surface soil sampling and analysis programme was undertaken in order to characterise the material to be excavated. The sampling programme was undertaken in accordance with the NSW Environment Protection Authority (EPA) (2004b) *Guidelines for the Assessment, Classification and Management of Liquid and Non-Liquid Waste*. The aim of the programme was to identify the risk associated with contamination across the stockyard and rail areas and to determine the suitability of the site for the development of the NCIG project. The findings of this process were that there existed a manageable risk associated with contamination and that the site was suitable for the proposed development.

In accordance with Condition 2.54, Schedule 2 of the Project Approval (06_0009) NCIG did not direct any contaminated materials removed from the site to a waste management facility that was not lawfully permitted to accept the materials.

3.6.2 Environmental Performance

During the reporting period, the following activities were undertaken as part of the Rail Flyover construction:

- Mobilisation to site by main contractor;
- Construction of on-site office storage facilities;
- Upgrading of some site access roads;

- Preliminary realignment works for Ausgrid power lines on western site margin;
- Imported gravel capping (Virgin Excavated Natural Material (VENM)) was used in ground improvement works for the Ausgrid power line realignment;
- Sand (VENM) was imported to foundations across the Deep Pond area.

In accordance with Condition 2.53, Schedule 2 of the Project Approval (06_0009) a Quarterly Progress Report was provided by ENVIRON, who are auditing the disturbance and recapping of the waste emplacement area during the flyover construction.

3.6.3 Reportable Incidents

No environmental incidents or complaints relating to land contamination were made during the reporting period.

3.6.4 Further Improvements

Construction of the Rail Flyover will continue during the next reporting period. Rail earthworks will be capped with low permeability material in accordance with the NCIG Environmental Assessment and this process will be reviewed by a third party auditor in accordance with Condition 2.53, Schedule 2 of the Project Approval (06_0009).

3.7 Acid sulfate soils

3.7.1 Environmental Management

In accordance with Condition 7.3(a), Schedule 2 of Project Approval (06_0009), an Acid Sulfate Soil Management Plan (ASSMP) was developed in accordance with the guidance provided in the *Acid Sulfate Soil Manual* (ASSMAC, 1998). This addresses the management of Acid Sulfate Soils (ASS) identified during excavations on the Project site. The ASSMP was approved by the Department of Planning and Infrastructure.

3.7.2 Environmental Performance

Table 12 outlines the monitoring locations, ASS monitoring parameters recorded, frequency of monitoring and ASS criteria for the Project in accordance with the ASSMP.

Table 12 Summary of the acid sulfate soils monitoring programme

Monitoring Parameter	Monitoring Sites	Frequency	Criteria
Presence of acid sulphate soils or potential acid sulphate soils.	Excavation sites	Prior to any excavation.	See ASSMP.
	ASS treatment area	After treatment	

Soil testing and assessments of the ASS risk was undertaken during excavations and major earthworks in previous reporting periods and it was determined the potential and actual ASS risk associated with these activities was limited. The ASSMP was however prepared to provide sampling, validation and management measures if ASS is encountered during further construction of the Project.

The NSW Acid Sulfate Soil Management Advisory Committee (ASSMAC), *Acid Sulfate Soil Manual* (1998), presents guidelines for the sampling, determination and management of ASS materials dependent on the quantity of material to be disturbed and the type of disturbance (linear, bulk). The guidelines provided in the *Acid Sulfate Soil Manual* (ASSMAC, 1998) are considered appropriate for use at the Project site.

The *Acid Sulfate Soil Manual* (ASSMAC, 1998) outlines ‘Action Criteria’ based on laboratory analysis of ASS characteristics. These Action Criteria are based on the soil texture together with the volume of material which is to be disturbed to determine if the material is to be managed as an ASS. The Action Criteria was used to assess ‘neutralisation’ of lime treated soils.

3.7.3 Reportable Incidents

No incidents or complaints were reported relating to acid sulphate soils management during the reporting period.

3.7.4 Further Improvements

No improvement to acid sulphate soils management is required for the next period.

3.8 Noise and vibration

3.8.1 Environmental Management

In accordance with Condition 2.9, Schedule 2 of the Project Approval (06_0009) NCIG and its contractors minimised noise emissions from plant and equipment operated on the Project site as outlined in the *NSW Industrial Noise Policy* (EPA, 2000).

In accordance with Condition 2.10, Schedule 2 of the Project Approval (06_0009), general site preparation, filling/preloading and construction works that may generate an audible noise at any residential receptor was only undertaken between 7.00 am and 6.00 pm.

In accordance with Condition 2.11, Schedule 2 of the Project Approval (06_0009) piling works was not to be conducted on Sundays or public holidays.

Construction noise management measures are further detailed in the Construction Noise Management Plan (CNMP).

In accordance with Condition 2.13, Schedule 2 of the Project Approval (06_0009), Stage 1 of the NCIG Terminal has been designed, constructed, operated and maintained to ensure that the noise contributions from the plant do not exceed the maximum allowable noise contributions specified in Table 14 below, at the locations and the time periods indicated.

In accordance with Condition 2.14, Schedule 2 of the Project Approval (06_0009), the assessment of noise contributions was:

- Measured at the most affected point on or within the Site boundary at the most sensitive receiver to determine compliance with $L_{Aeq(15\ minute)}$ night noise limits.
- Measured at one metre from the dwelling façade to determine compliance with $L_{A1(1\ minute)}$ noise limits.

- Subject to the modification factors provided in Section 4 of the New South Wales Industrial Noise Policy (EPA, 2000), where applicable.

In accordance with Condition 2.15, Schedule 2 of the Project Approval (06_0009), NCIG has taken steps to ensure that trains operated on the Site meet noise performance criteria established. This includes construction of dedicated noise abatement berms directly adjacent the NCIG rail line and design and construction of the rail alignment to reduce noise from locomotive and wagon wheels.

Operations noise management measures are further detailed in the Operations Noise Management Plan (ONMP).

3.8.2 Environmental Performance

Table 13 outlines the monitoring locations, noise and vibration monitoring parameters recorded, frequency of monitoring and noise and vibration criteria for the Project in accordance with the CEMP and ONMP.

Table 13 Summary of the noise and vibration monitoring programme

Monitoring Parameter	Monitoring Sites	Frequency	Criteria
Attended and unattended noise monitoring	N1, N3, N5, N13 and N14[1].	Monthly for the first 3 months then quarterly.	See below.
Unattended continuous noise monitoring.	Selected locations.	Minimum period of one week per quarter.	See below.
Ground vibration.	Adjacent industrial receivers within 180 m of piling activities.	Weekly when piling within 180m of industrial receiver.	See CNMP.
Attended noise monitoring	All static and mobile elements of terminal operations.	Quarterly	See ONMP.

1 The location of monitoring sites is shown on Figure 3.1.1.

The noise impact assessment criteria as defined by the Project approval and the Environmental Protection Licence (EPL12693) are provided in Table 14 and Table 15.

Noise and vibration monitoring was undertaken by specialist acoustic consultants during the reporting period. This monitoring was conducted on a quarterly basis to coincide with both construction works on the project and operations throughout the reporting period.

In addition, a Noise Audit Report was completed in October 2013 to confirm cumulative Stage 1, Stage 2AA and Stage 2F noise performance of the NCET as per Conditions 3.6 and 3.7 of PA 06_0009 Schedule 2.

Table 14 Residential Noise Impact Assessment Criteria

Location	Site ID	Day, Evening Night At all times	Night 10.00 pm to 7.00am Monday to Saturday 10.00pm to 8.00 on Sundays and Public Holidays	
		$L_{Aeq(15\ minute)}$	$L_{Aeq(night)}$	$L_{A1(1\ minute)}$
Fern Bay West	N1	41	37	57
Fern Bay East	N17	39	36	55
Stockton West	N3	41	37	57
Stockton East	N16	38	35	56
Mayfield West	N5	45	40	55
Mayfield	N9	44	39	62
Carrington	N15	36	33	52

The maximum allowable noise conditions apply under:

a) wind speeds of up to 3m/s at 10 metres above ground level
b) b) temperature inversion conditions of up to 3 degrees (°C) pert 10 metres and 2 m/s at 10 metres above ground level.

Table 15 Industrial Noise Impact Assessment Criteria

Non-residential Location	Land use	Intrusive $L_{Aeq(15\ minute)}$			Acceptable Amenity $L_{Aeq(period)}$ [1]			Maximum Amenity $LA_{eq(9\ hour)}$
		Day	Evening	Night	Day	Evening	Night	Night
Mayfield West	Commercial Steel River	Intrusive noise not applicable			65	65	65	70
Kooragang Island	Industrial	Intrusive noise not applicable			70	70	70	75
Mayfield North		Intrusive noise not applicable			70	70	70	75
Any	School	Intrusive noise not applicable			External 45 when in use			50
Any	Hospital	Intrusive noise not applicable			External 50 when in use			55

Note 1: Daytime 0700 hours to 1800 hours, Evening 1800 hours to 2200 hours, Night-time 2200 hours to 0700 hours.

The monitoring undertaken principally consisted of:

- Unattended noise monitoring – two (2) Type EL316 environmental noise loggers were deployed at the nearest potentially affected receptors for a period of one week. The noise loggers were programmed to record statistical noise level indices continuously in 15 minute intervals, including LAmax, LA1, LA50, LA90, LA99, LAmin and LAeq.

- Attended noise monitoring - operator attended noise survey was conducted at each noise logger location to assist in defining noise sources and the character of noise in the area and therefore to qualify unattended noise logging results. These measurements were conducted over 15 minute periods using a Bruel & Kjaer Type 2250 sound level meter.

- Vibration monitoring - In accordance with the CNMP, vibration monitoring was conducted during construction piling activities within 180m of adjacent industrial receivers (i.e. Blue Circle Southern). As mentioned, this did not take place during the monitoring period.

The conclusion of the specialised acoustic consultants was that the off-site environmental noise emissions from NCET Stage 2F comply with the PA environmental noise limits in accordance with Schedule 2, Noise Impacts, Operation Noise, Conditions 2-13.

3.8.3 Reportable Incidents

No environmental incidents were reported relating to noise or vibration during the reporting period. Complaints regarding noise received during the reporting period (see Section 3.13) were responded to in accordance with the Complaint Response Procedure.

3.8.4 Further Improvements

No improvement to noise monitoring is required for the next period. Notwithstanding, NCIG implements a Continuous Noise Improvement Program. The program will continue to be implemented as part of ongoing NCIG operations.

3.9 Heritage

3.9.1 Environmental Management

The DECCW advised that as the Project construction site has been the subject of extensive disturbance over a period of more than 50 years, it considers that no Aboriginal heritage objects of significance will be present (DEC, pers. comm. 15 February 2007).

Notwithstanding, the management of items of Aboriginal cultural heritage significance during construction of the Project incorporated the following elements:

- During induction training, NCIG personnel were advised of their responsibility to advise management if they uncover any item that could be of Aboriginal heritage significance.

- If potential archaeological material is identified, construction activities proximal to the potential archaeological material will cease and OEH's North East Branch - Environment Protection and Regulation Division, Regional Archaeologist will be contacted to determine appropriate management requirements.

- If items of Aboriginal cultural heritage significance are salvaged on-site, they will be stored in a keeping place on-site for the duration of the Project.

- At the cessation of the Project, if any salvaged Aboriginal objects are stored on-site their ongoing management will be determined in consultation with the Aboriginal community and the OEH.

3.9.2 Environmental Performance

During the reporting period induction training was attended by all NCIG personnel. This training included information relating to aboriginal heritage and the potential identification of items of archaeological significance.

During the reporting period there were no items of potential Aboriginal cultural heritage significance identified.

3.9.3 Reportable Incidents

No incidents or complaints were reported relating to heritage during the reporting period.

3.9.4 Further Improvements

No improvement to heritage is required for the next period.

3.10 Flora and fauna

3.10.1 Environmental Management

In accordance with Conditions 2.16 and 2.19, Schedule 2 of the Project Approval (06_0009) NCIG employed two qualified ecologists (Dr David Goldney and Dr Arthur White), approved by the Director-General, to undertake a pre-construction survey of areas affected by construction works for the presence of *Litoria aurea* (the Green and Golden Bell Frog) (see Figure 32). These ecologists also provided advice on the mitigation and management of impacts to listed threatened species that may be affected by the NCIG Project works.

Figure 32: The Green and Golden Bell Frog (Litoria aurea)

While Green and Golden Bell Frog individuals were not identified during the pre-construction survey, previous surveys have identified the presence of the species on the Project site. Therefore a management plan for the relocation of Green and Golden Bell Frog individuals was prepared in accordance with Condition 2.16, Schedule 2 of the Project Approval (06_0009). The Green and Golden Bell Frog Management Plan (GGBFMP) was developed in consultation with DECC and the Regional Land Management Corporation.

In accordance with Condition 2.17, Schedule 2 of the Project Approval (06_0009) NCIG has designed and constructed relevant rail infrastructure associated with the Project to include culverts, underpasses or other similar measures to permit the movement of *Litoria aurea* and other amphibian species under the NCIG rail infrastructure (see Figure 33). The culverts and underpasses were installed to include suitable habitat for the Green and Golden Bell Frogs and to provide protection from predators in accordance with guidance provided by Dr Arthur White.

In accordance with Condition 2.18, Schedule 2 of the Project Approval (06_0009) all employees and contractors involved in construction of the Project are trained in site hygiene management in accordance with *Hygiene Protocol for the Control of Disease in Frogs* (NPWS, 2001) prior to the commencement of work.

A Compensatory Habitat and Ecological Monitoring Program (CHEMP) has also been prepared to guide the construction of Green and Golden Bell Frog habitat which suitably replaces habitat damaged or destroyed by construction works. This plan was initially submitted to DECCW (now EPA) and DoP (now NSW Planning and Infrastructure) in 2008. Through discussions and agreed amendments, the first version of the CHEMP was approved by DoP on 16 November 2010. Details of compensatory habitat work completed in the period are given in Section 3.10.3.

A Vegetation Clearance Protocol (VCP) was also prepared to satisfy those commitments of the Project Environmental Assessment (EA) that relate to vegetation clearance during construction of the Project.

3.10.2 Environmental Performance

The Green and Golden Bell Frog *Litoria aurea* is listed as Endangered under the *Threatened Species Conservation Act, 1995* (TSC Act) and Vulnerable under the EPBC Act. The Green and Golden Bell Frog is estimated to have disappeared from 90% of its former range within NSW.

Known and potential Green and Golden Bell Frog habitat is located across the Project site and surrounds. Disturbance to Green and Golden Bell Frog habitat occurred as a result of construction activities which primarily involved completely infilling Big Pond and partial disturbance of Ponds H, K and Q (see Figure 33). Most of the known and potential Green and Golden Bell Frog habitat recorded across the Project site and surrounds (i.e. Ponds A, B, C, D, E, F, G, I, J, L, O, T, U, V, AA, AC, AD) has not however been directly disturbed by Project activities.

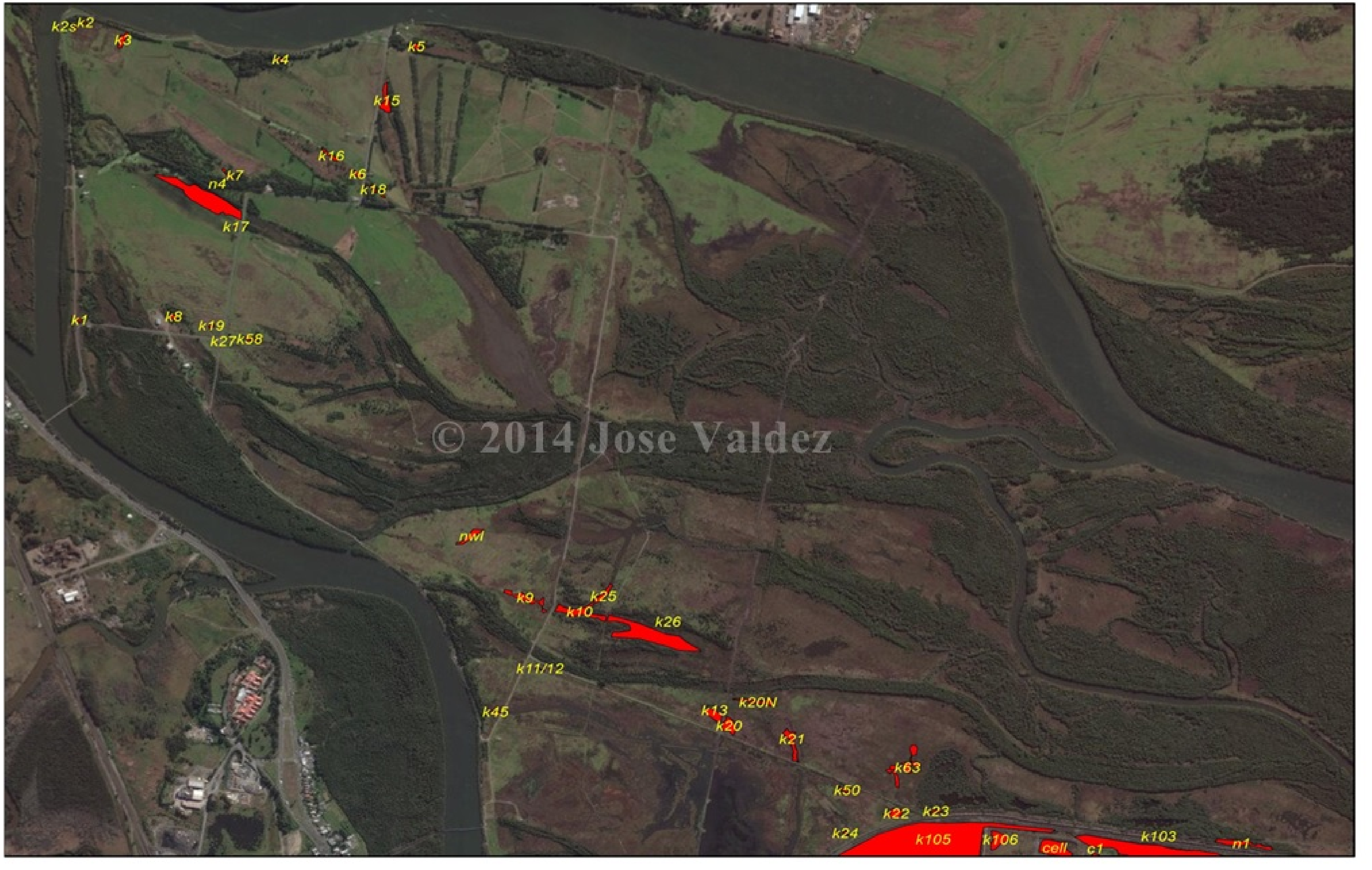


Figure 33: Green and Golden Bell Frog Surveyed Areas

In order to minimise Project-related impacts on the Green and Golden Bell Frog the following management procedures were implemented in accordance with the GGBFMP:

- environmental induction training;
- site hygiene management;
- delineation of disturbance areas;
- pre-clearance surveys;
- Green and Golden Bell Frog relocation procedures; and
- construction works procedures.

All employees and contractors involved in the construction of the Project were informed about the presence and importance of the Green and Golden Bell Frog as a part of the site induction process. Similarly, operations employees and contractors are informed about the presence of the Green and Golden Bell Frog in areas adjacent to the Stage 1/2AA operations site, in particular the NCIG rail facility. Training was also provided on appropriate site hygiene practices in accordance with *Hygiene Protocol for the Control of Disease in Frogs* (NPWS, 2001) prior to the commencement of work.

All major ground disturbance activities were completed previously on the site, therefore there were no pre-clearance surveys undertaken during the reporting period. Areas of active earthworks continued to be delineated by fencing, however, in order to prevent the movement of amphibian species back into a construction area that had been previously cleared, these fencelines were regularly monitored for the presence of the Green and Golden Bell Frog to confirm that there were no individuals in the vicinity that may be at risk.

If individual frogs were identified adjacent to the constructed delineation fencelines or elsewhere on the site, and thought to be at potential risk of harm, they were captured and translocated in accordance with the Green and Golden Bell Frog Management Plan. Details of the individual Green and Golden Bell Frogs managed in accordance to this process are outlined in Table 3.10.1.

Table 16 Translocated Green and Golden Bell Frogs

Date	Quantity	Health	Size (cm)	Location identified	Location translocated
19/8/2013	2	Good	4cm, 7cm.	Dump Station drainage line	Pond I
18/9/2013	1	Good	5cm	CV12	Pond I
1/10/2013	2	Good	5cm, 7cm	Outside of Frog Fence, Flyover	Pond I
2/10/2013	2	Good	3cm, 5cm	Outside of Frog Fence, Flyover	Pond I
15/10/2013	2	Good	3cm, 5cm	Outside of Frog Fence, Flyover	Pond I

Table 16 Translocated Green and Golden Bell Frogs

Date	Quantity	Health	Size (cm)	Location identified	Location translocated
30/10/2013	2	Good	7cm, 8cm	Outside of Frog Fence, Flyover	Pond I
12/11/2013	2	Good	6cm, 7cm	Outside of Frog Fence, Flyover	Pond I
13/11/2013	1	Good	5cm	Outside of Frog Fence, Flyover	Pond I
14/11/2013	1	Good	5cm	South End of Deep Pond	Pond I
16/11/2013	1	Good	7cm	Outside of Frog Fence, Flyover	Pond I
18/11/2013	4	Good	4cm, 6cm, 7cm, 8cm	Outside of Frog Fence, Flyover	Pond I
19/11/2013	13	Good	3x4cm, 2x5cm, 4x6cm, 2x7cm, 2x8cm	Outside of Frog Fence, Flyover	Pond I
19/11/2013	3	Good	1x6cm, 2x7cm	Rail Flyover Construction Area	Pond I
20/11/2013	4	3 good, 1 dead	5cm, 6cm, 7cm	Outside of Frog Fence, Flyover	Pond I
22/11/2013	1	Good	4cm	Outside of Frog Fence, Flyover	Pond I
4/12/2013	5	Good	4x4cm, 1x5cm	Rail Flyover Construction Area	Pond I
13/12/2013	1	Good	6cm	Outside of Frog Fence, Flyover	Pond I
6/1/2014	1	Good	5cm	Outside of Frog Fence, Flyover	Pond I
14/1/2014	3	Good	2x4cm (mal.), 1x5cm (fem.)	Rail Flyover Construction Area	Pond I
21/1/2014	1	Good	7cm (fem.)	Rail Flyover Construction Area	Pond I
22/1/2014	2	Good	2x5cm	Rail Flyover Construction Area	Pond I
3/2/2014	2	Good	5cm (fem.), 6cm (fem.)	Rail Flyover Construction Area	Pond I
4/2/2014	1	Good	5cm (fem.)	Rail Flyover Construction Area	Pond I
10/2/2014	1	Good	4cm (fem.)	Rail Flyover Construction Area	Pond I
11/2/2014	1	Good	5cm (fem.)	Rail Flyover Construction Area	Pond I
12/2/2014	16	Good	13x5cm, 3x6cm	Rail Flyover Construction Area	Pond I

Table 16 Translocated Green and Golden Bell Frogs

Date	Quantity	Health	Size (cm)	Location identified	Location translocated
13/2/2014	4	Good	2x4cm, 2x5cm (1 fem., 1 unknown)	Rail Flyover Construction Area	Pond I
4/3/2014	1	Good	6cm (fem.)	Rail Flyover Construction Area	Pond I
27/3/2014	1	Good	6cm	Admin Building Extension	Pond I

During the reporting period a total of eighty one (81) Green and Golden Bell Frogs were sighted on site and assessed as being at risk and subsequently translocated in accordance with the Green and Golden Bell Frog Management Plan. The majority of these animals were found in construction areas, particularly the Rail Flyover construction area. All specimens were alive and in good condition, ranging from 3–8cm in length, with the exception of one which was found dead (likely cause of death was brushcutting during the installation and maintenance of the frog exclusion fence). The frogs were considered to be mostly adults and some juveniles, based on size.

Monitoring of the Green and Golden Bell Frog was conducted in areas adjacent to the NCIG Project site, particularly areas surrounding the NCIG Rail Facility. During the 2013/14 season, monitoring was conducted by the University of Newcastle. This was funded cooperatively by both NCIG and Port Waratah Coal Services (PWCS). This was to satisfy the requirements of the NCIG Project *Environment Protection and Biodiversity Conservation Act, 1999* (EPBC Act) Particular Manner Decision and to provide baseline data on areas proposed for the PWCS T4 Coal Export Terminal. The objective of the monitoring is to monitor the dynamics of the Green and Golden Bell Frog within habitat areas on Kooragang Island.

Two methods were used to estimate the population per surveyed pond, namely Visual Encounter Surveys (VES) and Mark-recapture Surveys. Both these methods utilise recording of morphometrics of individuals surveyed, location and environmental conditions where individual locations were found and micro-chipping using Passive Induction Transponder (PIT) tags. The mark-recapture surveys were conducted multiple times over short periods (eg. in excess of four night surveys no greater than 48 hours apart) at a sub-set of ponds within the overall survey area. Models for population estimates were generated for each surveyed pond using established statistical designs and computer-based modelling software (eg. MARK). These estimates were correlated with results of visual encounter surveys, using a number of assumptions and limiting factors, to generate population estimates for remaining ponds. Table 17 provides population estimates at each pond for October 2013, December 2013, January 2014 and March 2014.

Table 17 Green and Golden Bell Frogs Population Estimate

Pond surveyed	October 2013		December 2013		January 2014		March 2014	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
C1	36	24	48	36	76	66	48	36

Table 17 Green and Golden Bell Frogs Population Estimate

Pond surveyed	October 2013		December 2013		January 2014		March 2014	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
C2	0	0	0	0	0	0	25	12
K1	88	78	82	82	80	80	67	67
K10	0	0	0	0	0	0	0	0
K100 centre	0	0	0	0	0	0	0	0
K100 east	26	13	0	0	0	0	0	0
K100 extension	0	0	104	95	22	9	0	0
K100 west	0	0	0	0	0	0	0	0
K101	0	0	0	0	0	0	0	0
K102	NS	NS	70	59	66	56	49	38
K103	0	0	146	140	0	0	30	18
K104	169	165	142	136	70	60	75	65
K105	89	79	198	196	72	62	114	106
K106	0	0	0	0	0	0	0	0
K107	0	0	0	0	0	0	0	0
K11/12	0	0	0	0	NS	NS	0	0
K13	0	0	0	0	0	0	43	31
K15	0	0	0	0	0	0	0	0
K16	0	0	0	0	0	0	0	0
K17	0	0	0	0	0	0	0	0
K18	0	0	0	0	0	0	0	0
K19	0	0	0	0	NS	NS	0	0
K2	0	0	0	0	0	0	0	0
K20	0	0	52	40	0	0	41	29
K21	0	0	22	9	0	0	24	10
K22/23	109	109	184	184	164	164	131	131
K24	27	14	0	0	0	0	0	0
K25	0	0	0	0	0	0	0	0
K26	0	0	52	41	0	0	0	0
K3	0	0	0	0	0	0	0	0
K4	0	0	0	0	0	0	0	0
K45	0	0	0	0	0	0	0	0
K5	0	0	0	0	0	0	0	0
K50	0	0	0	0	0	0	21	8
K58	0	0	0	0	0	0	0	0
K6	0	0	0	0	0	0	0	0
K63	0	0	0	0	0	0	0	0
K7	0	0	0	0	0	0	0	0
K8	0	0	0	0	0	0	0	0
K9	0	0	0	0	0	0	22	8
N1	0	0	52	40	153	148	102	94
N4	0	0	0	0	0	0	47	36

Table 17 Green and Golden Bell Frogs Population Estimate

Pond surveyed	October 2013		December 2013		January 2014		March 2014	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Rail loop	97	97	62	62	62	62	NS	NS
S1	0	0	30	17	0	0	20	6
S2	35	22	38	25	36	23	23	9
S3	0	0	0	0	17	3	0	0
S4	0	0	0	0	0	0	0	0
S5	0	0	22	9	47	36	41	29
S6	0	0	0	0	0	0	0	0
S7	0	0	0	0	0	0	0	0
W1	0	0	NS	NS	0	0	0	0
W2	0	0	NS	NS	NS	NS	NS	NS
W3	NS	NS	NS	NS	0	0	0	0

NS – not surveyed

Due to issues with access portions of the survey area, the university were not able survey some ponds on every occasion which could lead to an underestimate of the population size in any given month. The population estimates for KI/AI ranged between 639 and 1238 individuals, with an average estimate of 880 individuals across the season.

A monitoring programme was also conducted during the reporting period to survey the utilisation of Deep Pond, adjacent to the NCIG rail infrastructure area, by bird species with the primary focus on shorebirds. This Avifauna Monitoring Programme was undertaken by the Hunter Bird Observers Club and the resulting information was provided to NCIG by way of agreement. The results of the monthly surveys conducted during the 2013 calendar year are illustrated by Table 18. The aim of the monitoring programme is to identify the pattern of usage of Deep Pond by all birds over the annual cycle and determined the extent of any potential impact by the NCIG activities on this usage.

In comparison to the 2012 results, there has been a decrease (-39%) in the total number of birds using the pond from 9321 to 5772 in 2013. This is due mainly to an decrease in overall pond usage during most months, particularly May, June, July and December. This was likely due to:

- a peak in the resident shorebird population in January 2013 was likely due to favourable conditions in Deep Pond in that month, with more favourable conditions elsewhere for the remainder of the year;
- there was a low number of migratory shorebirds utilising the ponds due to above average pond levels. This discouraged shorebirds from using the pond as a refuge site.

Table 18 Avifauna 2013 Monitoring Results

Species	11/1/13	8/2/13	8/3/13	12/4/13	10/5/13	21/6/13	12/7/13	9/8/13	20/09/13	18/10/13	15/11/13	13/12/13	Total
Musk Duck *Biziura lobata*		1	2	3	1	1	3	1			1		13
Black Swan *Cygnus atratus*		28	13	19	4	2		7	32	18	62	82	267
Pacific Black Duck *Anas superciliosa*		4	7	5	5		1			6	4		32
Australasian Shoveler *Anas rhynchotis*		3						122				4	129
Grey Teal *Anas gracilis*	305							126		24	70	1	526
Chestnut Teal *Anas castanea*	615	211						32		46			904
Pink-eared Duck *Malacorhynchus membranaceus*				6					2		64	2	74
Hardhead *Aythya australis*	38			67	31	24	30	181		52	23	95	541
Australasian Grebe Tachybaptus novaehollandiae	22	9	4	45	34	14	5	20	3	24		31	211
Hoary-headed Grebe *Poliocephalus poliocephalus*	1	17	5	4	4	4	15	3	15	3	2	21	94
Australasian Darter *Anhinga novaehollandiae*		1											1
Little Black Cormorant *Phalacrocorax sulcirostris*	2	4	8	9	2				2	1	4	8	40
Great Cormorant *Phalacrocorax carbo*	1	4	3	4	2		2	2		2	3		23
Australian Pelican *Pelecanus conspicillatus*	53	2								8	18	5	86

Table 18 Avifauna 2013 Monitoring Results

Species	11/1/13	8/2/13	8/3/13	12/4/13	10/5/13	21/6/13	12/7/13	9/8/13	20/09/13	18/10/13	15/11/13	13/12/13	Total
White-faced Heron *Egretta novaehollandiae*	2					1			2	1	1		7
Little Egret *Egretta garzetta*	2					1				3	4	1	11
White-necked Heron *Ardea pacifica*											1		1
Eastern Great Egret *Ardea modesta*	2							1		2	4	1	9
Intermediate Egret *Ardea intermedia*		1									1		2
Australian White Ibis *Threskiornis molucca*	71									11	7		89
Royal Spoonbill *Platalea regia*	82	2									23		107
Purple Swamphen *Porphyrio porphyrio*		3	7	13	8	7					9		47
Dusky Moorhen *Gallinula tenebrosa*			2										2
Eurasian Coot *Fulica atra*		58	26	152	82	105	129	254	260	158	593	252	2069
Red-necked Stint *Calidris ruficollis*	143									57	72		272
Red-necked *Avocet Recurvirostra novaehollandiae*	148												148
Black-fronted Dotterel *Elseyornis melanops*										2			2
Masked Lapwing *Vanellus miles*	4									4	2		6
Silver Gull *Chroicocephalus novaehollandiae*	2									1	1		2
Black-necked Stork *Ephippiorhynchus asiaticus*									2				2

Table 18 Avifauna 2013 Monitoring Results

Species	11/1/13	8/2/13	8/3/13	12/4/13	10/5/13	21/6/13	12/7/13	9/8/13	20/09/13	18/10/13	15/11/13	13/12/13	Total
Glossy Ibis *Plegadis falcinellus*										3			3
Australian Spotted Crake *Porzana fluminea*	2												2
Banded Stilt *Cladorhynuchus leucocephalus*	1												1
Black-tailed Godwit *Limosa limosa*	6								4				4
Marsh Sandpiper *Tringa stagnatilis*											11		11
Whiskered Tern *Chlidonias hybridus*										21			21
Total 2013	**1502**	**348**	**77**	**327**	**173**	**159**	**185**	**751**	**320**	**447**	**984**	**499**	**5772**
Total 2012	**848**	**336**	**264**	**38**	**1347**	**1004**	**731**	**0***	**568**	**878**	**1060**	**2247**	**9321**
% change on 2012	**44**	**3**	**-71**	**89**	**-87**	**-84**	**-75**	**NA**	**44**	**-49**	**-8**	**-78**	**-39**

Note 1: The September survey was completed from the Ash Island side.
***Note 2**: No survey was performed in August 2012 due to lack of access; nil observations.

The Vegetation Clearance Protocol (VCP) was implemented to minimise impacts on threatened flora and fauna species within the Project area. The key components of the VCP are outlined below and include:

- delineation of areas to be cleared of existing vegetation;
- pre-clearance surveys;
- managing impacts on fauna; and
- vegetation clearance procedures.

3.10.3 Compensatory Habitat and Ecological Monitoring Program

A number of works have been undertaken in relation to the CHEMP between April 2013 and March 2014.The following points highlight the major works undertaken and milestones achieved during this reporting period.

Consultative Board –Consultative Board meetings were held on 6 June and 11 December 2013. The purpose of the Consultative Board meetings are to provide information on the Compensatory Habitat planning works completed to date and provide guidance on works to be completed, particularly in the coming 12 months. The Board consists of representatives from NSW Planning and Infrastructure, NSW Office of Environment and Heritage (National Parks and Wildlife Service), Hunter-Central Rivers Catchment Management Authority, the University of Newcastle, the DoPI-Approved Ecologist for the NCIG Project and NCIG. At each meeting, papers have been presented on a range of topics for the consideration and discussion of Board members. The topics discussed included updates on the following:

- Research areas and monitoring;
- Behavioural research;
- Compensatory habitat strategy;
- Shorebird compensatory habitat.

Research Areas and Monitoring – An update was provided in the June 2013 meeting on research, including tadpole and metamorph release; commencement of monitoring, visual encounter surveys and capture methods; tagging of animals, including coloured polymer tagging and micro-chipping; salt dosing of treatment ponds; installation of over-wintering habitat; presence of predators and non-target species; Chytrid fungus swabbing, noting that swabbing to date indicates that Chytrid is not present in the Research Area. The approval of the translocation process was also discussed.

At the December 2013 meeting, additional information was provided on the Chytrid fungus which indicates that Chytrid is the limiting factor for the persistence of the GGBF. Research has been conducted on the manipulation of habitat characteristics, in particular salinity, to establish optimal conditions to lessen the impact of Chytrid while maintaining adequate habitat quality.

Research area monitoring is also being conducted to understand how frogs use different habitat types within a habitat mosaic (breeding, foraging and terrestrial habitats). From

September 2013, research area monitoring was conducted at night due to unseasonably warm conditions. Over 120 animals were observed on one night, including calling males. Frogs were observed sitting high on vegetation to reach insects, highlighting the importance of reed vegetation. Preliminary analysis of results indicates that juvenile frogs prefer to spend time in ponds with warmer temperatures and higher salinity levels. While the monitoring results have been encouraging, it was noted in the December 2013 meeting that research area monitoring has only been conducted for 7 months and that significant trends will arise over a longer period.

Behavioural Research – An update on the conspecific attraction research project was included at both the June and December 2013 meetings. The objective of this behavioural research is to understand how habitat preferences are chosen, either by taking the habitat that is available based on habitat attributes or by letting another individual decide for you i.e. following conspecifics – Indavertent Social Information (ISI). A number of behavioural experiments have been conducted with juveniles and these will be repeated with adults to test preferences for aggregation. Initial results indicate the following:

- Bell frogs aggregate at all lifecycle stages (tadpoles, metamorphs, juveniles, adults).
- There is a strong tendency for tadpoles to aggregate, but not necessarily with kin.
- There is a strong tendency for tadpoles to aggregate in warm water.
- Calling males form groups known as 'leks'. Leks need to have a critical number of individuals to attract breeding females. Calling typically deters non-breeding females and juveniles, as there is a chance for sub-adults to be injured.
- Calling males will aggregate around call playback recordings and do not aggregate around control sites playing 'white noise'. Questions remain around artificially manipulating the distribution of frogs with speakers to improve distribution of the species as there is potential to interrupt relationships between individuals, as has been observed in bird populations from artificial calling.

Compensatory Habitat Strategy – The draft Compensatory Habitat and Ecological Monitoring Program (CHEMP) was updated prior to the June 2013 meeting, with the addition of proposed GGBF and Shorebird Compensatory Habitat to satisfy the conditions of MP06_0009 MOD2. The updated CHEMP was approved on 7 August 2013 and at this time, land for the GGBF Habitat on Ash Island had been secured. Discussions continue with DoPI and NPWS to secure land for the Migratory Shorebird Habitat on Ash Island (Fish Fry Flats/ Area E), including discussions of appropriate legal mechanisms to ensure in perpetuity protection of habitat.

At the time of the December 2013 meeting, land access and environmental processes were underway, including preparation of a Review of Environmental Factors (REF) which addresses issues such as existing biodiversity, heritage, water impacts and acid sulphate soils. The REF was submitted to NPWS in mid-January 2014.

Figure 34: CHEMP Consultative Board Inspection of GGBF Research Ponds

Figure 35: Green and Golden Bell Frogs Research Ponds

Shorebird Compensatory Habitat – Since the removal of floodgates at Fish Fry Creek 10 years ago, mangroves have been allowed to populate the area. NCIG installed a drop-board structure to hydrologically control water levels in Fish Fry Flats approximately 12 months ago. Various methods are being discussed for the removal of the mangroves i.e. manual versus mechanical removal. NCIG are continuing to liaise with DoPI and NPWS regarding the security of land within NPWS Estate (Fish Fry Flats/ Area E), including discussions around the best mechanism to ensure in perpetuity protection. The likely plan will be to enter a Deed of Agreement with NPWS over the land, with the shorebird habitat eventually captured in the Plan of Management for the National Park.

Figure 36: Creek 5 Drop board support structure prior to fitting of drop boards

Planned and completed compensatory habitat and ecological monitoring program (CHEMP) milestones corresponding to the current reporting period are outlined in Table 19.

Table 19 CHEMP Annual Works Program – April 2013 to March 2014

Works/Milestone/Stage	Intended Completion Date
Consultative Board Meetings	June and December 2013
Populating of trial habitat with captive-bred Green and Golden Bell Frogs	1st Quarter 2013
Commencement of Mark/Recapture GGBF Monitoring in trial site	1st Quarter 2013
Communication received from NPWS recognizing intent to utilize 78ha of land within Hunter Wetlands National Park for bell frog compensation	June 2013
Commissioning of a landscape architect to assist in developing a Green and Golden Bell Frog Compensatory Concept Plan.	June 2013
Consultation with stakeholders to discuss interaction with restoration activities in the National Park.	September 2013
Workshop at University of Newcastle on GGBF research learnings	November 2013
Submission of REF for GGBF compensatory habitat on Ash Island	January 2014
Licence provided by NPWS to NCIG for land access on Ash Island	March 2014
Continuation of Behavioural Research on the Green and Golden Bell Frog by the University of Newcastle	Throughout the coming reporting period
Continuation of hydrological management controls in Creek 5 (Fish Fry Creek) to limit propagation and reduce existing area of mangroves, currently managed by Local Land Services (LLS) – Kooragang Wetlands Rehabilitation Project	1st to 4th Quarter 2013

3.10.4 Reportable Incidents

No incidents or complaints were reported relating to flora and fauna management during the reporting period.

3.10.5 Further Improvements

Aside from ongoing implementation of the Compensatory Habitat and Ecological Monitoring Program, no improvement to flora and fauna management is required for the next period.

3.11 Traffic Management

3.11.1 Environmental Management

The Project Approval (06_0009) contains a range of requirements that pertain to road transport (Conditions 2.21 to 2.37, Schedule 2). These requirements are addressed where relevant in the Construction Traffic Management Protocol.

3.11.2 Environmental Performance

The road improvements proposed to conform to the Conditions of the Project Approval for the construction phase of the CET are generally those permanent works that would be required during the future operation of the proposed coal loader.

Traffic management during the construction phase focussed on the immediate imposition of movement restrictions at key intersections to limit the potential for delays to traffic flows on Cormorant Road.

NCIG has developed a Vehicle Traffic Management Plan (VTMP) in accordance with the Construction Traffic Management Protocol. This plan provides the approved traffic routes for NCIG construction traffic across the site. This plan also dictates the approved traffic routes for construction traffic on adjacent public roads, including the prevention of right-hand turns onto Cormorant Road from Egret Street, Pacific National Road and the NCIG Wharf Access Road intersection, in order to minimise any disruption to through traffic on this road. Each contractor on the NCIG project site also developed VTMPs to ensure that construction traffic is adequately managed on internal and external roads.

There were no road improvements performed during the reporting period.

In addition to the above, a Vehicle Traffic Management Plan has been developed for operational vehicles which came into effect at the commencement of NCIG operational activities.

3.11.3 Reportable Incidents

No incidents or complaints were reported relating to traffic management during the reporting period.

3.11.4 Further Improvements

No improvement to traffic management is required for the next period.

3.12 Waste management

3.12.1 Environmental Management

Measures to avoid and minimise the generation of wastes and promote waste re-use and recycling have been adopted during construction of the Project and include:

- waste avoidance – practices were developed that reduce the amount of waste on-site, via selective purchasing procedures and the use of bulk purchasing, where practicable;
- material reuse – reuse of recyclable or reusable materials where practicable; and
- recycling – materials such as metals, oil, timber, plastics, glass and paper were recycled where practicable.

In accordance with Conditions 2.54 and 2.56, Schedule 2 of the Project Approval (06_0009), all waste materials removed from the site were directed to a waste management facility lawfully permitted to accept the materials.

In accordance with Condition 2.57, Schedule 2 of the Project Approval (06_0009), waste was not received at the site during the reporting period. In addition, NCIG complied with the requirements of EPL No. 6437 as it relates to the on-going management of the Kooragang Island Waste Emplacement Facility.

3.12.2 Environmental Performance

The principles of waste management, being waste avoidance, material reuse and recycling have been adopted by NCIG and all construction contractors on the site during the reporting period. The focus of this process has been the avoidance of waste, however the recycling of waste products was also actively pursued with paper, aluminium, steel, plastics, timber and glass being the primary materials collected. Recycled concrete has also been incorporated into the pavement design for the rail and stockyard areas as a means of improving reuse of waste materials.

A 12,000 litre (L) waste oil tank was installed prior to operations to enable the collection and storage of waste hydrocarbons during NCIG operational activities, before being removed by licensed waste transporters on a periodic basis. A purpose built oil/water separator system has also been installed at the workshop and truck washdown areas, which is inspected and maintained on a regular basis during operations.

A Waste Management Plan has been developed and incorporated into the environmental management system for the operations of the NCIG Terminal. Waste volumes are tracked on a monthly basis, with the assistance of NCIG's waste management contractor.

During the reporting period there was no waste material stored, treated, processed or reprocessed or disposed of on the Kooragang Island Waste Emplacement Facility that would constitute a breach of the conditions of EPL No. 6437.

3.12.3 Reportable Incidents

No incidents or complaints were reported relating to waste management during the reporting period.

3.12.4 Further Improvements

No improvement to waste management is required for the next period. A Waste Management Plan has been incorporated into the environmental management system for the operational site. This will be developed on an ongoing basis.

3.13 Community relations

3.13.1 Environmental Management

During Project construction the following complaints handling system was implemented:

- In accordance with Conditions 6.2, Schedule 2 of the Project Approval (06_0009), NCIG established a telephone number, postal address and email address prior to the commencement of construction for community complaints and enquiries. Current details are provided below:

  - 24-hour complaints telephone hotline: 1800 016 304
  - Postal address for written complaints: PO Box 644
Newcastle NSW 2300
  - Email address for electronic complaints: enquiries@ncig.com.au

- In accordance with Condition 6.2, Schedule 2 of the Project Approval (06_0009), the community were informed of the phone, email and postal addresses via the NCIG website (www.ncig.com.au), notices in local newspapers and signage adjacent to the Project.

- In accordance with Conditions 6.3, Schedule 2 of the Project Approval (06_0009), NCIG recorded all complaints received in a Complaints Register.

- In accordance with Condition 6.4 of the Project Approval (06_0009), NCIG established and maintained a website for the provision of electronic information associated with the Project including all relevant Management Plans.

3.13.2 Environmental Performance

The general structure of Complaint Response Procedure is shown on Figure 37. . Upon receiving a complaint all details relating to the issue of concern were recorded in the Complaints Register including:

- the date and time, where relevant, of the complaint;
- the means by which the complaint was made (telephone, mail or email);
- any personal details of the complainant that were provided, or if no details were provided, a note to that effect;
- the nature of the complaint; and
- a record of any operational or meteorological conditions that may have potentially contributed to the complaint.

Within 2 working days of a complaint being registered, an initial response was provided to the complainant and a preliminary assessment commenced to determine likely causes of the complaint using relevant available information (i.e. climatic conditions, environmental monitoring results and current construction activities). Table 20 provides a summary of the complaints received during the reporting period. In every case the investigation of the complaint determined that the issue of concern was not as a result of an exceedence of relevant Project Approval or EPL criteria.

The outcome of the complaints handling process was recorded in the Complaints Register, including:

- action taken by NCIG in relation to the complaint, including all follow-up contact with the complainant; and
- details of the finding of the investigation and the reason(s) why no action was taken.

Every effort was made to ensure that the concerns of the complainant were addressed in a manner that resulted in a mutually acceptable outcome.

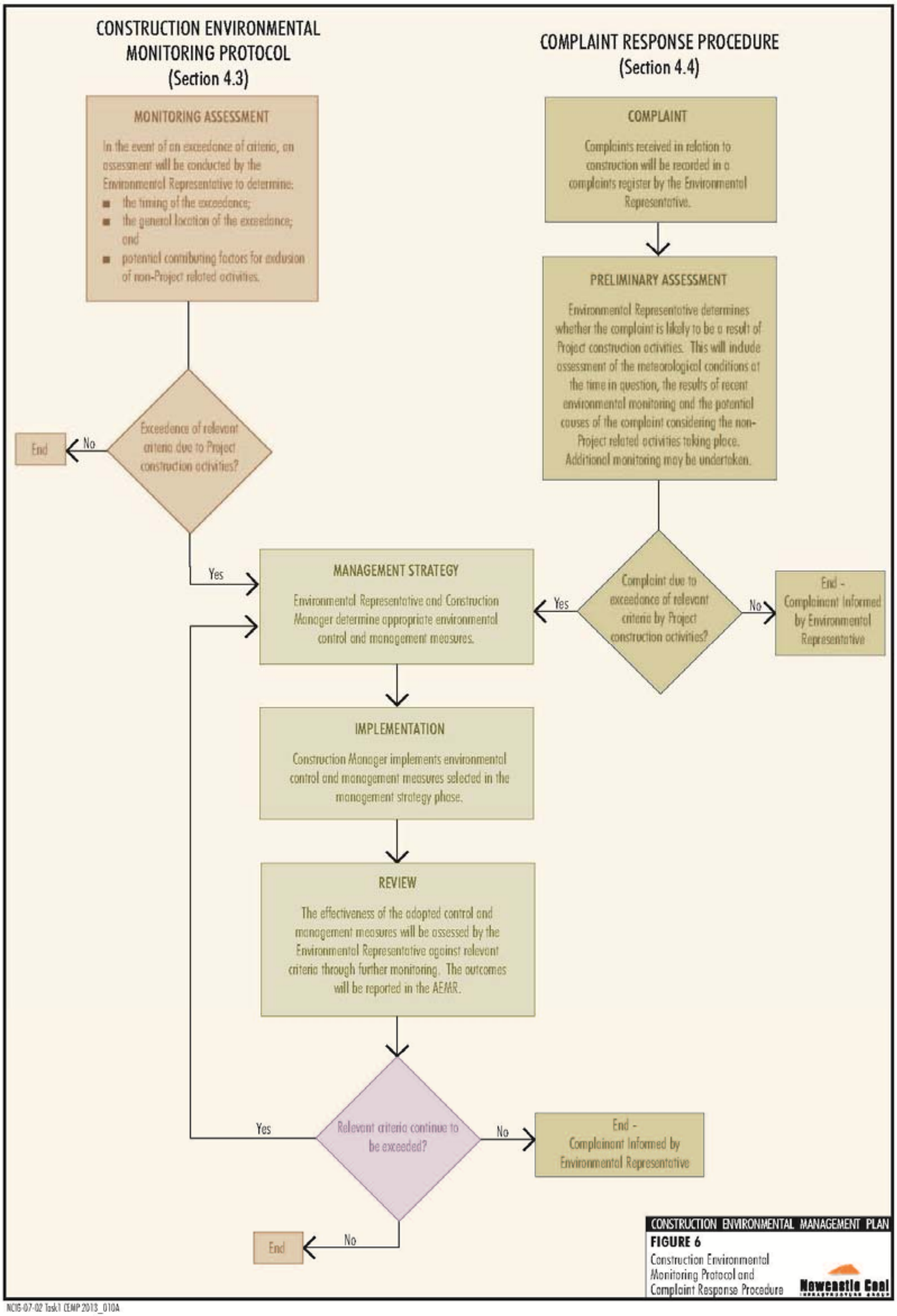


Figure 37: Complaint Response Procedure

Table 20 Community Complaints register summary

Date of complaint	Environmental concern raised	Issue	Action taken
11-Apr-2013	Coal	Reported by member of the public that coal fell from conveyor onto car and broke windscreen.	NCIG visited complainant to inspect the damage and the piece of coal. Photographs were taken and Nathan Juchau contacted complainant to follow up.
8-May-2013	Dust	Complaint regarding several issues, including dust, high cancer rates in Newcastle and recent fish kills. Stated distaste at level of industry and in general on local communities.	None taken.
30-May-2013	Noise	Complaint relating to noise described as a load roar hum, can be heard inside even with windows closed.	Noise monitoring undertaken at residence in conjunction with PWCS.
14-Jun-2013	Dust	Complained that coal dust covering pool and surrounding area due to strong westerly winds.	NCIG had phone discussions with complainant on two occasions. NCIG offered to complete dust sampling, complainant declined.
10-Sept-2013	Dust	Complainant had stopped on Cormorant Rd during Extreme Dust Risk conditions (i.e. >12m/s wind), SR02 was stacking and a highly visible dust plume was seen from stack point. The complainant took a photo and forwarded this to Fordcomm (NCIG PR consultants). This was forwarded to the NCIG General Manager. Complainant requested to know why operations were allowed to continue during high winds. It was noted that the complainant is a representative of the local newspaper, the Stockton	A response was forwarded to the complainant, recognising that the Automated Dust Management System applies water to these coal types and that in this circumstance there was a short period before this was actively managed.

Table 20 Community Complaints register summary

Date of complaint	Environmental concern raised	Issue	Action taken
		Messenger and that the photo was likely to be published in the next edition.	
26 September 2013	Dust	Member of Stockton Community drove along Cormorant Rd during extreme dust risk conditions and saw what he thought was SR01 reclaiming in extreme dust risk conditions. Checked with Control Room and SR01 was not reclaiming, rather was repositioning over belt with bucket wheel turning. Community member called NCIG enquiries line to complain and to make comment about overall effectiveness of dust management system in extreme conditions. Also complained that he could not see stockpile sprays operating from road when driving past. Complainant also called EPA regarding NCIG dust issue. It is understood he also called PWCS.	Discussed nature of complaint with complainant. Explained that NCIG System does not allow for all stockyard sprays to operate simultaneously. Complainant already aware. Also explained that SR01 was not reclaiming coal, despite bucket wheel turning. NCIG had stopped operations at time of call. Complainant mentioned that they would raise issue at NCCCE.
1 October 2013	Dust	The EPA called to ask if the NCIG Dust Management System was operating during the day. They asked specifically if the system was operating around 12.45pm. The enquiry was triggered by an anonymous complaint to the EPA that the stockpile sprays were not seen to be operating from Cormorant Road at 12.45pm.	Information was provided to the EPA, who were satisfied with the response. Noted that sprays were operating, and that sprays were likely operating in the northern half of the site at this time.
13 October 2013	Dust	Phone call received from the EPA during hot windy conditions. They had received a call from a member of the public that our spray guns were not working during extreme weather conditions. Particularly wanted to confirm that spray guns	Information was provided to the EPA at time of the enquiry, who were satisfied with the response. Explanation provided was similar to enquiry on 1st October

Table 20 Community Complaints register summary

Date of complaint	Environmental concern raised	Issue	Action taken
		were working.	2013.
13 October 2013	Dust	Stockton resident was driving past the stockyard on Cormorant Rd, noted that single sprays were not effective and saw a cloud of dust coming from the top of the coal pile. Also saw a number of people taking photos from Cormorant Rd both on the way from and to Stockton. Tried calling PWCS Supervisor first. PWCS Supervisor gave complainant NCIG Process Leader number.	Environmental Advisor called complainant back to discuss nature of incident. Offered to call back on Monday with a report on the health of the NCIG dust management system at time of complaint. Also asked if photos were available of NCIG site, and if these could be sent through. Also offered to take dust samples from complainant's house.
13 October 2013	Dust	The recorded registered complaint was received by Origin Energy who is an immediate neighbour on our eastern boundary. On the day, strong winds were experienced on site from the north-west. Origin Energy reported that these winds resulted in the presence of coal dust across their site and within their offices and workshop buildings.	A subsequent inspection of the site confirmed the presence of coal in the reported locations (laboratory analysis of dust samples taken identified a significant dust fraction). Discussion with the Origin Energy Site Manager suggested that anecdotally dust was primarily being generated by stacking and reclaiming in winds of up to 60km/hr.
23 October 2013	Dust	EPA called to enquire about NCIG dust management under hot windy conditions being experienced. They had a complaint from a member of the public about spray guns not visible and also received photos of dust generation during stacking.	Information provided to EPA on health of NCIG Dust Management System. System was fully healthy at time of complaint.

Table 20 Community Complaints register summary

Date of complaint	Environmental concern raised	Issue	Action taken
3 April 2014		The PWCS Watchman called with the contact details of the member of the public, who had detected an odour, likely to be spontaneous combustion. The member of the public was familiar with the issue as he worked in the coal industry. His main concern was that NCIG were aware of the issue and that it wasn't going to negatively impact on our operations.	An explanation was provided about what was in place to remedy the situation. He was satisfied that all was in hand.

NCIG participated in community consultation during the reporting period, in particular in conjunction with PWCS through their community consultation program. This happens between 2-4 times per year.

NCIG has developed an initiative titled the Community Support Program. This process involves engagement with local community groups and providing support to community based events and projects. The Program seeks applications on a six monthly basis from community groups that are seeking support for their endeavours. NCIG would undertake an assessment process and provide primarily financial support to these community events and projects. NCIG participated with the community groups in these project and events wherever possible. Through this process groups within the Fern Bay, Stockton, Mayfield and greater Newcastle area were assisted by NCIG.

Figure 38: Community Support Program May 2012

The chronology of community liaison held during the reporting period is outlined in Table 21 below.

Table 21 Community Liaison Summary

Date	Type
April 2013	Community Newsletter
September 2013	Community Support Program – submissions called, grants provided
November 2013	Community Newsletter
March 2014	Community Support Program – submissions called, as above.

3.13.3 Reportable Incidents

No incidents were reported relating to community relations during the reporting period. Complaints received during the period are detailed in the section above.

3.13.4 Further Improvements

No improvement to community relations is required for the next period.

3.14 Environmental monitoring program

An Environmental Monitoring Programme was implemented to monitor the environmental performance of the Project during construction in accordance with the Project Approval (06_0009), environmental licences and other statutory conditions. The programme was established and implemented at the commencement of construction works.

The Environmental Representative was responsible for the implementation of the construction environmental monitoring programme and is responsible for ensuring that adequate environmental monitoring is maintained throughout the Project construction.

The details of the monitoring undertaken are provided in the previous sections, however, an overview of the construction Environmental Monitoring Programme, as they are in both the Construction Environmental Management Plan (CEMP) and Operations Environmental Management Plan (OEMP), is provided in Table 22 and Table 23

Table 22 Construction Environmental Monitoring Program

Monitoring Focus	Monitoring Sites	Frequency	Criteria
Meteorology			
Temperature, relative humidity, net solar radiation rainfall, wind speed and direction and sigma theta (rate of change of wind direction).	Project automated meteorological station[1].	Continuously monitored and the data averaged over 15 minute periods.	N/A
Erosion and Sediment Control			
Structural stability and effectiveness in controlling sediment migration.	Drainage, erosion and sediment control infrastructure.	Monthly and following significant rainfall events (i.e. greater than 20 mm in 24 hours).	Structural stability and sediment load
Noise			
Attended and unattended noise monitoring.	N1, N3, N5, N9, N13 and N14[1].	Monthly.	Contained in EPL12693 and Construction Noise Management Plan
Unattended continuous noise monitoring.	Selected locations.	Minimum period of one week per quarter.	
Attended noise monitoring.	Reference locations proximal to the Project[1].	At the commencement of night-time land-based dredging support works and at two monthly intervals thereafter.	
Air Quality			
Dust deposition[2].	DG1, DG2, DG3, DG4, DG5, DG6[1], HVAS1, HVAS2, HVAS3, HVAS4, EBAM1, EBAM2, EBAM3, EBAM4	Monthly.	Maximum increase of 2g/m^2/month, up to a maximum of 4g/m^2/month, relevant NEPM and NHMRC Guidelines
Vibration			
Ground vibration.	Adjacent industrial receivers	Weekly during piling activities.	Contained in Construction Noise

Table 22 Construction Environmental Monitoring Program

Monitoring Focus	Monitoring Sites	Frequency	Criteria
	within 180 m of piling activities.		Management Plan
Surface Water			
pH, electrical conductivity (EC), total dissolved solids (TDS) and total suspended solids (TSS).	Primary settling ponds and EPL Release Point.	Weekly.	Contained in Construction Surface Water Management Plan
	Surface water monitoring sites.	Monthly.	
	Excavation sites that have accumulated water.	Weekly	
Water level.	Primary settling pond and EPL Release Point.	Following heavy rainfall (i.e. more than 20 mm of rainfall in a 24 hour period).	
Groundwater			
pH, EC, TDS, TSS, sulfate, polycyclic aromatic hydrocarbons (PAH), As III, Cd, Cu, Pb, Hg, Zn, Cr VI, Mn and Ni (refer Table 5).	GW1, K9/3S, K9/3N, K11/1S, K11/1.	Monthly.	Contained in EPL12693
Groundwater level.		Monthly	Contained in Construction Environmental Management Plan.
Acid Sulfate Soils			
Presence of acid sulfate soils or potential acid sulfate soils.	Excavation sites.	Prior to any excavation.	Contained in Acid Sulphate Soil Management Plan
	ASS treatment area.	After treatment.	

1 The location of monitoring sites is shown on Figure 3.1.1.

2 Dust deposition was analysed in accordance with AS/NZS 3580.10.1-2003 *Methods for Sampling and Analysis of Ambient Air – Determination of Particulate Matter – Deposited Matter – Gravimetric Method.*

Table 23 Operations Environmental Monitoring Program

Monitoring Focus	Monitoring Sites	Frequency	Criteria
Meteorology			
Temperature, relative humidity, net solar radiation rainfall, wind speed and direction and sigma theta (rate of change of wind direction).	Project automated meteorological station[1].	Continuously monitored and the data averaged over 15 minute periods.	N/A
Erosion and Sediment Control			
Structural stability and effectiveness in controlling sediment migration.	Drainage, erosion and sediment control infrastructure.	Monthly and following significant rainfall events (i.e. greater than 20 mm in 24 hours).	See Appendix C.
Noise			
Attended and unattended noise monitoring.	Fern Bay, Stockton, Mayfield, Carrington per Section 4.2 ONMP.	Quarterly.	See Appendix B.
Attended noise monitoring in case of complaint.	Reference locations proximal to the Project[1].	At the commencement of operation.	
Air Quality			
Dust monitoring.	DG1, DG2, DG3, DG4, DG5, DG6[1].	Monthly	See Appendix A.
	HVAS1, HVAS2, HVAS3, HVAS4.	Every 6 days	
	EBAM1, EBAM2, EBAM3, EBAM4.	Continuous	
	PWCS	Through regular consultation.	
Surface Water			
pH, electrical conductivity (EC),	Secondary settling	Monthly.	See Appendix C.

Table 23 Operations Environmental Monitoring Program

Monitoring Focus	Monitoring Sites	Frequency	Criteria
total dissolved solids (TDS) and total suspended solids (TSS).	ponds[4].		
	Surface water monitoring sites[4].	Monthly.	
Water level.	Primary and secondary settling ponds[4].	Following heavy rainfall (i.e. more than 20 mm of rainfall in a 24 hour period).	
Drainage, erosion and sediment control.	All areas of NCIG	Monthly.	
Groundwater			
pH, EC, TDS, TSS, sulfate, polycyclic aromatic hydrocarbons (PAH), As III, Cd, Cu, Pb, Hg, Zn, Cr VI, Mn and Ni (refer Table 5).	GW1[1].	6 Monthly.	See Appendix C.
Groundwater level.		6 Monthly	

1 The location of monitoring sites is shown on Figure 4.

2 Dust deposition will be analysed in accordance with AS/NZS 3580.10.1-2003 Methods for Sampling and Analysis of Ambient Air-Determination of Particulate Matter – Deposited Matter – Gravimetric Method.

3 PM_{10} will be monitored in accordance with the Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales (EPA,2001).

4 The location of monitoring sites in detailed in the OWMP (Appendix C) and Figure 4.

4 Compliance audits

Audits were undertaken in relation to NCIG Construction activities which considered the compliance status of the Project for the reporting period. These reviews were conducted to meet the requirements of Condition 5.1 of development Approval 06-009 a) as outlined below:

5.1 The Proponent shall develop and implement a Compliance Tracking Program to track compliance with the requirements of this approval. The Program shall include, but not necessarily limited to:

a) provisions for periodic review of the compliance status of the project against the requirements of this approval;

c) a program for independent auditing at least annually, or as otherwise agreed by the Director-General, in accordance with ISO19011:2002, Guidelines for Quality and/or Environmental Management Systems Auditing;

The details and outcomes of the audits conducted are illustrated below:

4.1 April 2013

A review of the compliance status of the NCIG Coal Export Terminal operational activities was undertaken by an NCIG Environmental Representative in April 2013. This review was undertaken to confirm the ongoing compliance of the NCIG project against the requirements of the Project Approval (06_0009). This review determined that NCIG met the requirements for all aspects of the consent that were relevant to the stage of the project development as at April 2013. With completion of the review, the Compliance Tracking Program document was revised and submitted to the Department of Planning.

4.2 October 2013

A review of the compliance status of the NCIG Coal Export Terminal operational activities was undertaken by an NCIG Environmental Representative in October 2013. This review was undertaken to confirm the ongoing compliance of the NCIG project against the requirements of the Project Approval (06_0009) in preparation for the commencement of the Rail Flyover construction. This review determined that NCIG met the requirements for all aspects of the consent that were relevant to the stage of the project development as at October 2013. With completion of the review, the Compliance Tracking Program document was revised and submitted to the Department of Planning.

4.3 January 2014

An independent audit of compliance against the Project Approval (06_0009) and the Modification of the Minister’s Approval MP06_0009 requirements was undertaken in January 2014 by Trevor Brown and Associates consultants.This was completed to the standards of *ISO19011:2002 Guidelines for Quality and/ or Environmental Management system Auditing*.

This review audited air quality, noise, biodiversity, traffic and transport, rail infrastructure and management, soil and water, surface water monitoring, groundwater, heritage, waste management, compliance tracking program, incident reporting and community complaints.

The outcome of the independent audit of the NCIG compliance status is as follows:

… The construction and operational activities of the NCIG Coal Export Terminal, generally demonstrated a high degree of compliance with the Project Approval and Environmental Protection Licence conditions for the environmental management of the project

The following recommendations were made in the audit:

- That a framework be set out describing the indicators that would be used to determine whether a documented decline in either Green and Golden Bell Frog population of Shorebird habitat usage is due to activities associated with development and operation of the CET over and above natural variation.

- That a review of the appropriateness of the 1:100 year ARI design capacity of the site's stormwater structures be implemented.

- In relation to surface water monitoring, to include consistent nomenclature between the documents and inclusion of surface water quality criteria within the *Operation Water Management Plan*. It was also recommended that sample identification nomenclature consistent with the Construction Surface Water Management Plan Figure 5 sampling points be used in the water monitoring electronic database and include surface water quality criteria consistent with the Construction Surface Water Management Plan and Operations Water Management Plan (note these are being reviewed as part of the Site Specific Trigger Value development).

- Recommendations similar to surface water monitoring data are made for groundwater quality criteria recording.

This review determined that NCIG met the requirements for all aspects of the consent that were relevant to the stage of the project development as at January 2014. With completion of the review, the Compliance Tracking Program document was revised and submitted to the Department of Planning.

5 Activities proposed in next AEMR period

Significant activity is proposed to be undertaken in the next AEMR period in accordance with the Project Approval and environmental management and monitoring programmes. The principle elements are:

- Continued operation of the combined 66 Mtpa capacity of the NCIG Coal Export Terminal (Stage 1, Stage 2AA and Stage 2F).

- Effective completion, commissioning and operation of the Rail Flyover.

Please note – the next AEMR reporting period will be April 2014 to June 2015 (15 month period), to align the end of the reporting period with the end of financial year. From this point on, future Annual Environmental Management Reports will align with the financial year period. This will better align with timing of subreports required to complete the AEMR, eg. annual Green and Golden Bell Frog Monitoring on Kooragang Island.

6 References

EES (2013) Groundwater Management Plan – Site D1 – Kooragang Island, Newcastle, NSW

SKM (2013), NCIG Coal Export Terminal Model Validation Report Conditions 3.3 and 3.4 of Project Approval 06_009

7 Limitations

ENVIRON Australia prepared this report in accordance with the scope of work as outlined in our proposal to NCIG dated April 2014 and in accordance with our understanding and interpretation of current regulatory standards.

A representative program of sampling and laboratory analyses was undertaken as part of this investigation, based on past and present known uses of the site. While every care has been taken, concentrations of contaminants measured may not be representative of conditions between the locations sampled and investigated. We cannot therefore preclude the presence of materials that may be hazardous.

Site conditions may change over time. This report is based on conditions encountered at the site at the time of the report and ENVIRON disclaims responsibility for any changes that may have occurred after this time.

The conclusions presented in this report represent ENVIRON’s professional judgment based on information made available during the course of this assignment and are true and correct to the best of ENVIRON’s knowledge as at the date of the assessment.

ENVIRON did not independently verify all of the written or oral information provided to ENVIRON during the course of this investigation. While ENVIRON has no reason to doubt the accuracy of the information provided to it, the report is complete and accurate only to the extent that the information provided to ENVIRON was itself complete and accurate.

This report does not purport to give legal advice. This advice can only be given by qualified legal advisors.

7.1 User Reliance

This report has been prepared exclusively for NCIG and may not be relied upon by any other person or entity without ENVIRON’s express written permission.

Appendix A

Meteorological (other than rainfall) summary

Table 24 Meteorological statistics by month

Month	Wind speed			Sigma theta			Solar radiation		
	Monthly average	Hourly min	Hourly max	Monthly average	Hourly min	Hourly max	Monthly average	Hourly min	Hourly max
	m/s	m/s	m/s	-	-	-	W/m²	W/m²	W/m²
April 2013	2.31	0.0	7.2	21	2	100	134	6	774
May 2013	2.99	0.0	9.8	18	3	98	102	5	599
June 2013	2.84	0.2	14.2	19	1	103	70	7	628
July 2013	2.54	0.2	11.9	19	1	101	96	7	647
August 2013	3.90	0.2	13.3	17	3	103	139	7	688
September 2013	3.34	0.2	15.0	19	2	95	171	5	934
October 2013	3.47	0.3	16.9	21	1	103	222	6	1090
November 2013	3.32	0.2	10.3	21	3	101	203	5	1145
December 2013	3.45	0.3	13.4	20	3	99	262	4	1199
January 2014	3.4	0.0	12.3	17	4	98	238	5	1121
February 2014	2.9	0.0	8.4	21	1	90	194	5	1144
March 2014	2.44	0.2	14.1	20	3	92	179	5	926

Table 24 Meteorological statistics by month

	Temperature @ 2 m elevation, (T_2)			Temperature @ 10 m elevation, (T_{10})			Delta Temp (T_{10}-T_2)	
	Monthly average	Hourly min	Hourly max	Monthly average	Hourly min	Hourly max	Number of hours when $T_{10}>T_2$.	
	°C	°C	°C	°C	°C	°C	Hours	% of month
April 2013	19.2	11.7	27.7	18.6	10.8	27.7	23	3.2
May 2013	16.1	8.5	28.5	15.6	7.8	28.1	23	3.1
June 2013	14.2	6.7	22.2	13.7	6.1	21.8	16	2.2
July 2013	13.4	5.1	22.9	12.9	5.1	22.2	58	7.8
August 2013	14.9	5.1	28.6	14.4	4.6	27.7	107	14.3
September 2013	19.1	9.5	34.5	18.6	8.7	13.8	74	10.3
October 2013	20.2	9.0	35.3	19.6	8.5	34.3	49	6.6
November 2013	20.5	11.3	35.2	19.9	10.5	34.5	13	1.8
December 2013	23.0	13.3	37.3	22.3	12.3	36.2	6	0.8
January 2014	24.0	17.6	37.3	23.3	17.4	36.3	4	0.5
February 2014	23.4	16.5	32.7	22.7	16.1	31.7	6	0.9
March 2014	22.7	15.2	31.3	22.1	14.5	30.6	5	0.7

Appendix B

Surface Water Monitoring Results

pH	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14	Mar-14
Pond 1	7.79	8.25	8.36	8.46		7.78	8.46	8.62	8.92	8.56	8.16	8.54	8.33	8.18	8.55
Pond 2	7.69	8.59	8.33	8.39	8.43	7.55	8.54	8.62	8.66	8.61	8.16	8.46	8.38	8.1	8.54
Pond 3	8.25	8.63	8.27	8.27	8.37		8.61	8.6	8.48	8.46	8.18	8.47	8.3	8.04	8.49
Clearwater	8.06	8.48	8.29	8.13	8.2	7.94	8.53	8.42	8.15	8.22	8.22	8.39		9.02	8.61
Black Swan Pond			8.86	9.31	8.22	7.69	8.37	8.72	9.34	8.6	8.47	8.61	8.37	8.94	8.53
Deep Pond	8.35	7.5	7.47	8.45	7.99	7.79	8.64	8.56	8.53	8.47	8.05	9.33	8.48	8.45	8.6
Swan Pond										7.82	7.89	8.57	8.63	8.6	8.66

EC (mS/cm)	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14	Mar-14
Pond 1	1.52	1.08	2.71	2.37	1.23	1.64	3.17	1.72	1.75	0.88	1.59	1.71	2.206	2.345	2.513
Pond 2	1.13	0.87	2.3	1.715	1.23	1.68	2.81	1.93	1.32	0.81	1.41	1.89	2.116	1.804	2.851
Pond 3	1.4	0.67	1.962	1.506	0.897	1.71	1.79	2.21	1.43	1.12	1.14	1.81	2.437	1.176	1.869
Clearwater	1.58	1.08	1.456	1.379	1.285	1.54	1.57	2.2	3.73	3.44	0.705	1.89	0	1.397	2.118
Black Swan Pond		1.44	1.785	2.235	1.74	2.15	1.74	2.03	2.19	2.39	1.32	1.79	13.7	8.25	6.149
Deep Pond	3.55	0.82	1.127	0.687	0.55	0.561	0.73	1.24	1.56	1.77	1.08	1.55	4.007	4.263	4.01
Swan Pond										27.8	12.12	16.08	68.689	39.662	45.306

Turbidity (NTU)	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14	Mar-14
Pond 1	51.8	315	133.1	27.1	220	164	194	132.8	157	480	101.1	240	260	15.7	179
Pond 2	55.3	90.6	32.1	21.9	721	66.3	61.8	26	63.2	375	42.1	36.3	224	32.8	6.4
Pond 3	23.5	83.2	20	24	403	37.6	167	80.6	78.2	125	19.4	59.7	257	29.4	82

Clearwater	72.1	14.4	513	17.2	130.2	36.5	111	74.5	130	15.7	54.1	79.8	Dry	23.3	1.2
Black Swan Pond		12.1	5.7	7.6	25.3	11.8	4.2	4	11.7	125.5	6.7	17.3	243	0.6	19.4
Deep Pond	123.7	13.2	8.3	12.6	7.2	12.8	12.4	22.7	19.7	20.1	7.4	2.8	421	94.4	143
Swan Pond										14.5	11.8	11.7	279	48.7	112

Water Temp (°C)	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14	Mar-14
Pond 1		34.4	35.7	32.8	24.2	19.6	19.5	20.5	24.3	27.7	26.8	34.2	24.1	24.9	23.6
Pond 2		32	33.6	34.9	24.2	18.3	19.3	19	21.1		26.6	23.9	25.1	25.2	23.5
Pond 3	37.8	33.3	32.8	25.3	21.6	19	19.4	19.9	21.4		26.6	22.7	24.5	25.4	23.5
Clearwater		26.5	35.1	25.8	22.7	20.2	20.8	19.7	23.3		27.6	35.2		24.9	22.9
Black Swan Pond		26.9	37.1	33.8	23.5	19.6	18.9	22.6	26.5		27.4	37.4	22.2	23.9	23.3
Deep Pond	32	27.2	34	28.8	24.7	17.1	18.8	22.8	24.7		25.9	30.1	21.1	22	23.2
Swan Pond										25.6	26.1	35.9	24.7	23.6	23.5

TABLE 1 Flyover Surface Water Analytical Results

Sample Identification	PQL	Guideline			SW1	SW1	SW2	SW2
Date		90% Fresh [A]	90% Marine [A]	Recreational [B]	Oct-13	Jan-14	Oct-13	Jan-14
Depth to Groundwater								
Dissolved Metals								
Aluminium pH>6.5	0.01	0.08	ID	4	< 0.01	< 0.01	0.03	0.02
Arsenic (V)	0.001	0.042	ID	0.2	0.002	0.003	0.002	0.005
Cadmium	0.0001	0.0004	0.014	0.04	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	0.0001	0.006	0.02	1	< 0.001	< 0.001	< 0.001	< 0.001
Copper	0.001	0.0018	0.003	40	< 0.001	< 0.001	< 0.001	< 0.001
Lead	0.001	0.0056	0.0066	0.2	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	0.001	0.013	0.2	0.4	0.002	0.002	0.002	0.004
Zinc	0.005	0.015	0.023	60	< 0.005	0.005	< 0.005	< 0.005
Manganese	0.001	2.5	ID	10	0.062	0.35	0.19	0.085
Iron	0.05	ID	ID	6	< 0.05	< 0.05	0.12	< 0.05
Bromide	0.5	--	--	--	86	100	1.9	4.4
Biochemical Oxygen Demand (BOD)								
Biochemical Oxygen Demand (BOD)	2	--	--	--	6	12	4	14
BTEXN								
Benzene	0.001	1.3	0.9	0.001	< 0.001	< 0.001	< 0.001	< 0.001
Toluene	0.002	*0.18*	--	0.8	< 0.001	< 0.001	< 0.001	< 0.001
Ethylbenzene	0.002	*0.08*	--	0.3	< 0.001	< 0.001	< 0.001	< 0.001
meta- & para-Xylene	0.002	0.25	--	--	< 0.002	< 0.002	< 0.002	< 0.002
ortho-Xylene	0.002	0.47	--	--	< 0.001	< 0.001	< 0.001	< 0.001
Total Xylenes	0.002	--	--	0.6	< 0.003	< 0.003	< 0.003	< 0.003
Total Recoverable Hydrocarbons (Amended 2013)								
C6-C10 Fraction	0.02	--	--	--	< 0.02	< 0.02	< 0.02	< 0.02
TRH >C10-C16	0.05	--	--	--	< 0.05	< 0.05	< 0.05	< 0.05
TRH >C16-C34	0.1	--	--	--	< 0.1	< 0.1	< 0.1	0.3

TRH >C34-C40	0.1	--	--	--	< 0.1	< 0.1	< 0.1	< 0.1
TRH C6-C40	0.27	--	--	--	--	--	--	0.3
Polycyclic Aromatic Hydrocarbons								
Acenaphthene	0.001	--	--	--	< 0.001	< 0.001	< 0.001	< 0.001
Acenaphthylene	0.001	--	--	--	< 0.001	< 0.001	< 0.001	< 0.001
Anthracene	0.001	*0.0015*	*0.0015*	--	< 0.001	< 0.001	< 0.001	< 0.001
Benz(a)anthracene	0.001	--	--	--	< 0.001	< 0.001	< 0.001	< 0.001
Benzo(a)pyrene	0.001	*0.0004*	*0.0004*	0.002	< 0.001	< 0.001	< 0.001	< 0.001
Benzo(b&j)fluoranthene	0.001	--	--	--	< 0.001	< 0.001	< 0.001	< 0.001
Benzo(g.h.i)perylene	0.001	--	--	--	< 0.001	< 0.001	< 0.001	< 0.001
Benzo(k)fluoranthene	0.001	--	--	--	< 0.001	< 0.001	< 0.001	< 0.001
Chrysene	0.001	--	--	--	< 0.001	< 0.001	< 0.001	< 0.001
Dibenz(a.h)anthracene	0.001	--	--	--	< 0.001	< 0.001	< 0.001	< 0.001
Fluoranthene	0.001	*0.0017*	*0.0017*	--	< 0.001	< 0.001	< 0.001	< 0.001
Fluorene	0.001	--	--	--	< 0.001	< 0.001	< 0.001	< 0.001
Indeno(1.2.3-cd)pyrene	0.001	--	--	--	< 0.001	< 0.001	< 0.001	< 0.001
Naphthalene	0.001	0.037	0.09	--	< 0.001	< 0.001	< 0.001	< 0.001
Phenanthrene	0.001	*0.004*	*0.004*	--	< 0.001	< 0.001	< 0.001	< 0.001
Pyrene	0.001	--	--	--	< 0.001	< 0.001	< 0.001	< 0.001
Total PAH	0.001	--	--	--	< 0.001	< 0.001	< 0.001	< 0.001

All results in mg/L

PQL = Practical Quantitation Limit.

[A] ANZECC 2000 90% Protection Level for Receiving Water Type

[B] NHMRC Australian Drinking Water Guidelines, 2008

ANZECC arsenic guideline based on As (V)

ANZECC and NHMRC guidelines for chromium are based on Cr (VI)

Results for TRH have been compared to TPH guidelines.

Results shaded grey are in excess of the primary acceptance criteria: ANZECC 90%, NHMRC

Ressults in *italics* indicate low reliability guideline values

Appendix C

Dust Deposition Monitoring Results

Month	Limit	DG1 (Fern Bay)	DG2 (Stockton)	DG3 (Kooragang Island)	DG4 (Mayfield)	DG5 (Mayfield West)	DG6 (Mayfield Rail)
Apr-13	4	0.4	1.0	1.1	0.7	1.1	1.8
May-13	4	0.5	1.6	1.6	0.9	1.2	1.6
Jun-13	4	0.7	1.2	1.1	0.5	1.1	1.5
Jul-13	4	0.5				1.2	1.6
Aug-13	4	0.5	1.7	2.1	0.8	1.9	2.1
Sep-13	4	0.8	2.2	4.2	1.4	2.1	2.2
Oct-13	4	0.7	3.1	4.2	2.7	2.4	2.2
Nov-13	4	0.7	0.8	1.3	11.6	1.9	1.5
Dec-13	4	0.6	1.3	4.5	7.3	1.8	2.2
Jan-14	4	0.7	1	2.2	8.1	1.9	1.4
Feb-14	4	1.4	1.4	1.6	11.2	1.9	0.7
Mar-14	4		0.9	1.4	6.4	1.3	0.9

Appendix D

Groundwater Monitoring Results

Cells with a green shade indicate that the trigger level associated with this result has not been exceeded

Cells with a yellow shade indicates that the LOR is greater than the trigger value,and although undected by the laboratory could exceed criteria

Cells with a red shade indicate that the trigger level associated with this result has been exceeded

Indicates no guideline specified (site specific or ANZECC)

ID= Insufficient data to provide trigger value

Bore GW1

	Reporting Units	95% Marine Waters ANZECC Trigger Level Sourced from CEMP	95% Marine Waters ANZECC Trigger Level Sourced from OWMP	EP Licence Trigger Level (Site specific)	1/07/2011	2/12/2011	8/06/2012	11/12/2012	13/06/2013	2/12/2013
EPA Point Number					1	1	1	1	1	1
Sample Number					07116902001	12116902001	06126902001	12126902001	06136902001	12136902001
Date of Sampling					1/07/2011	2/12/2011	8/06/2012	11/12/2012	13/06/2013	2/12/2013
Time of Sampling					11:20	11:15	11:50	13:10	11:05	13:15
Sampler					C. South	K. Hawes	K. Hawes	K.Hawes	K. Hawes	K. Hawes
Groundwater Level	metres				2.15	1.43	1.38	1.54	1.32	1.49
Temperature	°C				19.0	20.0	19.0	20.0	19.4	20.5
Analyte										
pH	pH units	7.0-8.5	7.0-8.5		7.4	7.7	7.3	7.56	7.8	7.95
EC	µS/cm				9240	9810	9960	9930	11410	9900
TDS	mg/L				6348	6559	6514	7100	7082	7288
4575	mg/L				21	26	25	28	33	42
Metals - Dissolved										
Al	mg/L		ID		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cd	mg/L	0.0055			0.0086	0.0022	<0.0001	0.0002	0.0002	0.0001
Co	mg/L		0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cu	mg/L		0.0013		0.004	0.003	<0.001	0.001	0.004	0.003
Pb	mg/L	0.0044			0.004	<0.001	<0.001	<0.001	<0.001	<0.001
Mn	mg/L	0.08	0.08		0.032	0.176	0.093	0.204	0.03	0.132

Ni	mg/L	0.07	0.07		0.002	0.001	<0.001	<0.001	0.002	<0.001
Zn	mg/L	0.015	0.015		0.019	0.015	<0.005	0.02	0.046	0.038
Fe	mg/L		ID		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
As III	µg/L	ID			<1	<1	<1	<2	<1	<1
Hg	mg/L	0.0004			<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001
Hexavalent Cr	mg/L	0.0044			<0.010	<0.010	<0.010	<0.01	<0.01	<0.01
Cations - Dissolved										
Mg	mg/L		ID		101	104	114	114	151	119
Na	mg/L		ID		1930	2040	2110	2210	2800	1920
K	mg/L		ID		122	127	140	132	173	114
PAH										
Polynuclear Aromatic Hydrocarbons - 16 analytes	µg/L		ID		<0.5	<0.5	<0.5	<0.5	<0.5	<1.0
TPH										
C6-9 Fraction	µg/L				<20	<20	<20	<20	<20	<20
C10-14 Fraction	µg/L				<50	<50	<50	<50	<50	<50
C15-28 Fraction	µg/L				<100	<100	<100	<100	<100	<100
C29-36 Fraction	µg/L				<50	<50	<50	<50	<50	<50
BTEX										
Benzene	µg/L				<1	<1	<1	<1	<1	<1
Toluene	µg/L				<5	<5	<2	<2	<2	<2
Ethyl Benzene	µg/L				<2	<2	<2	<2	<2	<2
m+p Xylene	µg/L				<2	<2	<2	<2	<2	<2
o Xylene	µg/L				<2	<2	<2	<2	<2	<2
Cyanide										
Free	µg/L				<4	<4	<4	<4	<4	<4
Total	µg/L				<4	<4	<4	<4	<4	<4
Ammonia	µg/L				100	<100	<100	780	50	470
Phenol	µg/L				<1	<1	<1	<1	<1.0	<1.0
Sulfate	mg/L				500	698	640	642	638	628

Bore K9/3 N

	Reporting Units	95% Marine Waters ANZECC Trigger Level Sourced from CEMP	95% Marine Waters ANZECC Trigger Level Sourced from OWMP	EP Licence Trigger Level (Site specific)	1/07/2011	2/12/2011	8/06/2012	11/12/2012	13/06/2013	2/12/2013
EPA Point Number					20	20	20	20	20	
Sample Number					07116902002	12116902002	06126902002	12126902002	06136902002	12136902002
Date of Sampling					1/07/2011	2/12/2011	8/06/2012	11/12/2012	13/06/2013	2/12/2013
Time of Sampling					10:35	10:45	9:25	11:45	12:55	15:15
Sampler					C. South	K. Hawes	K. Hawes	K.Hawes	K. Hawes	K. Hawes
Groundwater Level	metres				2.91	2.75	Stand pipe damaged	2.84	2.57	2.62
Temperature	°C				18.5	20.0		20.0	20.3	21.0
Analyte										
pH	pH units	7.0-8.5	7.0-8.5		7.1	7.2		7.5	7.5	7.77
EC	µS/cm				19000	19620		9120	7560	6560
TDS	mg/L				15417	14974		6580	4376	4575
TSS	mg/L				20	12		167	44	27
Metals - Dissolved										
Al	mg/L		ID		<0.01	<0.01		0.03	0.02	<0.01
Cd	mg/L	0.0055			0.0014	0.0015		<0.0001	<0.0001	<0.0001
Co	mg/L		0.001		<0.001	<0.001		<0.001	<0.001	<0.001
Cu	mg/L		0.0013		0.008	0.004		<0.001	<0.001	<0.001
Pb	mg/L	0.0044			<0.001	<0.001		<0.001	<0.001	<0.001
Mn	mg/L	0.08	0.08		0.014	1.47		4.73	0.541	0.49
Ni	mg/L	0.07	0.07		0.003	0.002		0.002	<0.001	0.001
Zn	mg/L	0.015	0.015		0.029	0.023		0.018	<0.005	0.01
Fe	mg/L		ID		<0.05	<0.05		2.35	0.14	<0.05
As III	µg/L	ID			<1	<2		<2	<1	<1
Hg	mg/L	0.0004			<0.0001	<0.0001		<0.0001	<0.0001	<0.0001
Hexavalent Cr	mg/L	0.0044			<0.010	<0.010		<0.010	<0.01	<0.01

Cations - Dissolved									
Mg	mg/L		ID		476	417	146	109	90
Na	mg/L		ID		5400	3910	2070	1890	1340
K	mg/L		ID		202	203	107	113	58
PAH									
Polynuclear Aromatic Hydrocarbons - 16 analytes	µg/L		ID	1	<0.5	<0.5	<0.5	<0.5	<1.0
TPH									
C6-9 Fraction	µg/L			20	<20	<20	<20	<20	<20
C10-14 Fraction	µg/L			50	<50	<50	<50	<50	<50
C15-28 Fraction	µg/L			100	<100	<100	<100	<100	<100
C29-36 Fraction	µg/L			50	<50	<50	<50	<50	<50
BTEX									
Benzene	µg/L			700	<1	<1	<1	<1	<1
Toluene	µg/L			180	<5	<5	<5	<2	<2
Ethyl Benzene	µg/L			5	<2	<2	<2	<2	<2
m+p Xylene	µg/L			75	<2	<2	<2	<2	<2
o Xylene	µg/L			350	<2	<2	<2	<2	<2
Cyanide									
Free	µg/L			4	<4	<4	<4	<4	<4
Total	µg/L			81.1	<4	<4	4	<4	<4
Ammonia	µg/L				100	1090	2900	3580	510
Phenol	µg/L			400	<1	<1	<1	<1.0	<1.0
Sulfate	mg/L				1690	2310	643	400	433

Bore K9/3 S

	Reporting Units	95% Marine Waters ANZECC Trigger Level Sourced from CEMP	95% Marine Waters ANZECC Trigger Level Sourced from OWMP	EP Licence Trigger Level (Site specific)	1/07/2011	2/12/2011	8/06/2012	11/12/2012	13/06/2013	2/12/2013
EPA Point Number					21	21	21	21	21	
Sample Number					07116902003	12116902003	06126902003	12126902003	06136902003	12136902003
Date of Sampling					1/07/2011	2/12/2011	8/06/2012	11/12/2012	13/06/2013	2/12/2013
Time of Sampling					10:40	10:30	9:30	12:10	12:40	15:25
Sampler					C. South	K. Hawes	K. Hawes	K.Hawes	K. Hawes	K. Hawes
Groundwater Level	metres				2.02	1.99	1.91	2.13	2.00	2.00
Temperature	°C				18.0	21.0	Stand pipe damaged	21.0	19.3	21.5
Analyte										
pH	pH units	7.0-8.5	7.0-8.5		7.4	7.6		7.6	7.6	7.89
EC	µS/cm				9940	10010		11890	8960	7520
TDS	mg/L				6791	6790		10400	4770	5003
TSS	mg/L				698	1240		18985	4350	2902
Metals - Dissolved										
Al	mg/L		ID		<0.01	0.08		<0.01	0.02	0.01
Cd	mg/L	0.0055			0.0004	0.0043		<0.0001	0.0003	0.0003
Co	mg/L		0.001		0.001	<0.001		<0.001	<0.001	<0.001
Cu	mg/L		0.0013		0.003	0.003		<0.001	0.004	0.012
Pb	mg/L	0.0044			<0.001	<0.001		<0.001	<0.001	<0.001
Mn	mg/L	0.08	0.08		0.358	0.348		0.842	0.39	0.328
Ni	mg/L	0.07	0.07		0.002	0.002		<0.001	0.002	0.005
Zn	mg/L	0.015	0.015		<0.005	0.063		<0.005	0.013	0.102
Fe	mg/L		ID		<0.05	<0.05		0.13	0.05	<0.05
As III	µg/L	ID			<1	<1		<5	<1	<1
Hg	mg/L	0.0004			<0.0001	<0.0001		<0.0001	<0.0001	<0.0001

Hexavalent Cr	mg/L	0.0044			<0.010	0.01	<0.01	<0.01	<0.01
Cations - Dissolved									
Mg	mg/L		ID		151	171	211	139	83
Na	mg/L		ID		1910	2040	2820	2380	1270
K	mg/L		ID		83	118	129	129	55
PAH									
Polynuclear Aromatic Hydrocarbons - 16 analytes	µg/L		ID	1.1	<0.5	<0.5	<0.5	<0.5	<1.0
TPH									
C6-9 Fraction	µg/L			20	<20	<20	<20	<20	<20
C10-14 Fraction	µg/L			50	<50	<50	<50	<50	<50
C15-28 Fraction	µg/L			100	<100	<100	<100	<100	<100
C29-36 Fraction	µg/L			50	<50	<50	<50	<50	<50
BTEX									
Benzene	µg/L			700	<1	<1	<1	<1	<1
Toluene	µg/L			180	<5	<5	<5	<2	<2
Ethyl Benzene	µg/L			5	<2	<2	<2	<2	<2
m+p Xylene	µg/L			75	<2	<2	<2	<2	<2
o Xylene	µg/L			350	<2	<2	<2	<2	<2
Cyanide									
Free	µg/L			4	<4	<4	<4	<4	<4
Total	µg/L			21.8	5	<4	7	<4	<4
Ammonia	µg/L				100	<100	2420	1610	1170
Phenol	µg/L			400	<1	<1	<1	<1.0	<1.0
Sulfate	mg/L				699	886	935	538	380

Bore K11/1

	Reporting Units	95% Marine Waters ANZECC Trigger Level Sourced from CEMP	95% Marine Waters ANZECC Trigger Level Sourced from OWMP	EP Licence Trigger Level (Site specific)	1/07/2011	2/12/2011	8/06/2012	11/12/2012	13/06/2013	2/7/13 *Retest*	2/12/2013
EPA Point Number					22	22	22	22	22	22	22
Sample Number					07116902004	12116902004	06126902004	12126902004	06136903004	07136902001	12136902004
Date of Sampling					1/07/2011	2/12/2011	8/06/2012	11/12/2012	13/06/2013	2/07/2013	2/12/2013
Time of Sampling					11:58	10:15	13:00	11:05	12:10	14:55	16:00
Sampler					C. South	K. Hawes	K. Hawes	K.Hawes	K. Hawes	C. South	K.Hawes
Groundwater Level	metres				1.50	1.66	1.58	2.11	1.49	1.41	1.30
Temperature	°C				19	18	19	19.0	19.2	22	18
Analyte											
pH	pH units	7.0-8.5	7.0-8.5		7.2	7.2	7.4	7.5	7.3		8.25
EC	µS/cm				3310	914	709	995	854		879
TDS	mg/L				2239	528	437	618	504		550
TSS	mg/L				121	180	271	74	208		850
Metals - Dissolved											
Al	mg/L		ID		<0.01	<0.01	0.01	0.01	0.04		<0.01
Cd	mg/L	0.0055			<0.0001	0.0002	<0.0001	<0.0001	<0.0001	Retest analysis conducted due to TPH C10-C14 Fraction result from June 2013 sampling. Only TPH analysis conducted on this event.	<0.0001
Co	mg/L		0.001		<0.001	0.002	<0.001	<0.001	<0.001		<0.001
Cu	mg/L		0.0013		<0.001	<0.001	<0.001	<0.001	<0.001		0.009
Pb	mg/L	0.0044			<0.001	<0.001	<0.001	<0.001	<0.001		0.001
Mn	mg/L	0.08	0.08		0.746	1.04	0.296	0.744	0.17		1.16
Ni	mg/L	0.07	0.07		<0.001	0.001	<0.001	<0.002	0.001		0.001
Zn	mg/L	0.015	0.015		0.018	0.007	<0.005	0.016	0.046		0.006
Fe	mg/L		ID		<0.05	1.38	<0.05	0.22	0.19		<0.05
As III	µg/L	ID			<1	1	<1	<1	<1		<1
Hg	mg/L	0.0004			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001
Hexavalent Cr	mg/L	0.0044			<0.010	<0.010	<0.010	<0.010	<0.01		<0.01
Cations - Dissolved											

Mg	mg/L		ID		23	10	11	12	15		12
Na	mg/L		ID		516	86	49	81	85		52
K	mg/L		ID		13	7	10	11	12		4
PAH											
Polynuclear Aromatic Hydrocarbons - 16 analytes	µg/L		ID	2.2	<0.5	<0.5	<0.5	<0.5	<0.5		<1.0
TPH											
C6-9 Fraction	µg/L			20	<20	<20	<20	<20	<20	<20	<20
C10-14 Fraction	µg/L			50	<50	<50	<50	<50	130	<50	<50
C15-28 Fraction	µg/L			100	<100	<100	<100	<100	<100	<100	<100
C29-36 Fraction	µg/L			50	<50	<50	<50	<50	<50	<50	<50
BTEX											
Benzene	µg/L			700	<1	<1	<1	<1	<1		<1
Toluene	µg/L			180	<5	<5	<2	<2	<2		<2
Ethyl Benzene	µg/L			5	<2	<2	<2	<2	<2		<2
m+p Xylene	µg/L			75	<2	<2	<2	<2	<2		<2
o Xylene	µg/L			350	<2	<2	<2	<2	<2	Retest analysis conducted due to TPH C10-C14 Fraction result from June 2013 sampling	<2
Cyanide											
Free	µg/L			4	<4	<4	<4	<4	<4		<4
Total	µg/L			16.6	<4	<4	<4	<4	<4		<4
Ammonia	µg/L				680	310	130	0.39	0.11		250
Phenol	µg/L			400	<1	<1	<1	<2	<1.0		<1.0
Sulfate	mg/L				112	49	23	30	32		75

Bore K11/1 S

	Reporting Units	95% Marine Waters ANZECC Trigger Level Sourced from CEMP	95% Marine Waters ANZECC Trigger Level Sourced from OWMP	EP Licence Trigger Level (Site specific)	1/07/2011	2/12/2011	8/06/2012	11/12/2012	13/06/2013	2/12/2013
EPA Point Number					23	23	23	23	23	
Sample Number					07116902005	12116902005	06126902005	12126902005	06136902005	12136902005
Date of Sampling					1/07/2011	2/12/2011	8/06/2012	11/12/2012	13/06/2013	2/12/2013
Time of Sampling					12:10	9:45	12:25	10:40	11:50	15:45
Sampler					C. South	K. Hawes	K. Hawes	K.Hawes	K. Hawes	K. Hawes
Groundwater Level	metres				2.64	2.52	2.22	2.40	2.13	2.52
Temperature	°C				19.0	19.0	19.5	19.0	19.3	18.5
Analyte										
pH	pH units	7.0-8.5	7.0-8.5		7.3	7.6	7.0	7.4	7.4	7.8
EC	µS/cm				18240	17930	17380	15250	17250	12490
TDS	mg/L				14544	12373	6607	12000	10772	9163
TSS	mg/L				83	14	5	8	16	48
Metals - Dissolved										
Al	mg/L		ID		<0.01	<0.01	<0.01	0.01	<0.01	0.02
Cd	mg/L	0.0055			<0.0001	0.0001	<0.0001	0.0001	<0.0001	<0.0001
Co	mg/L		0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cu	mg/L		0.0013		0.002	0.002	<0.001	<0.001	<0.001	<0.001
Pb	mg/L	0.0044			<0.001	<0.001	<0.001	0.002	<0.001	<0.001
Mn	mg/L	0.08	0.08		0.627	0.416	0.543	0.408	0.39	0.317
Ni	mg/L	0.07	0.07		<0.001	0.002	<0.001	<0.001	<0.001	0.001
Zn	mg/L	0.015	0.015		<0.005	0.007	<0.005	<0.005	<0.005	0.009
Fe	mg/L		ID		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
As III	µg/L	ID			<1	<2	<5	<5	<2	<1
Hg	mg/L	0.0004			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Hexavalent Cr	mg/L	0.0044			<0.010	<0.010	<0.010	<0.010	<0.010	<0.01
Cations - Dissolved										

Mg	mg/L		ID		376	311	306	177	158	125
Na	mg/L		ID		3910	4400	4720	3830	3530	2600
K	mg/L		ID		184	186	212	199	174	136
PAH										
Polynuclear Aromatic Hydrocarbons - 16 analytes	µg/L		ID	1.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0
TPH										
C6-9 Fraction	µg/L			20	<20	<20	<20	<20	<20	<20
C10-14 Fraction	µg/L			50	<50	<50	<50	<50	<50	<50
C15-28 Fraction	µg/L			100	<100	<100	<100	<100	<100	<100
C29-36 Fraction	µg/L			50	<50	<50	<50	<50	<50	<50
BTEX										
Benzene	µg/L			700	<1	<1	<1	<1	<1	<1
Toluene	µg/L			180	<5	<5	<2	<2	<2	<2
Ethyl Benzene	µg/L			5	<2	<2	<2	<2	<2	<2
m+p Xylene	µg/L			75	<2	<2	<2	<2	<2	<2
o Xylene	µg/L			350	<2	<2	<2	<2	<2	<2
Cyanide										
Free	µg/L			4	<4	<4	<4	<4	<4	<4
Total	µg/L			75.6	<4	<4	<4	5	<4	<4
Ammonia	µg/L				4950	<100	4920	6110	5360	5840
Phenol	µg/L			400	<1	<1	<1	<1	<1.0	<1.0
Sulfate	mg/L				809	786	740	682	567	472

TABLE 1 Flyover Groundwater Analytical Results

Sample Identification	Guideline			BH19S	BH20S	BH19D	BH20D	BH21S	BH21S	BH21D	BH21D	BH23S	BH23S	BH23D	BH23D
Date	90% Fresh A	90% Marine A	Recreational B	Oct-13	Jan-14	Oct-13	Jan-14	Oct-13	Jan-14	Oct-13	Jan-14	Oct-13	Jan-14	Oct-13	Jan-14
Depth to Groundwater				3.65	3.15	3.82	3.51	5.20	5.13	7.03	7.16	5.01	4.97	7.25	7.38
Dissolved Metals															
Aluminium pH>6.5	0.08	ID	4	< 0.01	< 0.01	< 0.01	< 0.01	0.06	**0.71**	0.03	**0.24**	0.03	0.02	< 0.01	< 0.01
Arsenic (V)	0.042	ID	0.2	0.002	0.002	0.002	0.001	0.01	0.005	0.002	0.004	0.006	0.001	0.001	< 0.001
Cadmium	0.0004	0.014	0.04	0.0004	0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	0.006	0.02	1	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Copper	0.0018	0.003	40	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Lead	0.0056	0.0066	0.2	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	0.013	0.2	0.4	0.007	0.007	0.002	0.004	0.002	0.004	0.002	0.01	0.002	< 0.001	0.004	0.003
Zinc	0.015	0.023	60	**0.034**	**0.018**	**0.22**	**0.029**	< 0.005	< 0.005	0.006	< 0.005	**0.046**	**0.031**	**0.034**	**0.054**
Manganese	2.5	ID	10	0.98	**3.5**	1.6	**5.1**	< 0.001	< 0.001	0.48	0.001	0.35	0.63	2.4	2.2
Iron	ID	ID	6	0.08	< 0.05	**7.2**	0.22	0.11	0.06	3.4	0.06	0.65	4	< 0.05	< 0.05
Bromide	--	--	--	60	< 0.5	66	52	1.3	1.9	19	1.4	0.7	0.7	40	44
Biochemical Oxygen Demand (BOD)															
BOD	--	--	--	27	< 2	27	38	110	< 2	47	4	120	< 2	100	< 2
BTEXN															
Benzene	1.3	0.9	0.001	< 0.001	< 0.001	< 0.001	< 0.001	**0.002**	< 0.005	< 0.001	< 0.005	< 0.001	< 0.001	< 0.001	< 0.001
Toluene	*0.18*	--	0.8	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.005	< 0.001	< 0.005	< 0.001	< 0.001	< 0.001	< 0.001
Ethylbenzene	*0.08*	--	0.3	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.005	< 0.001	< 0.005	< 0.001	< 0.001	< 0.001	< 0.001
meta- & para-Xylene	0.25	--	--	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.01	< 0.002	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002
ortho-Xylene	0.47	--	--	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.005	< 0.001	< 0.005	< 0.001	< 0.001	< 0.001	< 0.001
Total Xylenes	--	--	0.6	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.015	< 0.003	< 0.015	< 0.003	< 0.003	< 0.003	< 0.003

Total Recoverable Hydrocarbons (Amended 2013)															
C6-C10 Fraction	--	--	--	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.03	< 0.02	< 0.03	< 0.02	< 0.02	< 0.02	< 0.02
TRH >C10-C16	--	--	--	< 0.05	< 0.05	< 0.05	< 0.05	0.37	0.44	0.14	0.34	< 0.05	< 0.05	< 0.05	< 0.05
TRH >C16-C34	--	--	--	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.3	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TRH >C34-C40	--	--	--	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TRH C6-C40	--	--	--	--	--	--	--	0.47	0.74	0.14	0.34	--	--	--	--
Polycyclic Aromatic Hydrocarbons															
Acenaphthene	--	--	--	< 0.001	< 0.001	< 0.001	< 0.001	0.006	0.005	< 0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001
Acenaphthylene	--	--	--	< 0.001	< 0.001	< 0.001	< 0.001	0.007	0.006	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001
Anthracene	*0.0015*	*0.0015*	--	< 0.001	< 0.001	< 0.001	< 0.001	0.005	0.005	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Benz(a)anthracene	--	--	--	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.003	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Benzo(a)pyrene	*0.0004*	*0.0004*	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	**0.003**	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Benzo(b&j)fluoranthene	--	--	--	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.003	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Benzo(g.h.i)perylene	--	--	--	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Benzo(k)fluoranthene	--	--	--	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Chrysene	--	--	--	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.003	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dibenz(a.h)anthracene	--	--	--	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Fluoranthene	*0.0017*	*0.0017*	--	< 0.001	< 0.001	< 0.001	< 0.001	0.012	0.018	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001
Fluorene	--	--	--	< 0.001	< 0.001	< 0.001	< 0.001	0.009	0.007	< 0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001
Indeno(1.2.3-cd)pyrene	--	--	--	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Naphthalene	0.037	0.09	--	< 0.001	< 0.001	< 0.001	< 0.001	**0.21**	**0.26**	**0.078**	**0.2**	< 0.001	< 0.001	< 0.001	< 0.001
Phenanthrene	*0.004*	*0.004*	--	< 0.001	< 0.001	< 0.001	< 0.001	0.027	0.027	0.002	0.004	< 0.001	< 0.001	< 0.001	< 0.001
Pyrene	--	--	--	< 0.001	< 0.001	< 0.001	< 0.001	0.009	0.013	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Total PAH	--	--	--	< 0.001	< 0.001	< 0.001	< 0.001	0.29	0.36	0.08	0.21	< 0.001	< 0.001	< 0.001	< 0.001

All results in mg/L

PQL = Practical Quantitation Limit.

[A] ANZECC 2000 90% Protection Level for Receiving Water Type

[B] NHMRC Australian Drinking Water Guidelines, 2008

ANZECC arsenic guideline based on As (V)

ANZECC and NHMRC guidelines for chromium are based on Cr (VI)

Results for TRH have been compared to TPH guidelines.

Results shaded grey are in excess of the primary acceptance criteria: ANZECC 90%, NHMRC

Ressults in *italics* indicate low reliability guideline values

Appendix E

CHEMP Quarterly Reports and Minutes

Compensatory Habitat Consultative Board Meeting – Minutes
Meeting No: 5
6th June, 2013 1100 – 1400
Venue: NCIG Administration Building

Attendees:	Apologies:
Mr Ado Zanella (AZ) – NSW Department of Planning and Infrastructure Ms Liane Corocher (CC) – Hunter/Central Rivers Catchment Management Authority Mr Deon Von Rensburg (DVR) – NSW Office of Environment and Heritage, NPWS Dr Jose Rodriguez (JR) – Newcastle University Professor Michael Mahony (MM) – Newcastle University Ms Alexandra Callen (AC) – Newcastle University Dr Arthur White (AW) – DoPI-approved Ecologist Mr Paul Beale (PB) – Newcastle Coal Infrastructure Group Mr Nathan Juchau (NJ) – Newcastle Coal Infrastructure Group Mr Philip Reid (PR) – Newcastle Coal Infrastructure Group Mr Michael Hector (MH) - Newcastle Coal Infrastructure Group	Dr John Clulow (JC) – Newcastle University Dr Ligia Pizzatto (LP) – Newcastle University

Item	Description	Action Owner
1.0	Welcome / Introductions	
1.1	Meeting Open 1110hrs	
2.0	Update on Green and Golden Bell Frog Research Habitat	
2.1	PR and AC provided an update on the progress of the NCIG GGBF Research Area: - Approval of Translocation Proposal - Tadpole and Metamorph release - Commencement of monitoring, visual encounter surveys and capture methods - Tagging of animals, including coloured polymer tagging and micro-chipping - Salt dosing of treatment ponds - Installation of over-wintering habitat - Presence of predators and non-target species - Chytrid swabbing – noted that swabbing to date indicates that Chytrid is not present in the Research Area	
2.2	- MM raised importance of hydrology in research area ponds, in particular interconnectedness and groundwater influence, and mentioned this is the first time this experiment has been done on this scale. - AC mentioned that successional vegetative habitat would change over time with addition of salt. 0-3-0.5 ppt salt in non-treatment ponds,~3ppt in treated ponds. - Salt concentrations appear to stratify in ponds. AW commented this is similar to ponds on Broughton Island. - JR mentioned effect of wind on salt mixing of ponds. - AC and MM mentioned significance of installing over-wintering habitat was to	PR to check weather

	ensure animal welfare and fill data gap in GGBF life cycle. - AW mentioned that freshly cut grass had been used on other sites as over-wintering habitat for GGBF. - Recognised that Chytrid may arise in the landscape. Difficult to exclude. Question is how best to limit effect of Chytrid through environmental conditions, namely salt. - Recognised there may be a need to manage predators, particularly feral predators. Work with NPWS to find best solution. - MM explained how a Population Viability Model will be built of the Research Area population over time. This will predict survivability rate at different life stages, in particular tadpoles and Adult females. Currently 0.01% for tadpoles, 20% for 1st year females, 20% for 2nd year females. AW explained the age structure on Broughton Island includes numbers of 6, 7 and 8 year old females, which is very different to the Homebush population.	records.
3.0	Conspecific Attraction Research Update	
3.1	In the absence of LP, MM gave a brief update on the status of the behavioural research project. Updates included results showing a strong tendency for tadpoles to aggregate, but not necessarily with kin. Also tendency for GGBF tadpoles to aggregate in warm water. Results also show that calling males will aggregate around call playback recordings, did not aggregate around control sites playing “white noise”.	
4.0	Update on Compensatory Habitat Strategy	
4.1	NJ provided an update on the NCIG compensatory habitat strategy, including recent changes to the draft Compensatory Habitat and Ecological Monitoring Program (CHEMP). Update included a presentation of proposed GGBF and Shorebird Compensatory Habitat to satisfy the conditions of MP06_0009 MOD2.	
4.2	Discussion around details and challenges of the proposal: - DVR highlighted that GGBF habitat locations were potential habitat locations, subject to constraints mapping not impacting on other species and proposals. - AZ gave background on MOU for permission to provide offsets in Hunter Estuary National Park. NPWS would assume management of Ash Island, based on the setting aside of land for offsetting (GGBF). - Question regarding yellow-hatching shown on GGBF habitat areas. DVR mentioned this was City Farm, managed by Kooragang Wetlands Rehabilitation Project (KWRP). The land is managed by the Environment Minister. However existing use allows KWRP to manage this specific part of Ash Island. - Highlighted by NJ that if GGBF compensatory habitat is not successful based on KPI’s set in the conditions (viable/breeding habitat by 2019), then purchase of other GGBF habitat may be required. MM believed this is a tight timeframe given lifecycle and ecology of GGBF. Discussed this may be increasingly difficult with the wetting and drying cycles of the region. AZ mentioned that if there are issues in achieving this, it should be discussed with DoPI with the support of the agencies. - Question raised regarding existing mangrove management currently practised in Area E (KWRP). This is utilising the drop board structure installed by NCIG, to manipulate water level and therefore limit the expansion of the mangrove forest. Discussed that this is an adaptive management approach and it is currently too early to tell the effectiveness of the water level control. - LC raised question around existing Endangered Ecological Communities (EEC), such as saltmarsh, and potential impact from proposal. PR responded that a vegetation assessment has been completed as part of the constraints	

	mapping, and these limitations would be assessed during the Review of Environmental Factors (REF) process with NPWS. DVR confirmed this.	
5.0	Proposed Green and Golden Bell Frog Habitat Concept (Master Plan)	
5.1	MH gave a brief presentation on the development of the GGBF Master Plan, which was developed with the assistance of AW. A series of figures were displayed, showing the development of the plan using constraints and opportunities mapping. Considerations as part of the plan included: - Vegetation surveys, including rehabilitation work conducted by KWRP and EECs - Topographical survey - Catchment area and ability to capture water under various conditions (hydrological engineer input) - Habitat survey - Expert advice provided by Project-approved Ecologist, Arthur White	
5.2	- NJ highlighted the importance of a mosaic of species habitat types, including breeding, foraging, sheltering and over wintering habitat. - LC raised question about the consideration of sea level rise. DVR mentioned that if sea level rise has a significant effect on GGBF habitat, this will not only be for constructed habitat, but also existing habitat near Kooragang Island. PR mentioned that sea level rise was considered as part of the hydrological engineer input. Refuge areas have been included for major flood events, which factors in sea level rise.	
6.0	Next Meeting	
7.1	TBA, in 6 months.	PR
7.2	Minutes to be distributed to attendees and those not present.	PR
7.3	Meeting close 1400hrs.	

Newcastle Coal
INFRASTRUCTURE GROUP

Compensatory Habitat Consultative Board Meeting – Minutes
Meeting No: 6
11th December, 2013 1100 – 1430
Venue: NCIG Administration Building

Attendees:	Apologies:
Mr Ado Zanella (AZ) – NSW Department of Planning and Infrastructure Mr Cal Cotter (CC) – Hunter/Central Rivers Catchment Management Authority Mr Deon Von Rensburg (DVR) – NSW Office of Environment and Heritage, NPWS Professor Michael Mahony (MM) – Newcastle University Dr John Clulow (JC) – Newcastle University Ms Alexandra Callen (AC) – Newcastle University Dr Ligia Pizzatto do Prado (LP) Mr Paul Baird (PBa) – Hunter Bird Observers Club Dr Arthur White (AW) – DoPI-approved Ecologist Mr Paul Beale (PB) – Newcastle Coal Infrastructure Group Mr Allan Greer (AG) - Newcastle Coal Infrastructure Group Mr Nathan Juchau (NJ) – Newcastle Coal Infrastructure Group Mr Philip Reid (PR) – Newcastle Coal Infrastructure Group	Mr Jose Rodriguez (JR) – Newcastle University

Item	Description	Action Owner
1.0	Welcome / Introductions	
1.1	Meeting Open 1110hrs	
2.0	Overview and Update of the NCIG Compensatory Habitat Plan	
2.1	NJ provided an update on the implementation of the NCIG Compensatory Habitat and Ecological Monitoring Program (CHEMP). This included: - Approval of the updated CHEMP achieved 7th August 2013, as required by Condition 2.20A of the Project Modification (MOD 2) Land for GGBF Habitat on Ash Island (Hunter Wetlands National Park) secure, through MoU and land availability from NPWS. - Continued discussions with DoPI and NPWS to secure land for Migratory Shorebird habitat on Ash Island (Fish Fry Flats/Area E), including appropriate legal mechanisms to ensure in perpetuity protection of habitat. Mentioned discovery of healthy GGBF population on NCIG Terminal Site, proves ability of species to persist in industrial zone. JC requested the GPS coordinates of the population on the NCIG site A compensatory habitat bond with a value of $10.1M has been provided to Department of Planning and Infrastructure. This bond has been provided as surety against the commitments made by NCIG in the CHEMP.	PR to provide JC with GPS coordinates of GGBF population
3.0	Green and Golden Bell Frog Research Area and Monitoring	
3.1	AC provided an update on monitoring and research conducted at the NCIG Research Area ponds. Points of interest regarding GGBF: - Research has focussed around manipulation of habitat characteristics, in	

ABN 35 111 228 221 Phone 02 4920 3900 Mailing Address Locked Bag 6003 HRMC NSW 2310
Website www.ncig.com.au Fax 02 4920 3901 Project Office 30 Raven St Kooragang NSW 2304

	particular salinity, to establish optimal conditions to lessen the impact of Chytrid fungus, while maintaining adequate habitat quality. - Chytrid is the limiting factor for the persistence of the species. Solutes act as a fungicide, supported by evidence from other research. - Objective is to understand how frogs use different habitat types within a habitat mosaic (breeding, foraging and terrestrial habitats). - Research Area monitoring reverted to night monitoring in September due to unseasonally warm conditions. Over 120 animals observed on one night, no Chytrid observed since warmer conditions. - While monitoring results have been encouraging, it is noted that this has been only 10 months (<1 year). Potential for significant trends to arise over a longer period. - Calling males have been observed. Frogs have dispersed after rain, however only a distance of 1 to 2 ponds from original position. Large dispersal against fence indicates a portion of the population looking to disperse significant distance. - 'Feeding nights' observed on warm still nights when insect activity is high. Highlights importance of reed vegetation, as frogs were observed sitting high on vegetation to reach insects. - Preliminary analysis of results shows that juveniles prefer to spend time in ponds with warmer temperatures and higher salinity levels.	
3.2	Points of interest regarding habitat conditions: - Conditions saw drying of Research Area habitat over Spring, with 5 ponds drying completely. Subsequent rain saw ponds recharge. - Good Water Quality, which supporting population, and vegetation is providing good protection. - While ponds have recharged from recent rains, there has been a lag in the recharge of deep ponds, which indicates a likely groundwater influence in deep ponds. - Steady increase in salinity in ponds since recharge, however salinity levels are still not at concentrations prior to drying.	
3.3	Uni has also provided following assistance to NCIG: - Uni provided a population estimate to NCIG at the end of Winter to understand if the Research Area population required introduction of a second generation to ensure persistence for the period of research. It was established a second generation should be introduced into the ponds. This is currently occurring. - Uni developed CHEMP guidelines for preferable habitat traits based on research, both at NCIG ponds and other site. These will be applied where feasible in the NCIG GGBF Compensatory Habitat.	
3.4	Upcoming work: - The next 6 months will be spent understanding the Chytrid infection load of frogs across the site at different times of the year.	
3.5	AW mentioned that pathways in terrestrial vegetation had been mown to provide movement pathways for GGBF. This could be applied to Research Area.	
4.0	Behavioural Research Update	
4.1	LP provided an update on the Behavioural Research project. Points of interest: - Key is to understand how habitat preferences are chosen; (i) take the habitat that is available based on habitat attributes, or (ii) let another individual choose for you, i.e. follow conspecifics – Inadvertent Social Information (ISI). - Bell frogs aggregate at all lifecycle stages (tadpoles, metamorphs, juveniles,	

	adults). - A number of behavioural experiments have been conducted with juveniles (see Quarterly Report). These will be repeated with adults to test preferences for aggregation. - Calling males form groups known as 'leks'. Leks need to have a critical number of individuals to attract breeding females. Calling typically deters non-breeding females and juveniles, as there is the chance for sub-adults to be injured. - Question of artificially manipulating distribution of frogs with speakers to improve distribution of species: o Potential to interrupt relationships between individuals o PBa gave examples of disturbance in bird populations from artificial calling - Experiments indicate the tadpoles 'familiar' sibling conspecifics for aggregation, as opposed to 'unfamiliar' non-siblings.	
4.2	AW gave example of Uperolia sp. and territorial nature. Previous experiment conducted using speakers playing calling male noise.	
5.0	GGBF Compensatory Habitat Update	
5.1	PR and AG gave update of progress of GGBF compensatory habitat: Points of interest include: - GGBF Master Plan has been updated since CHEMP to further consider constraints and opportunities - Land access and environmental assessment processes underway, including preparation of an REF. Issues in REF include existing biodiversity, heritage, water impacts and acid sulphate soils. - Ongoing consultation with NPWS and KWRP to develop Master Plan. Including a site consultation meeting on 2 September, with all three parties to identify potential limitations, opportunities and impacts on existing environmental projects, eg. Plantings - Consultation with KWRP regarding interaction between NCIG compensatory habitat and Kooragang Wetlands Project will be ongoing after construction of GGBF habitat. This will be recognised in an NCIG GGBF Habitat Management Plan. - Consultation also undertaken with Worimi LALC regarding potential for Aboriginal Heritage in habitat. - REF is majority complete with field investigations complete. 7-part tests for significance are close to completion. - Submission of REF to NPWS is scheduled for mid-January 2014. - University recommendations for GGBF Habitat have been adopted in design in Master Plan, eg. Deeper, more permanent ponds. - Further modification of Master Plan also includes avoidance of utilities, enhanced constructability - Tender documentation is being developed for GGBF Habitat construction. EOI process commenced with 4 companies willing to take part. Pre-qualification of tenderers also to commence soon. - NCIG intends to issue documents to tenderers mid-January	
5.2	CC mentioned that Awabakal LALC should also be consulted re: GGBF Habitat works. KWRP has Aboriginal Consultation Document (Birrlinbin) for Ash Island. NB/ NCIG consulted with Awabakal LALC on 19 Dec, after Consultative Board meeting.	
5.3	CC asked what the strategy for GGBF Habitat is regarding the issue of seal level rise, with the potential for GGBF habitat areas to be inundated within 30 years. PR stated that current NCIG GGBF Habitat areas most suitable in estuary based on consultation	

	with government departments. DVR understood that the commitment of NCIG is provide for the habitat as it is stated in the CHEMP, and manage this habitat, not to perpetually relocate habitat into the future.	
5.4	CC asked if there are control areas for monitoring of GGBF outside of NCIG comp habitat boundary, eg. Adjacent swales. Purpose would be to assess what needs to change in habitat moving forward. PR stated that this was the purpose of the CHEMP Consultative Board, to assess effectiveness of habitat and manage accordingly using an adaptive management approach.	
5.5	A general comment from the board that the success of the NCIG project relates to the success of overall management of the species on Kooragang and Ash Islands, including management of other compensatory habitat projects.	
5.6	DVR asked if the outcome of the NPWS/KWRP consultation had been communicated back to both parties, i.e. modification to the Master Plan. Master Plan was near finalisation, and this would be provided back to both KWRP and NPWS.	PR to make final Master Plan available to NPWS and KWRP (completed on 19 Dec.)
5.7	CC asked question about function of areas between ponds, i.e. remaining rank kikuyu pastures. PR discussed that intent of areas is to provide movement corridors for frogs between pond sites. MM mentioned that old pastures will not be an impediment for movement of animals. Monitoring would provide evidence of usage of these areas, as well as ponds, over time.	
5.8	DVR stated that NCIG would not be taking ownership of entire management of areas being occupied for GGBF habitat, rather would be responsible for certain management practices in areas relating to management of GGBF (in the form of a licence). This would be captured in the NCIG GGBF Habitat Management Plan. Overall responsibility would lie with NPWS.	
6.0	Shorebird Compensatory Habitat Update	
6.1	NJ provided an update on the Shorebird Habitat planning. Points of interest below: - Removal of floodgates at Fish Fry Creek allowed mangroves to populate the area (10 years ago). - NCIG installed drop-board structure to hydrologically control water levels in Fish Fry Flats. KWRP installed drop board <12 months ago. - Continued liaison with DoPI and NPWS regarding security of land in NPWS Estate (Fish Fry Flats/Area E). Will include an extension of deadline to secure land potentially by 3 months from submission of covenant terms. - Discussions around best mechanism to ensure in perpetuity protection. Likely pathway will be to place covenant over land, with shorebird habitat eventually captured in the Plan of Management for the National Park. - Noted that the Infrastructure SEPP which currently covers the land is unlikely to be lifted, but allows environmental works without consent. - Also discussed various methods being investigated for removal of mangroves., eg. Manual vs mechanical removal.	
6.2	CC recognised that public funding had gone toward management of this area. This was recognised by the group, as well as NCIG investment into hydrological control structure.	
6.3	General question regarding ongoing responsibility of habitat area after NCIG has completed mangrove removal. NCIG will be responsible for management of habitat for the life of the terminal. However, will not be responsible for creation of new habitat	

	within the context of sea-level rise (longer time frame issue).	
6.4	PBa asked about potential for HBOC to be involved in development of survey plan for shorebird usage of habitat after mangrove removal. However, HBOC does not have resources to provide full survey service. NCIG is happy to involve HBOC in development of plan.	
6.5	CC recognised risk of actualising mangrove removal at Fish Fry Flats, in context of likely approval processes, including Fisheries approval. NJ recognised this will be a significant part of the project and would require “all of government” support. Recognised that this area would provide best outcome for shorebirds.	
7.0	GGBF and Shorebird Habitat Schedules	
7.1	PR, AG and NJ presented schedules for implementation of GGBF and Shorebird projects: - Mentioned that REF and subsequent determination from NPWS is critical path for GGBF habitat. DVR recognised that 40 day period applies for most REF’s but this may be extended based on complexity of assessment process. - Shorebird implementation focusses largely around security of land and subsequent approvals.	
6.0	Next Meeting	
7.1	TBA, in 6 months.	PR
7.2	Minutes to be distributed to attendees and those not present.	PR
7.3	Meeting close 1400hrs.	

Newcastle Coal
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Compensatory Habitat and Ecological Monitoring Program – Quarterly Report

DATE: *5 June 2013*

AUTHOR: Philip Reid, Dr Ligia Pizzatto (Uni of Newcastle), Melanie James (Uni of Newcastle), Dr John Clulow (Uni of Newcastle)

APPROVAL: Nathan Juchau

INTRODUCTION

This report provides an update of activities relating to the NCIG Compensatory Habitat and Ecological Monitoring Program since the previous Quarterly Report from 27 March 2013. The report aims to provide information on key components of the program and how these are being implemented. An update will be provided to members of the Consultative Board every 3 months, in the form of a Quarterly report and presentations (every 6 months) coinciding with Board Meetings.

Research Area Ponds and Associated Monitoring

In the previous quarter it was reported that captive-bred tadpoles were gradually being released into the Research Area, specifically in eight (8) of the sixteen ponds (shown in Figure 1). The release ponds were selected at random, with animals initially introduced into 1m^3 baskets placed in ponds to monitor health for the period following introduction. It was established that the captive-bred animals adapted well to the constructed ponds, and subsequently the remaining animals were released directly into the open ponds.

Release efforts were completed in mid March. In total, approximately 7500 animals were released over a period of one month. The latter release events included animals that had already partially developed, called metamorphs.

One clutch of tadpoles, approximately 500-700 individuals, developed symptoms in the breeding facility, which appeared to be due to pathogen infection. This type of infection is commonly referred to as 'bloat'. Pathology samples were sent to the Australian Wildlife Health Network at Taronga Zoo. The pathogen was unable to be identified. While the animals showed signs of recovery from infection, they were not released into the ponds as a precautionary measure. These animals were humanely euthenaised in the laboratory.

Figure 1. Research Area Pond Numbers and Release sites

Monitoring of the Research Area has commenced, which is currently carried out nightly on a weekly basis. Monitoring involves observation surveys and catching to collect morphometric data (body weight and length), taking swabs to later determine potential chytrid infection loads, determine VIE status (VIE - visible plant elastamer, which is what the tadpoles were tagged with so it can be determined which ponds the frogs were originally released into as tadpoles), checking for microchips (mark-recapture pond choice and frog movement data). Captured animals are inserted with a microchip, if the animal does not already have one. Monitoring began in April and will continue weekly until there are a lesser number of frogs oberved at the site at night than during the day. Frog surveys will then switch to diurnal weekly surveys. Quadrats have been delineated for field survey purposes (shown in Figure 2).

Salt dosing of selected ponds commenced mid-may but progress has been hampered by recent rains. Approximately 70% of the required concentration has been achieved in 4 shallow ponds (6, 9, 14, 16) and 4 deep ponds (7, 10, 12, 15). Recent rains have likely resulted in mixing of pond waters between some salt dosed ponds, with only one low dose pond (11) potentially confounded by mixing with the high salt dose ponds of 15 and 7 (both ponds interconnect with pond 11 during periods of high rainfall). Approximaly 1.5 tonnes of salt have been distributed across these ponds, with approximately 600kg remaining.

Figure 2. Pond 7, NCIG Research Area, showing open water and emergent vegetation and flagging to delineate quadrats.

Concurrent to salt dosing, monitoring of aquatic macroinvertebrates and pond/quadrat vegetation has commenced. This will be undertaken on a fortnightly-monthly basis. Surface water quality monitoring continues to be undertaken weekly.

Dedicated overwintering habitat is being installed onsite, to ensure animals have adequate overwintering opportunities and to test optimal overwintering conditions. This includes construction of nested pipes and brick piles, as shown in Figure 3. This has received approval from the University Animal Ethics Committee and will be installed in early June and then passively monitored weekly using optic fibre technology to reduce disturbance to frogs. Frogs will be removed from habitats and swabbed monthly. Temperature and humidity of these habitats will be recorded by data loggers. Existing habitats across the site will also be monitored (reeds and pond rocks). It is noted that nested pipes and brick piles are not an acceptable feature of the landscape in full-scale constructed habitat. It is expected that findings from this part of the research will assisting in achieving similar overwintering conditions using more suitable habitat features, such as boulders.

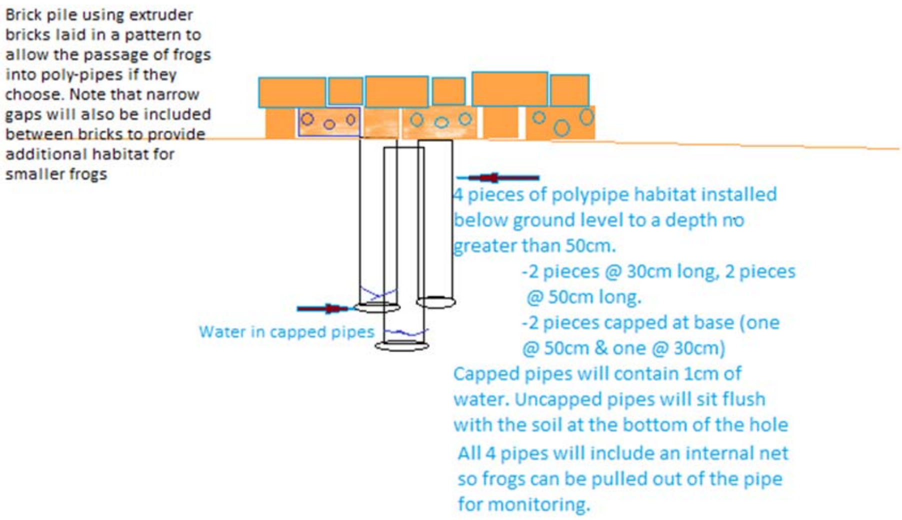

Figure 3. Schematic of Research Overwintering Habitat

It is a requirement of the translocation proposal, that chytrid be tested in the released population. DNA extraction and Polymerase Chain Reaction (PCR) analysis, a method of analysing DNA, have commenced for swabs taken from frogs during night surveys. This is an ongoing process that will hopefully build a picture of infection loads of chytrid across the site over the seasons against a field temperature gradient.

There has been evidence of predators in the Research Area ponds. Potential predators observed include White-faced Herons (*Egretta novaehollandiae*), Red-bellied Black Snakes (*Pseudechis porphyriacus*) and Rats (*Rattus rattus*). Mice (*Mus musculus*) have also been observed in area. There have also been other frog species recorded in the ponds, including Common Eastern Froglet (*Crinia signifera*), Striped Marsh Frog (*Limnodynastes peronii*), and Eastern Dwarf Tree Frog (*Litoria fallax*). The presence of these animals has not caused an effect in the introduced bell frog population, and as such, there is currently no requirement for management response.

Other minor maintenance measures are being employed in the Research Area. This includes opportunistic pulling of Typha reeds, which has the potential to form a dense monoculture of emergent vegetation. Weekly perimeter searches for fence holes are undertaken, and these are repaired on a needs basis. Vegetation growth around the exclusion fence is currently being managed by trampling to avoid the use of weed killer. This is to prevent breach of the fence by frogs climbing vegetation. A small scaffold platform and removable ladders have been installed at the entrance to the site to allow safe access into and out of the Research Area for University staff and volunteers (shown on Figure 4). To date, there has been no requirement to add potable water to the system as ponds have retained adequate water levels.

Figure 4. NCIG Green and Golden Bell Frog Research Area, Ash Island, May 2013

Figure 5. University Students and Volunteers working at the NCIG Research Area.

Annual Green and Golden Bell Frog Monitoring

As part of Project Approval 06_0009, NCIG are required to undertake monitoring of Green and Golden Bell Frogs in locations around the NCIG Terminal on Kooragang Island. PWCS are currently monitoring this area for Green and Golden Bell Frogs as part of the T4 pre-feasibility study. NCIG has a monitoring sharing agreement with PWCS, and the T4 data will be used to satisfy this condition. Hunter Development Corporation (HDC), who is responsible for monitoring the former waste emplacement cells inside the NCIG rail loop, will also provide their monitoring data to NCIG. The University of Newcastle conducts this monitoring for both parties. Information sharing will extend to the results of research being conducted for both NCIG and PWCS.

Breeding Program

The breeding pairs utilised for NCIG's Research Area will be retained at the University of Newcastle, with the intent of utilising these either for experimental pursposes or breeding of future generations for translocation to Ash Island. Future generations may be released into NCIG or PWCS compensatory habitat developments or into existing habitat with the potential to support the local Green and Golden Bell Frog population. Costs for managing the breeding individuals are currently assumed by both NCIG and PWCS.

Behavioural Research

(**1) Post-doctoral fellowship funded by NCIG GGBF Research Programme**

Dr. Ligia Pizzatto is conducting research on conspecific attraction in Green and Golden Bell frogs, as accepted in the original research programme proposal. Research question 1 in the proposed Research Program asks if green and golden bell frogs (*Litoria aurea*) are attracted to areas occupied by conspecifics.

Dr Pizzatto conducted experiments using Green and Golden Bell frogs for testing kin and familiarity preference among schooling tadpoles. In the last report, analyses for those experiments were pending and have now been conducted.

Experiment 1 - tested the preference of tadpoles for siblings vs non-siblings. Green and golden bell frogs were bred in captivity. Clutches were split at the day they were laid, and were reared in separated containers to create tadpoles that (1) were siblings and familiar to each other (i.e. raised together), (2) unfamiliar siblings (sibs raised in separated containers), and (3) unfamiliar non-siblings.

Methods: Preference was tested in core trays filled with rain water. These trays have three visually separated lanes (thus allowing three individuals to be tested simultaneously in each tray). Each lane was divided in five compartments of equal size, and the two compartments in the ends of each lane were separated by fly screen mesh. Five tadpoles, siblings (but unfamiliar) to the testing individuals, were placed in one of the end compartments, and five tadpoles, non-siblings and unfamiliar with the testing individuals were placed in the other end. The testing individuals were released in the centre of the lane, and the experiment was filmed for 45 minutes. A total of 42 tadpoles from five clutches were tested.

Analyses and Results: The time each tadpole spent in each compartment (near sibling, middle, or near non-sibling) was scored and compared using Kruskall-Wallis test. Tadpoles spent slightly less time in the middle compartment, and slightly longer time near the kin. However, those differences were not statically significant (X^2 = 4.07, df = 2, p = 0.131).

Experiment 2 – tested the preference of tadpoles for familiar vs unfamiliar (all siblings). Captive laid eggs were raised and tested according to the design described for exp. 1. In this experiment the stimulus groups were formed by siblings that were familiar to the testing individuals vs. unfamiliar.

Methods: Preference was tested in core trays filled with rain water, as described for exp. 1. Five tadpoles, siblings and unfamiliar to the testing individuals, were placed in one of the end compartments, and five tadpoles, siblings and familiar with the testing individuals were placed in the other end. The testing individuals were released in the centre of the lane, and the experiment was filmed for 45 minutes. A total of 42 tadpoles from two clutches were tested.

Analyses and Results: The time each tadpole spent in each compartment (near sibling, middle, or near non-sibling) was scored and compared using Kruskall-Wallis test. Two tadpoles were excluded from the analyses as they did not move through the gutter during the experiment. Tadpoles spent significantly less time in the middle compartment, and similar time near familiar or unfamiliar groups (X^2 = 16.08, df = 2, p = 0.0003,).

General interpretation of experiment 1 and 2: green and golden bell frog tadpoles spent less time in the middle section, confirming former studies that show they aggregate with conspecifics, forming schools. However, they did not show any preference for aggregating with kin or familiar individuals. Thus, in the wild it is possible that tadpoles from different clutches, laid in the same pond, school together.

One experiment (exp. 3) to test water temperature preference by green and golden bell frog tadpoles was conducted and as described in the previous report. Final analysis for this experiment is still pending. Volunteers have been conducting the same experiments for other species of tadpoles, some of which can co-occur with bell frogs. This study will give insights on better ways to design ponds that present thermal properties beneficial to green and golden bell frog tadpoles, and how the different species co-occur in these compounds.

Experiment 4 - Do tadpoles recognize alarm pheromones from conspecific? Previous work has shown that *L. aurea* tadpoles do not recognize the introduced mosquito fish as predator (Harris 1995; Hammer 2002). This inability to recognize a predator probably contributes for high mortality of tadpoles in the field and the failure of re-introduction projects. Several researches show that naive tadpoles can be conditioned and taught to recognize new predators, and then will show anti-predator behaviour (e.g. decrease in activity) towards these new predators. This learning process is based on chemical cues. One of the learning mechanisms is by association (Pearce 2008), and can be achieved by pairing the predator scent with alarm pheromones. Alarm pheromones are substances released by larval amphibians and fish when they are injured (e.g. in a predation event). Conspecifics recognize these substances as signal of danger and respond by decreasing activity levels or swimming away from the area where the cue is (Epp & Gabor 2008; Ferrari et al 2010; Hagman & Shine 2008). Alarm pheromones can be experimentally obtained by crushing tadpoles in water (sucking with a syringe, using a pestle and mortar, or an electric blender). This method is being largely used by researchers around the world (see some of the references above cited) in experiments dealing with alarm pheromones.

The ability to respond to alarm pheromones is a pre-requisite for the associative learning, in which the animal associate the odour of a new predator with the alarm pheromone (representing the death of a conspecific). However there is no previous work showing that *L. aurea* tadpoles respond to these pheromones. Thus this experiment 4 was designed for this purpose, and if *L. aurea* tadpoles are repelled by the alarm pheromone, we will conduct learning experiments.

Methods: This experiment was conducted with the participation of undergraduate student Ben MacAndrew. Alarm pheromone to be used as stimulus was prepared by macerating 0.4 g of *L. aurea* tadpole in 50 ml of water (this is about 1-2 individuals). Prior maceration tadpoles were euthanized in ice slurry (tadpoles placed in icy water [<4^{o}C] for 1h). Once tadpoles were dead, they were macerated in an electric multi grinder. The solution was then diluted to a volume of 500 ml (in water), and filtered through filter paper (stimulus solution).

The avoidance experiment was conducted in plastic gutters as in Exp. 1. 50ml of stimulus solution was added to the mesh chamber at one end of the tray. Food colouring (0.1 ml/300ml of solution) was added to the stimulus solution and to controls (just water) to allow us to establish a visual gradient of the stimulus in the arena. For each replica, we manually mix the stimulus and control solutions from the source point until dispersed throughout half of the arena (as indicated by the dispersal of dye). We then added a single testing tadpole to the centre of the arena (i.e., at the presumptive chemical front) and filmed its position for 35 min; the first 5min was used as an acclimation period (Figure 6). Half of the tadpoles were exposed to the 50ml stimulus solution (alarm pheromone)+dye and the other half was exposed to 50ml control (water)+dye. We used a total of 60 tadpoles from three different clutches.

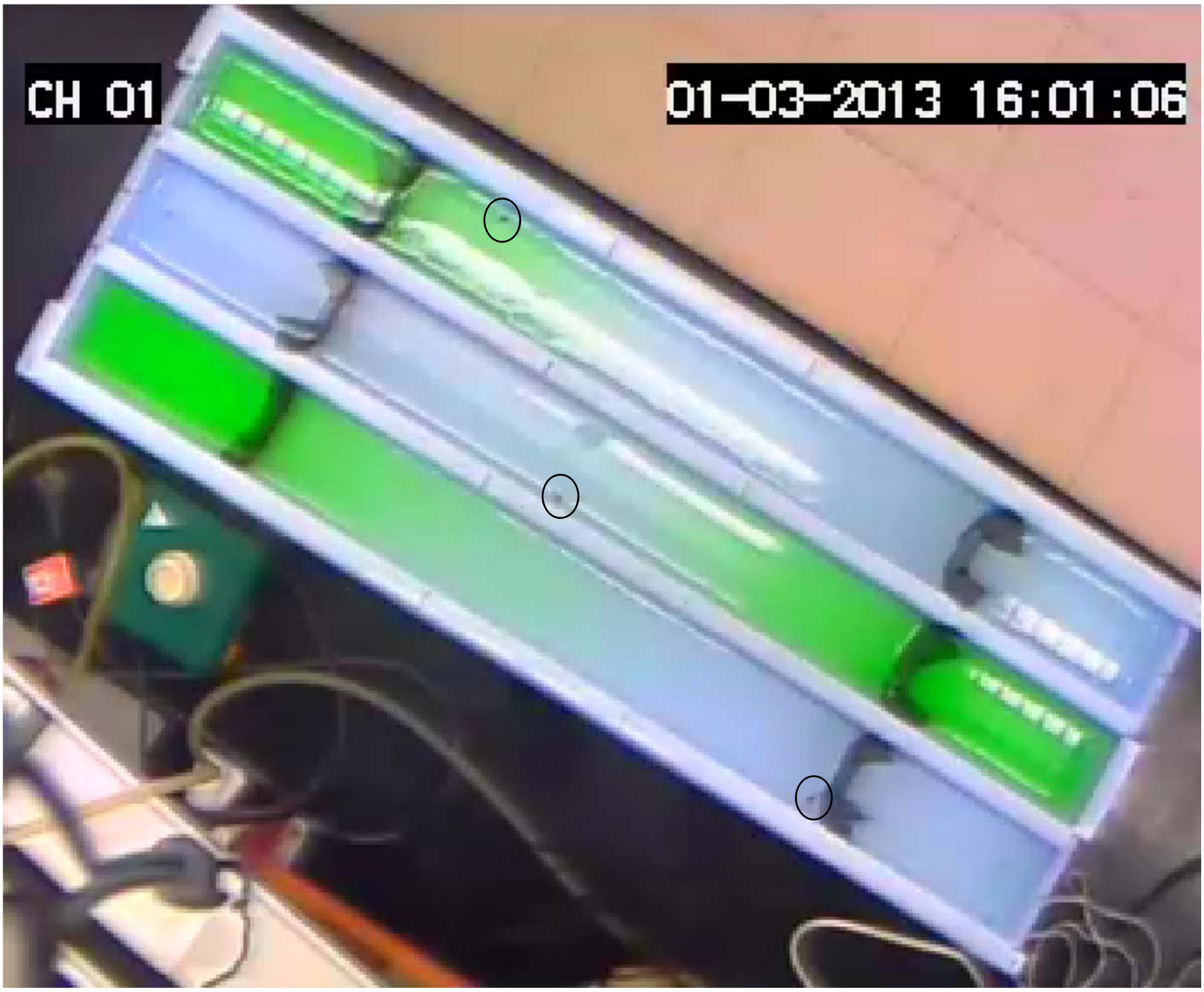

Figure 6. Experimental arena in use in avoidance experiment. The green dye indicates the distribution of stimulus (either alarm pheromone or water). The circles show the position of the tadpoles at the time of the photograph.

Videos are being scored and analyses for this experiment will be based on the position of the tadpoles in relation to the dye or time spent in each compartment.

(2) Progress on role of auditory cues in conspecific attraction (PhD study of Melanie James)

Laboratory study - Can the production of conspecific choruses alter the distribution of *Litoria aurea* under laboratory conditions?
This study is separated into two parts (questions) described below.

1. *Are adults attracted to the calls of conspecifics?*

Methods: to observe the behavioural response of *L. aurea* to conspecific call playback, captive males and females will be subject to a controlled laboratory experiment. One adult *L. aurea* will be placed into the centre of a basket (Figure 7) and exposed to three experimental states: a treatment (with *L. aurea* calls from speakers = T), a manipulative control (with static from speakers = MC) and a control (with no sound emitted from speakers = C).

Figure 7. Basket (lateral and front view) to be used as experimental arena in the call attraction experiments. The basket is 2m long and can be fitted with solid dividers to form three chambers and run three replicates at once.

Each chamber of the basket will be visually divided into sections using lines drawn on the ground and we will score the distance away from speakers to quantify the influence of speakers (Figure 8).

Figure 8. Diagrammatic representation of view of the experimental arena (basket) with three chambers. The black squares represent the area where animals will be released, and where CCTV infrared cameras will be suspended to film the experiment. The sound symbol represents the speaker.

Order of exposure to control, treatment and manipulative control

This experiment is organised as a cross-over design, where individuals will be exposed to three experimental states, a control, a manipulative control and a treatment (Martin and Bateson 2007). Crossover designs are prone to a number of confounding influences such as order and carry-over effects. To control sources of variation due to order effects, treatments were administered in a specified, sequence, ensuring all possible orders of T, C and MC were used (Díaz-Uriarte 2001). Individual frogs can be recognised through their Passive Integrated Transponder (PIT) tags. A minimal sample size of six individuals of each sex will provide a counterbalance in a cross-over design to the order of the applied conditions, strictly defining which order an individual will receive the predictor variables (see Table 1). Under this design, all individuals will be exposed to all three experimental states; however no individual will be exposed to the experimental states in the same order. Therefore the design balances the sequence of experimental states thus, balancing any order effects. To account for possible carry-over effects between experimental states, a resting period, known as a 'wash-out period' will be giving to the animals between trials.

Table 1. A cross-over design and order of exposures for the three states in the conspecific call attraction laboratory study on *Litoria aurea.* Predictor variables: treatment with *L. aurea* calls from speakers (T), manipulative control with static from speakers (MC) and the control with no sound (C).

	First exposure	**Second exposure**	**Third exposure**
Animal 1	C	T	MC
Animal 2	C	MC	T
Animal 3	T	MC	C
Animal 4	T	C	MC
Animal 5	MC	C	T
Animal 6	MC	T	C

Trials for adults will begin on the onset of the 2013/2014 breeding season (September or October, depending on temperature changes).

2. *Do juveniles and tadpoles avoid calling adults?*

In addition to the movement of adults, the response of juveniles and tadpoles to the calls of conspecifics will be assessed. As adult bell frogs cannibalise younger conspecifics, tadpoles and juveniles may actively choose to move away from adults. As calling is a conspicuous indicator of the presence of a conspecific adult, tadpoles and juveniles may choose to move away from calls. These experiments are designed as for part 1 described above.

However, for the tadpoles, the arenas are the core trays used for the kinship and familiarity experiments (Figure 9). Currently a total of 36 tadpoles (18 individuals from 2 clutches) have been already tested under all three treatments. Videos are being scored to follow analyses.

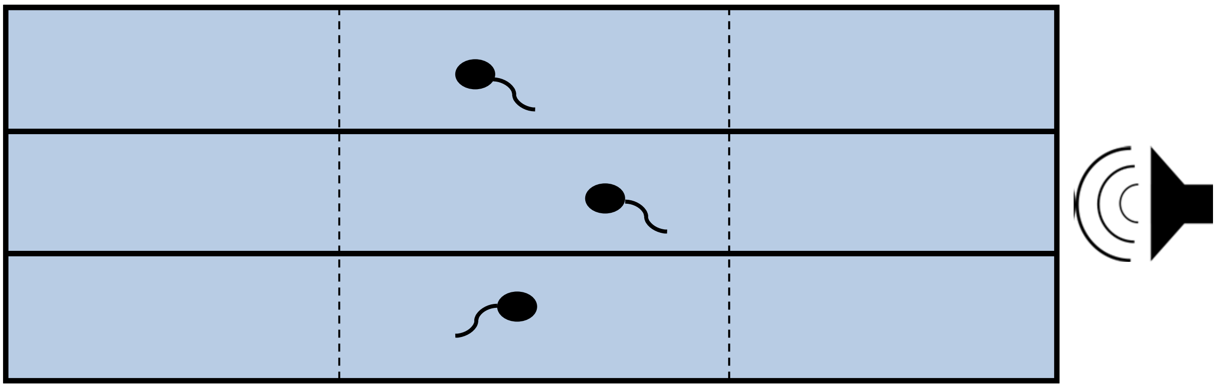

Figure 9. Diagrammatic representation of view of the testing arena for tadpoles. The tray is split into three 'runs' or lengths for testing of three animals at a time. Tadpoles are released at the centre of the tray. The sound symbol represents the speaker.

Field study on habitat selection of calling males (Do green and golden bell frogs use the presence of conspecifics (social information theory) to determine habitat suitability?)

This study aims to determine if male *L. aurea* choose locations to call from based on habitat features. These features will then be compared to the availability of habitat within ponds, to determine if there is selection of microhabitat by chorusing males.

To date, 25 nights have been undertaken in Sydney Olympic Park (SOP) in the Brickpit (ponds C1, S1, 13, 12 and 11s) and the Northern Water Feature (NWF), and five nights in Kooragang Island (K22). Due to the continued poor weather for breeding, multiple attempts to find calling males on Kooragang Island (ponds K22 and 23 near the rail line on Bell Frog track) have failed. Despite the heavy rain between the 28th January and 2nd February, calling detected by survey teams (from the Amphibian Laboratory at the University of Newcastle) did not continue for more than two nights, and multiple attempts to locate calling males in the Island have failed. This study will continue for at least one more breeding season, when further ponds on Kooragang will be surveyed to locate calling. Calling male *L. aurea* in SOP have been found aggregating in certain sections of large ponds (13, 12, 11s and NWF). This reflects trends observed in the 2011/2012 breeding season and suggests that either conspecific attraction or habitat selection are operating in this species (or both occurring together). Due to successful the presence of calling males in SOP, habitat variables at calling locations and non-calling locations have been recorded. Currently, the data collected to date has been collated and discussion with a consulting statistician has commenced. The statistical analysis will compare calling locations to non-calling locations, factoring in multiple variables to detect trends in occupancy within ponds and between ponds.

NCIG Compensatory Strategy

NCIG received state approval from the Planning and Assessment Commission (PAC) for the Rail Flyover Modification on 13 May 2013, applied for under Section 75W of the *Environmental Planning and Assessment Act 1979*. This was a modification under the existing Project Approval 06_0009 for the NCIG Coal Export Terminal. As part of the approval, the Department of Planning and Infrastructure has revised a number of conditions, including conditions relating to compensatory habitat. These conditions effectively increase NCIG's requirements for provision of compensatory habitat, both for Green and Golden Bell Frogs and Shorebirds. Condition 2.20(b)(i) requires that 75ha of *Litoria aurea* habitat be established, including a mosaic of wetland, terrestrial and breeding habitat. If it is established that the original population impacted by the NCIG Project is less than 37.5ha using a scientific methodology agreed to by the DoPI, then the amount of bell frog compensatory habitat provided may be reduced accordingly. This habitat must provide a viable and sustainable population[1]. Condition 2.20(b)(ii) requires NCIG to establish 8ha of migratory shorebird habitat, including endangered ecological communities, in a location agreed by the Director-General.

Timing of delivery of compensatory habitat has been established in the updated conditions. This includes delivery of 75ha of bell frog habitat before 31 December 2016 and 8ha of migratory shorebird habitat before 31 December 2014, as outlined in Condition 2.20(i). NCIG is also to provide financial assurety to DoPI for compensatory works, in the form of a Conservation Bond. This bond may be used in part or in full, should NCIG be unsuccessful in meeting its commitments around delivery and timing of compensatory habitat. These requirements have been included in an updated version of the Compensatory Habitat and Ecological Monitoring Program (CHEMP), which will be provided to NSW DoPI and NSW OEH on 7 June 2013.

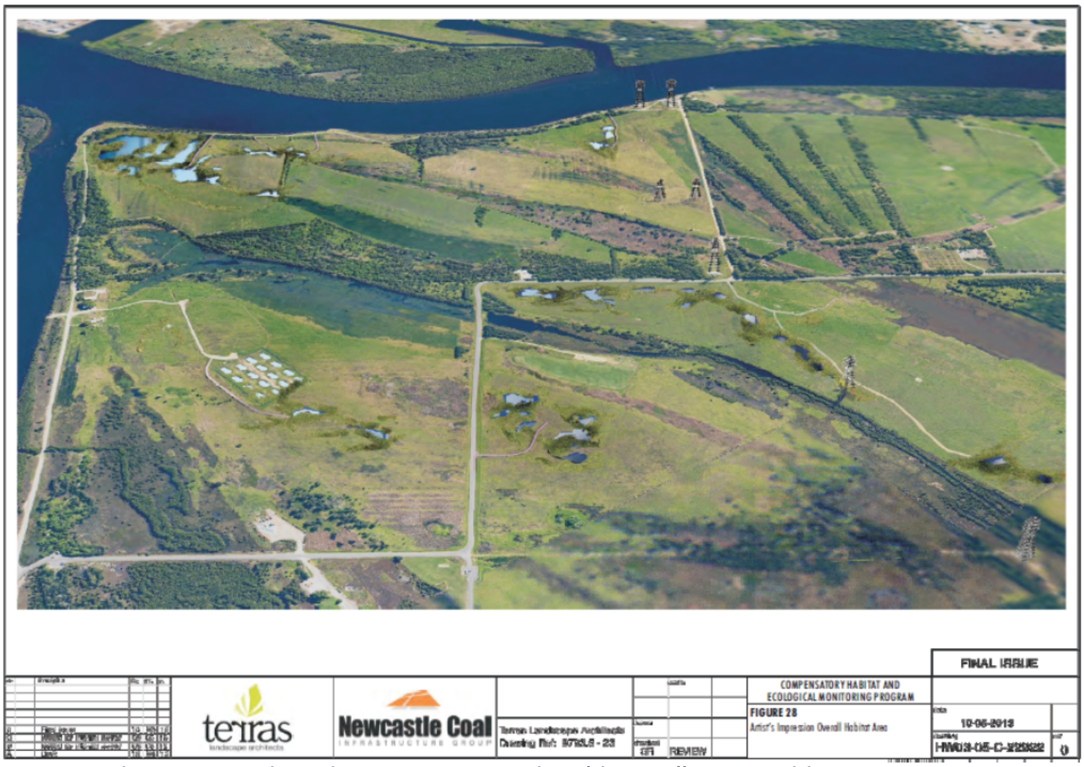

Figure 10. Artist's Impression of NCIG Green and Golden Bell Frog Habitat

[1] A viable population, as defined in the Modification Approval, evidence of at least 5 reproductively mature individuals identified in new aquatic and/or terrestrial habitat in each of two seasons when breeding events occur. Such evidence will include evidence presence of calling males with nuptial pads and gravid females.

Compensatory, or offset, locations are to be secured by 31 December 2013. NCIG has received communication from National Parks and Wildlife Service, recognising intent to utilise 78ha of land within Hunter Wetlands National Park for bell frog compensation, and allowing investigations to be undertaken to confirm suitability of these areas. These areas were described in the previous quarterly report. NCIG proposes to focus efforts in Area E of the Hunter Wetlands National Park to create migratory shorebird habitat. This specifically includes the removal of 8ha of mangroves.

NCIG has commissioned a landscape architect to assist in providing concept plans for bell frog habitat. These plans have been developed with advice from NCIG Project-approved Ecologist, Dr Arthur White. Additional detail on information used to develop this concept is included in the following section. Figure 10 provides an artist's impression of how this habitat may look.

Similarly, an artist's impression has been developed for Area E, showing how migratory shorebird habitat would appear if mangroves were removed. This is shown in Figure 11. Removal of mangroves in Area E and subsequent establishment of shorebird habitat will require agreement with National Parks and Wildlife Service and approval from NSW Department of Primary Industries – Fisheries. It is noted that shorebird compensatory habitat was effectively commenced with the installation of the drop board structure at Fish Fry Creek and subsequent hydrological management of tidal water.

Figure 11. Artist's impression of Migratory Shorebird Habitat, Area E, Ash Island

NCIG is currently in discussions with the Commonwealth's Department of Sustainability, Environment, Water, Populations and Communities (SEWPaC) regarding its obligations under the national environmental legislation, namely the *Environment Protection and Biodiversity Conservation Act 1999*. Depending on whether rail modification works have a significant impact on Matters of National Environmental Significance, NCIG may be required to provide additional compensatory habitat to that already outlined in the revised CHEMP.

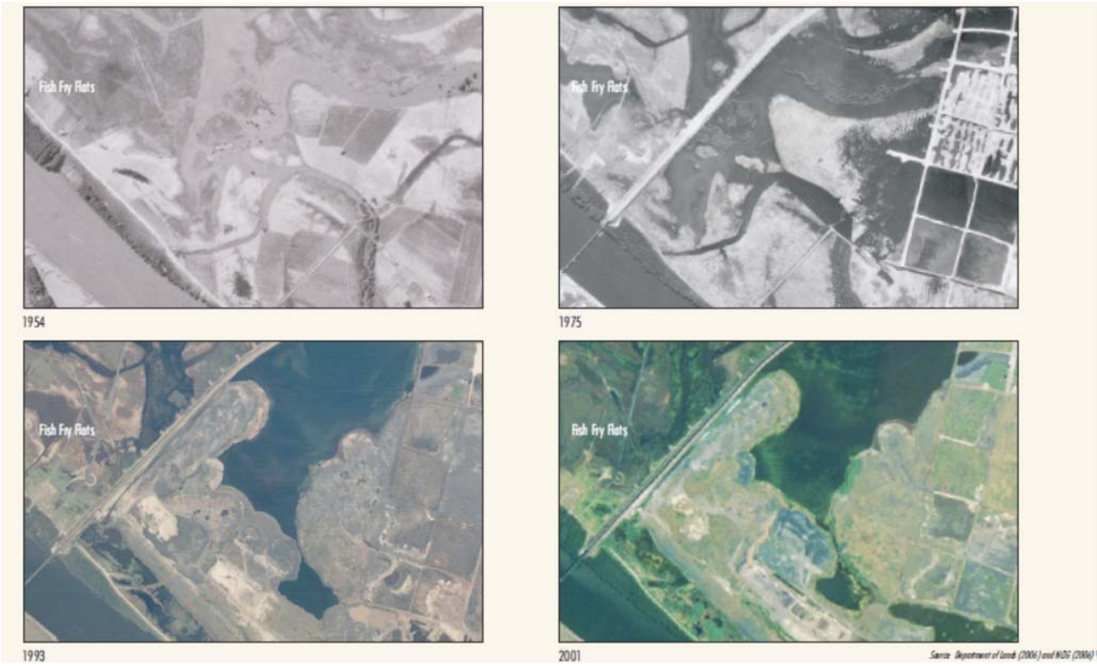

Figure 12. Historical Aerial Photographs of Kooragang Island, including Area E and Fish Fry Flats (note lack of mangroves in this area).

Figure 13. Google Image of Kooragang Island, including Area E and Fish Fry Flats (note extensive mangroves).

Green and Golden Bell Frog Compensatory Concept Plan

As discussed in the previous section, NCIG has employed the services of a landscape architect for the development of a Green and Golden Bell Frog Compensatory Concept Plan, otherwise referred to as a Master Plan. This was carried out with the assistance of Dr Arthur White. A number of other information sources were used for development of the plan. This includes:

- flora studies carried out by FloraSearch consultants;
- habitat assessment, including potential existing habitat for the Green and Golden Bell Frog;
- information on Kooragang Wetlands Rehabilitation Project work carried out to date, in particular revegetation works;
- Australian National Museum Green and Golden Bell Frog constructed habitat at Scotts Point;
- Expert advice from a hydrological engineer identifying ways to best harness and capture water across the landscape; and
- Topographical survey work

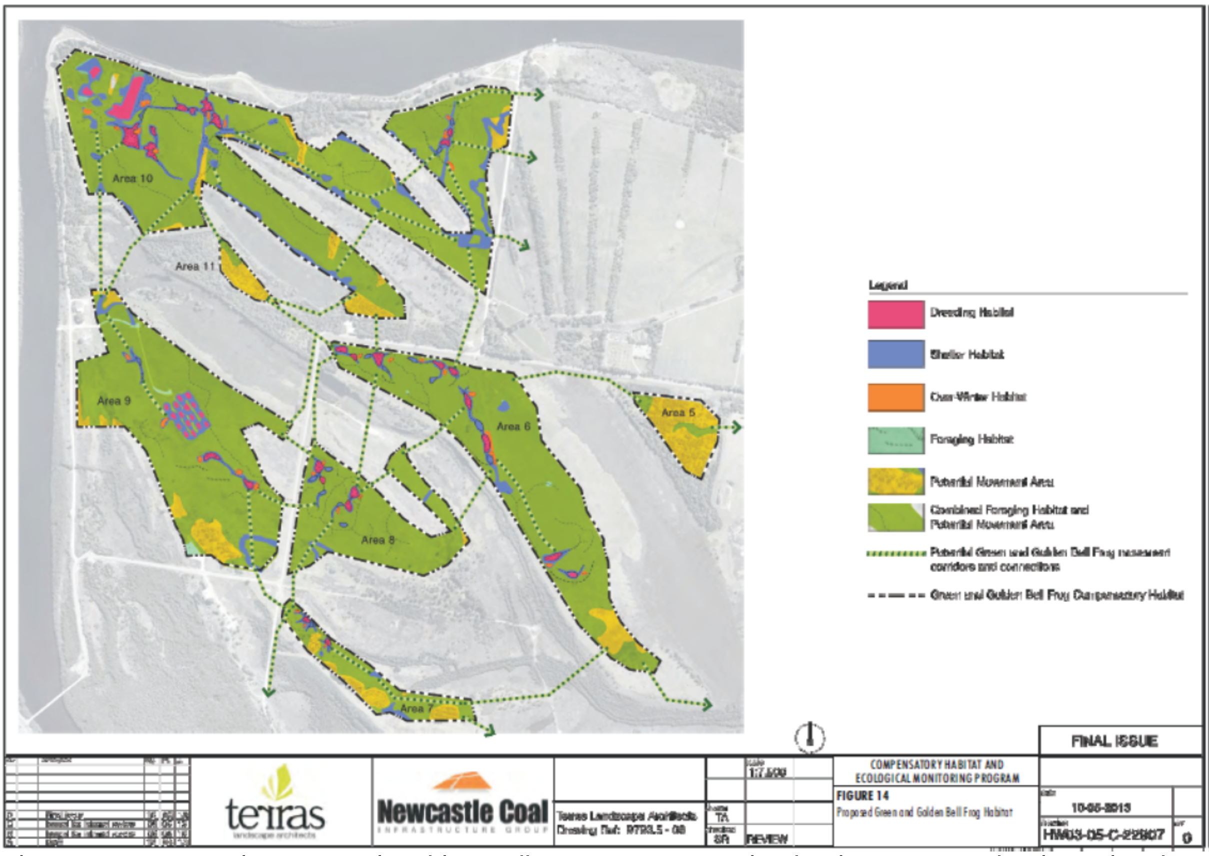

Figure 14. Proposed Green and Golden Bell Frog Concept, Ash Island, Hunter Wetlands National Park

A process of identifying constraints and opportunities was used, utilising the abovementioned information. This has resulted in the development of ideal locations for breeding habitat, shelter habitat, over-wintering habitat and foraging habitat. The Master Plan also incorporates movement areas. This can be seen in Figure 14 above. It is noted that this is a concept plan and does not definitively outline the size, shape and exact location of final constructed ponds and associated habitat. These may be refined prior to construction, as a result of further investigations of subsurface conditions, namely groundwater and acid sulphate soils.

Hydrodynamic Management, Fish Fry Creek

Kooragang Wetlands Rehabiliation Project continues to utilise the drop board structure at Fish Fry Creek (Creek 5) constructed by NCIG, for the purpose of hydrological management of Area E. The purpose of this is to manage mangrove expansion in the area through water level manipulation. The management regime is still in its early stages and therefore there is no clear effect on mangroves to date. The project encompasses an adaptive management philosophy, where alterations may be made to the regime based on monitoring results and changes in the distribution of mangroves.

Compensatory Habitat and Ecological Monitoring Program – Quarterly Report

DATE: *13 September 2013*

AUTHOR: Philip Reid, Dr Ligia Pizzatto (Uni of Newcastle), Melanie James (Uni of Newcastle), Alex Callen (Uni of Newcastle)

APPROVAL: Nathan Juchau

INTRODUCTION

This report provides an update of activities relating to the NCIG Compensatory Habitat and Ecological Monitoring Program since the previous Quarterly Report from 5 June 2013. The report aims to provide information on key components of the program and how these are being implemented. An update will be provided to members of the Consultative Board every 3 months, in the form of a Quarterly report and presentations (every 6 months) coinciding with Board Meetings.

1. Research Area Ponds

1.1. Research and Monitoring

In the previous quarter it was reported that the translocation component of the program was completed in mid-March, resulting in the release of approximately 7500 green and golden bell frog tadpoles and metamorphs across eight of the 16 ponds at the Trial Site on Ash Island. Monitoring of the distribution and abundance of juvenile frogs across the site, their growth and potential chytrid infection load also commenced during this period with one- two night surveys per week.

In this current quarter monitoring has continued, with a reduction to once weekly surveys as the observed relative abundance of frogs declined (see Figure 6). Night monitoring continued into mid July because bell frogs were still detectable as a result of the unseasonally warm weather. Day monitoring commenced once night temperatures dropped and will continue until evening temperatures increase (probably early September if weather conditions remain stable). A period of intense night monitoring occurred for about a fortnight after the detection of a chytrid outbreak at the site on 27 June where animals exhibiting symptoms of the disease were returned to the laboratory for heat treatment. Night surveys were undertaken about three times per week during this period to retrieve any unwell or dead individuals.

The presumption of an outbreak of chytrid at the Trial Site due to detection of dead and dying individuals was confirmed by DNA extraction and Polymerase Chain Reaction (PCR) analysis of swabs taken from these individuals. During this quarter, seven frogs have been observed dead in the field, and a further 18 have been recovered from the field for heat treatment back at the university laboratory.

Figure 1. Chytrid-infected individual recovered from the site and successfully treated and released. Note the reddening of hands, a clinical indication of the disease

Figure 2. A deceased chytrid-infected individual recovered from the site

Of these 18, six died during treatment and were in the advanced stages of the disease chytridiomycosis. Given the highly infectious nature of this disease it is likely that the mortality of individuals in the site population is in magnitudes greater than the numbers observed during site surveys. Successfully treated frogs were released back into the field at their point of capture. PCR analysis of all swabs continues as an ongoing process that will hopefully build a picture of infection loads of chytrid across the site over the seasons against a field temperature gradient.

Completion of the salt dosing of eight selected ponds was also achieved this quarter, having commenced in mid-May with progress hampered by frequent heavy rainfall events. These rains mixed pond water between some salt dosed ponds, with only one low dose pond potentially influenced by mixing with the high salt dose ponds. Approximately 2.1 tonnes of salt have been distributed across these ponds in an attempt to achieve a high salt concentration of three parts per thousand (‰), which is anticipated to arrest the proliferation of the chytrid disease but not impact upon the survivability of the frog or its eggs or tadpoles. The frequent rainfall events of the first half of the year have caused the pond water level to be at or over capacity at nearly all of the 16 ponds at the site, with deep ponds particularly over-full most likely due to the continual recharge of the groundwater system in the area. As a result, most dosed ponds have not yet reached the critical 3 % threshold, although this is expected to occur as water levels recede. Water monitoring continues weekly to ensure ponds do not evaporate to levels where salinity within them becomes toxic to frogs. Contingency water supply is available if required to supplement pond water to avoid this scenario.

Concurrent to salt dosing, monitoring of aquatic macroinvertebrates and pond/quadrat vegetation continues on a fortnightly/monthly basis. Dedicated overwintering habitat (installed in the previous quarter) to ensure adequate overwintering opportunities and to test optimal overwintering conditions) is monitored once weekly during the coldest daylight hour (approximately 7am) to record the incidence of use of the habitats by the bell frog and non-target species such as other frogs and reptiles. Temperature and humidity of these habitats is recorded hourly by data loggers and temperature of existing habitats across the site is also being monitored (reeds and pond rocks). Monitoring of reeds and pond rocks has been hampered by their inundation from localised flooding as a result of the frequent rainfall events at the site. The sunken pipes associated with the constructed habitat also suffered groundwater ingress regardless of their distance from the ponds. Little evidence of bell frog use of constructed and existing natural habitat has been recorded at the site. Minimal use of constructed habitats by other frogs (Eastern Striped Marsh Frog *Limnodynastes peronii* and Common Eastern Froglet *Crinia signifera*) and by other non-target species has been observed. Constructed overwintering habitat will be made unavailable for use by wildlife at the commencement of spring.


Figure 3. Localised flooding at Pond 15 as a result of frequent rainfall and high groundwater levels


Figure 4. Brick housing of overwinter habitat at each pond


Figure 5. Sunken pipe inside brick housing for overwinter habitat

1.2. Population Prediction

The confirmation of chytrid at the Trial Site since June, and continued observation of ill or deceased individuals in the field provides the impetus to consider the need for another breeding event this spring/summer (2013/2014) to bolster population numbers. The population dynamics of the species in other research sites across mainland NSW are characterised by small populations with a high population turnover (low survivability). Such populations are generally susceptible to a population crash as a result of disease or stochastic events (Franklin 1980; Franklin and Frankham 1998; Traill, Bradshaw et al. 2007), and this is characteristic of the natural populations on Kooragang and Ash Islands. This has also been well documented with over five years of research on the population of bell frogs at Sydney Olympic Park, where intervention through a captive breed and release program was instigated as a result of early detection of population decline. (Bower *et al*. in press).

Visual encounter surveys undertaken at the NCIG Trial Site demonstrate a declining trend in the numbers of individuals observed in surveys since April 2013. The effectiveness of using encounter surveys as a surrogate for mark-recapture surveys has been recently assessed as suitable for detecting changes in the abundance of populations of the species at Sydney Olympic Park (Bower *et al.* in press). It has been used here to anticipate the potential for the population at the NCIG Trial Site to decline to extinction in the absence of a full suite of seasonal data.

Figure 6 illustrates the relative abundance (the number of individuals observed per minute) of green and golden bell frogs across the Trial Site for each weekly survey period since April. The blue vertical line indicates the first field observation of the presence of chytrid at the site, which was later confirmed by PCR analysis. The red line represents air temperature at the time of each survey period, which fluctuates markedly within seasons. The increase in air temperature from early July is a result of the switch from evening to daytime surveys where low evening temperatures were considered likely to contribute to low detectability of frogs. Importantly, the relative abundance of frogs at the Trial Site has oscillated below 0.05 frogs per minute for the last three survey periods and since the initial observation of chytrid-infected individuals at the site (27 June 2013).

It is likely that there are a number of factors that influence the decline in the relative abundance of the green and golden bell frog at the Trial Site during survey periods, including a reduction in detectability of the frogs as a result of cooler winter temperatures where individuals are not observed in winter but expected to re-emerge once temperatures increase into spring. The impact of this temporal-temperature population depression may confound the population decline illustrated in Figure 6, however this cannot be quantified until spring and summer surveys resume. Waiting for the results of a more full and robust population estimate for the site will preclude a captive breed and release program this season 2013/14, and is likely to result in a population crash.

In the absence of a full annual dataset to support a population estimate for the Trial Site, population impacts may be reasonably inferred from the results of other studies of green and golden bell frogs on mainland NSW. Long-term monitoring at Sydney Olympic Park observed annual green and golden bell frog population decreases of between 60-80%, evenly spread across winter and summer (Pickett *et al*., 2013). Similar results have been observed at other research sites in the lower Hunter.

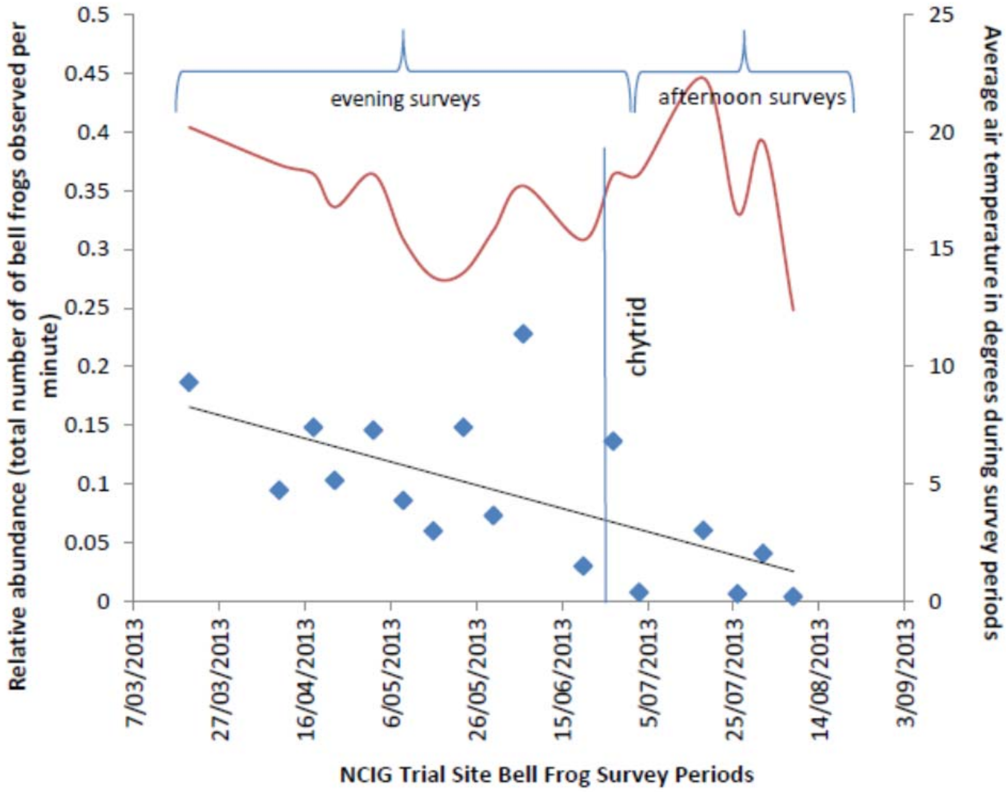

Figure 6. Relative abundance of green and golden bell frogs observed at the NCIG Trial Site between April and August 2013

These estimates of population losses can be reasonably expected to apply at the NCIG Trial Site, which would presume that the population has sustained a conservative minimum 30% mortality since the release of tadpoles in Feb/Mar 2013. An average of 0.13 frogs per minute were observed in the warmer months of the year (Mar-May), which suggests the relative abundance of frogs emerging into spring could be expected to be less than 0.09 frogs per minute. Further losses to the population would be expected to occur over the summer of 2013/14, and given that the site population will not have reached sexual maturity, no population gain through breeding will occur. Therefore a net summer loss of a minimum of 30% of the population could also be reasonably expected to occur, further reducing the potential relative abundance of frogs to 0.06 by March 2014.

Based on known population dynamics at other sites, once abundance estimates drop below 0.05 frogs observed per minute a population crash is considered highly likely. While in open populations recruitment may provide some potential for population persistence to counter-balance the impact of mortality-induced events, the Trial Site population is isolated from natural recruitment opportunities and we consider it is likely to crash without chance of recovery based on the current relative abundance estimates from site survey data. While some bell frog populations persist at low levels (particularly at Sydney Olympic Park), this may be as a result of large spatial scale (large areas with many ponds) which provides a buffer to populations from disease-induced mortality events. The NCIG Trial Site does not support such an environment.

Additionally, over 70% of individuals with clinical signs of chytrid observed at the Trial Site (fatal or otherwise) had a snout-vent length (SVL) of 40.0 mm or greater, suggesting they were nearing maturity. Individuals with a SVL of 45 mm are generally considered to have reached maturity, suggesting the disease may impact upon the future age-class structure of the population at the site in relation to sexual maturity and future reproductive potential. Previous studies of other local populations also show high winter mortality rates in adults (Stockwell 2011).

The decline in relative abundance of frogs at the NCIG Trial Site to below 0.05 frogs per minute in several survey periods, together with high proportion of sub-adult mortality observed in chytrid-infected individuals suggests the population of bell frogs at the site is susceptible to an irreversible crash. These preliminary results, together with the conservative predicted mortality rate inferred from the research undertaken at Sydney Olympic Park provide strong justification for a population intervention through a captive breed and release event this coming spring. Without supplementation of the original population we believe that the research objectives of the project are likely to be rendered inconclusive. Additionally, we do not believe this supplementation will confound the current and future research at the site.

2. Annual Green and Golden Bell Frog Monitoring

As part of Project Approval 06_0009, NCIG are required to undertake monitoring of Green and Golden Bell Frogs in locations around the NCIG Terminal on Kooragang Island. PWCS are currently monitoring this area for Green and Golden Bell Frogs as part of the T4 pre-feasibility study. NCIG has a monitoring sharing agreement with PWCS, and the T4 data will be used to satisfy this condition. Hunter Development Corporation (HDC), who is responsible for monitoring the former waste emplacement cells inside the NCIG rail loop, will also provide their monitoring data to NCIG. The University of Newcastle conducts this monitoring for both parties. Information sharing will extend to the results of research being conducted for both NCIG and PWCS.

The Monitoring Report for season 2012/13 has been completed and is currently under review by PWCS. NCIG will receive a copy of this report shortly.

3. Breeding Program

The breeding pairs utilised for NCIG’s Research Area are being retained at the University of Newcastle, with the intent of utilising these either for experimental pursposes and for re-populating the NCIG Research Area in the coming season, in accordance with Section 1.2.

Future generations may be released into NCIG or PWCS compensatory habitat developments or into existing habitat with the potential to support the local Green and Golden Bell Frog population. Costs for managing the breeding individuals are currently assumed by both NCIG and PWCS.

4. Behavioural Research

4.1. Post-doctoral fellowship funded by NCIG GGBF Research Programme

Dr. Ligia Pizzatto is conducting research on conspecific attraction in Green and Golden Bell frogs, as accepted in the original research programme proposal. Research question 1 in the proposed Research Program asks if green and golden bell frogs (*Litoria aurea*) are attracted to areas occupied by conspecifics.

Dr Pizzatto conducted experiments using Green and Golden Bell frogs for testing kin and familiarity preference among schooling tadpoles. Results were presented in the last report; however the analyses for these experiments were revised, which resulted in considerable change in the outcomes. Thus, we present those results again and explain the reasons for changing the analyses.

Green and golden bell frogs were bred in captivity. Clutches were split at the day they were laid, and were reared in separated containers to create tadpoles that (1) were siblings and familiar to each other (i.e. raised together), (2) unfamiliar siblings (sibs raised in separated containers), and (3) unfamiliar non-siblings.

Experiment 1 – Do green and golden bell frog tadpoles prefer to aggregate with kin?

Methods: Preference was tested in core trays filled with rain water. These trays have three visually separated lanes (thus allowing three individuals to be tested simultaneously in each tray). Each lane was divided in five compartments of equal size, and the two compartments in the ends of each lane were separated by fly screen mesh. Five tadpoles, siblings (but unfamiliar) to the testing individuals, were placed in one of the end compartments, and five tadpoles, non-siblings and unfamiliar with the testing individuals were placed in the other end. The testing individuals were released in the centre of the lane, and the experiment was filmed for 45 minutes. A total of 42 tadpoles from five clutches were tested.

Analyses and Results: The time each tadpole spent in each compartment (near sibling, middle, or near non-sibling) was scored. For the new analyses we excluded the time the tadpoles spent in the middle compartment, as it represents a no-choice and it can mask differences between time usages in the two compartments of interest. Then, the proportional time the tadpoles spend in the in the compartment adjacent to kin and non-kin were compared using one tailed t-test. Tadpoles spent more time near the kin ($t = -2.34$, $df = 60$, $p = 0.0227$; Fig.7).

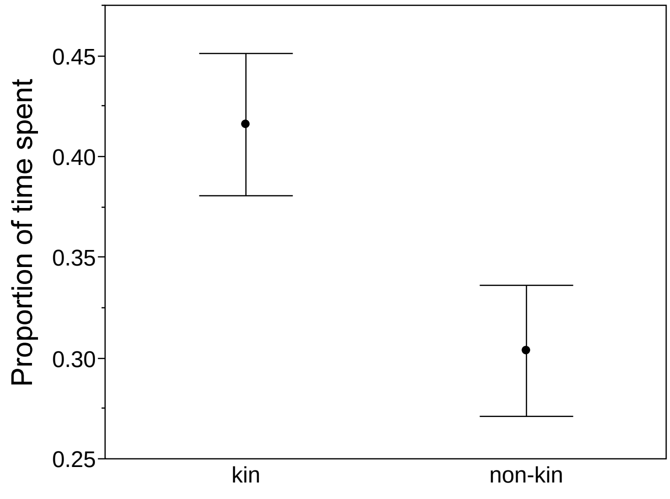

Figure 7. Proportion of time *Litoria aurea* tadpoles spent in the compartments adjacent to kin and non-kin tadpoles. Black circles represent means and bars represent standard error.

Experiment 2 – Do green and golden bell frog tadpoles prefer to aggregate with familiar conspecifics?

Methods: Captive laid eggs were raised and tested according to the design described for exp. 1. In this experiment the stimulus groups were formed by siblings that were familiar to the testing individuals vs. unfamiliar. A total of 42 tadpoles from two clutches were tested.

Analyses and Results: The time each tadpole spent in each compartment (near sibling, middle, or near non-sibling) was scored. Two tadpoles were excluded from the analyses as they did not move through the gutter during the experiment. As for exp. 1 the new analyses excluded the time the tadpoles spent in the middle compartment. Then, the proportional time the tadpoles spend in the in the compartment adjacent to familiar and non-familiar conspecifics were compared using one tailed t-test. Tadpoles spent more time near familiar conspecifics ($t = -2.45$, $df = 72$, $p = 0.0166$; Fig.8).

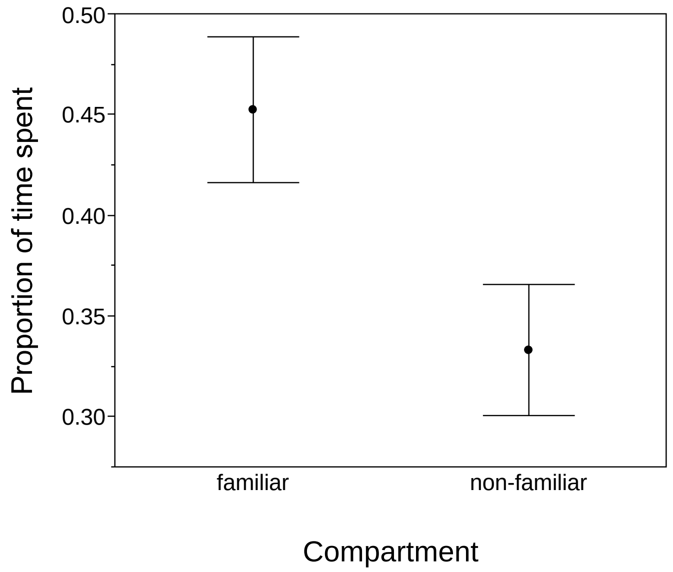

Figure 8. Proportion of time *Litoria aurea* tadpoles spent in the compartments adjacent to familiar and non-familiar tadpoles. Black circles represent means and bars represent standard error.

Experiment 3 – Do green and golden bell frogs tadpoles prefer to aggregate with conspecifics vs. heterospecifics?

This experiment was conducted to complement the two previous experiments.

Methods: Preference was tested in core trays filled with rain water, as described for exp. 1 and 2. Five *L. aurea* tadpoles, non-kin and non-familiar to the testing individuals, were placed in one of the end compartments, and five striped mash tadpoles (*Lymnodynastes peronii*) were placed in the other end. The testing individuals were released in the centre of the lane, and the experiment was filmed for 45 minutes. A total of 20 tadpoles were tested.

Analyses and Results: scoring and analyses were as for experiments one and two. Tadpoles spent more time near conspecifics than non-conspecifics ($t = -4.88$, $df = 37$, $p < 0.0001$; Fig.9).

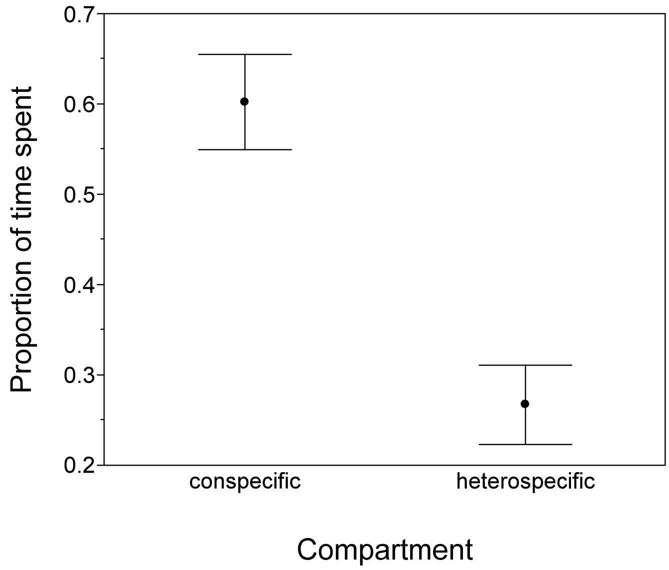

Figure 9. Proportion of time *Litoria aurea* tadpoles spent in the compartments adjacent to conspecific and heterospecific tadpoles. Black circles represent means and bars represent standard error.

General interpretation of experiment 1 to 3 and future plans: The three experiments elucidate rules of aggregations in green and golden bell frog tadpoles. The tadpoles recognize and strongly prefer to aggregate with conspecifics. They also recognize and prefer to group with familiar conspecifics than non-familiar, and prefer kin over non-kin. Visual and chemical cues might be in use for the recognition as during the trials the tadpoles were able to see and scent chemicals from the stimulus tadpoles in the water. These results agree with studies on other gregarious species that show preference for schooling with kin and familiar conspecifics. Despite the encouraging results a close inspection of the data evinced that the significance of the differences were largely due to tadpoles from one of the clutches. Thus, we plan to test some tadpoles from at least another clutch (after the next breeding event in the coming spring) to make the experiment more robust and ready for scientific publication.

Experiment 4 - Do green and golden bell frog tadpoles recognize alarm pheromones from conspecific?

As stated in the previous report this experiment was finished but the data is yet to be analysed.

Experiment 5 – Do green and golden bell frogs choose a ‘poor habitat’ where conspecifics are present over a ‘rich habitat’ where there are no conspecifics?

This experiment addresses the research question 2 in the original proposal: Do green and golden bell frogs use the presence of conspecifics (social information theory) to determine habitat suitability?

Methods: We have shown in previous experiments that green and golden bell frog juveniles prefer to occupy habitats closer to conspecifics when those can be seen and smelled (February 2013 report). We also have tested the preferred micro-habitat in experimental arenas to be used as a 'suitable' habitat in this experiment. In this experiment we used the same arenas as for the experiment testing the effects of visual+scent of conspecifics on habitat choice. The arena was divided in four sections. The two end sections were divided from the two middle sections by a perforated clear acrylic sheet, allowing the visual and chemical communication with the middle. All sections were lined with clean pebbles and had a water dish. The two middle sections were not separated by any barrier and only one contained artificial plants in addition to the pebbles and water dish (Fig. 10). As our previous experiments showed the frogs prefer habitats containing those plants over habitats with pebbles only (February 2013 report), the section containing plants represented the 'rich habitat' and the section with only pebbles and water represented the 'poor habitat'. Five *L. aurea* juveniles were placed in the end section adjacent to the poor habitat, and the section adjacent to the rich habitat remained empty. After 30min acclimatization a testing individual was released in the centre of the arena and filmed infra-red with CCTV cameras. A total of 24 individuals were tested.

Figure 10. Habitat choice arena. During the trials the right compartment held five frogs and the left compartment was left empty. The right half of the middle compartment represented the poor habitat (no cover) and the left right was the rich habitat.

Analyses and Results: One individual had to be excluded of the analyses as it took refuge right after release and did not become active during the trial. We scored the time each frog spent in each section of the arena during the first two hours of activity. We compared the proportion of time spent in each section during activity using the non-parametric Kruskal-Wallis test. When active, frogs tented to spent more time in the poor than in the rich habitat sections, but the differences were not statistically significant ($X^2 = 0.75$, df=1, $p = 0.385$; Fig. 11).

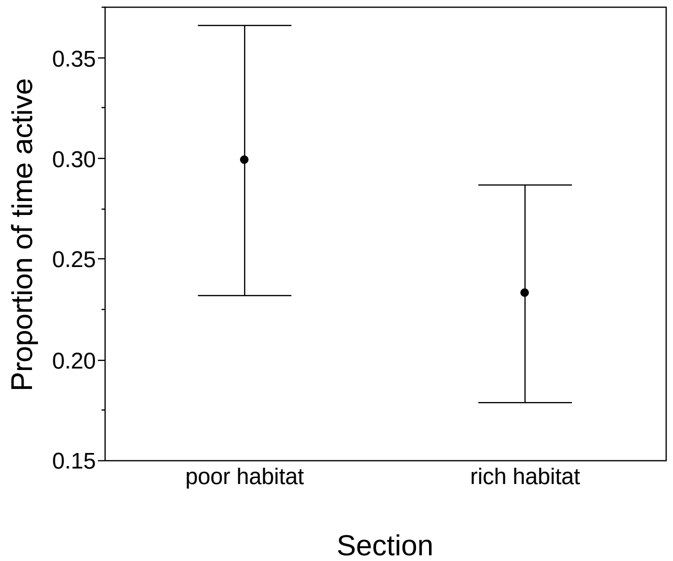

Figure 11. Proportion of time *Litoria aurea* juveniles spent in the poor and rich habitat sections of the experimental arana. Black circles represent means and bars represent standard error.

General interpretation: During the experiments it was clear the interest of the testing individuals towards the conspecifics. Some frogs spent several minutes sitting in the poor habitat, facing the conspecifics (obviously watching them), or repetitively inspected the acrylic barrier. In the absence of difference in habitat quality frogs prefer to stay close to conspecifics (February 2013 report), but the results of the present experiment show no preference when habitat quality differs. This suggests that some frogs still have the capacity to distinguish and prefer and the rich habitat, but the social cue from conspecifics (follow what the others are) is strong enough to make the frogs to stay in a poor habitat for long time when active. All but one frog sought shelter in the artificial plants when inactive (rich habitat) - another suggestion that the social cue is not strong enough to compromise the individuals' assessment of the habitat.

Future directions: this experiment tested only one component that composes a 'good habitat' – the vegetation cover. Other experiments that encompass more components (for example food availability and temperature differences) are being planned.

4.2. Progress on role of auditory cues in conspecific attraction (PhD study of Melanie James)

Laboratory study - Can the production of conspecific choruses alter the distribution of *Litoria aurea* under laboratory conditions?

The methods for this study had been improved based on pilot trials. New components were added, and the study now comprises three main questions bellow described.

1. *Are reproductive adults attracted to the calls of conspecifics?*
2. *Do non-gravid females avoid calling males?*

Methods: to observe the behavioural response of *L. aurea* to conspecific call playback, captive breeding males (n=6), gravid females (n=6), and non-gravid females (n=6) will be subject to a controlled laboratory experiment. Animals will be exposed to three conditions, a treatment (conspecific calls) and two controls (no calls and speaker static). Non-gravid females have been added to the experiment in order to test for avoidance. Previous research on *L. aurea* has identified a biased operational sex ratio (more males in ponds than females). This is probably due non-reproductive *L. aurea* females avoiding harassment by chorusing males, thus spending time in the terrestrial zone and in non-chorusing ponds (Pickett 2009). This hypothesis will be tested to determine if calling acts as the mechanism by which females avoid chorusing males until ready to breed (gravid).

The experimental arenas are constructed, as shown in the previous report. We have planned the set up for the experiment to house artificial plants and small water bowls (Figure 12), and trials will start in November and continue through to the end of January. Depending on the number of animals available this year, the study may continue over two breeding seasons.

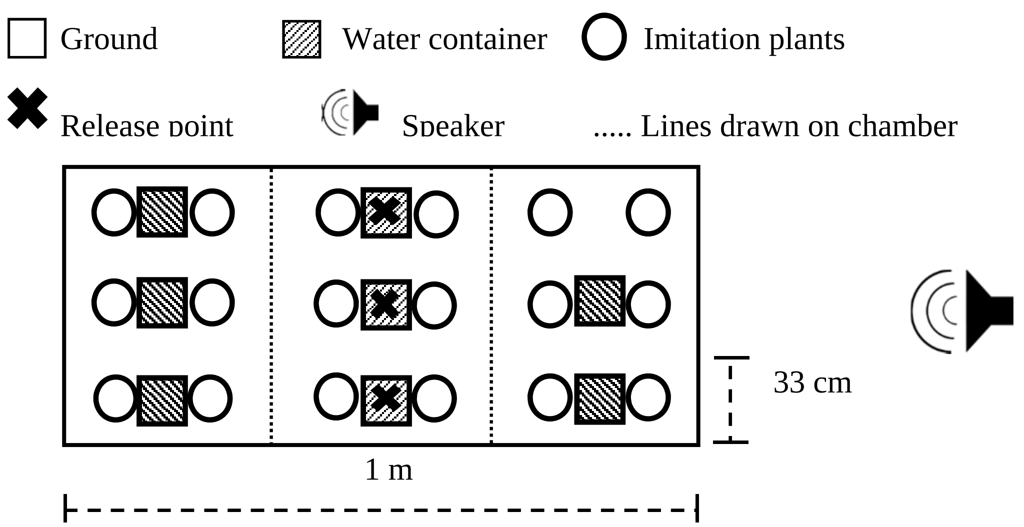

Figure 12. Updated details for the experimental arena for adult *Litoria aurea* conspecific attraction and avoidance lab experiment.

3. *Do juveniles, metamorphs and tadpoles avoid calling adults*

In addition to the movement of adults, the response of juveniles, *metamorphs* and tadpoles to the calls of conspecifics is being assessed. We aim to determine whether conspecific calling act as the mechanism driving the aggregated distribution of immature individuals (including larvae) seen in the field. Hearing development occurs throughout metamorphosis and it has been proposed tadpoles can hear through the opercularis system (Boatright-Horowitz and Simmons 1995). Although this has been explored through dissection and analysis of opercular structures throughout development, a thorough literature review found no research on the influence of sound on tadpole behaviour. The addition of metamorphs will give a more detailed knowledge of hearing development and may assist in determining the stage tadpoles and metamorphs develop hearing and respond to conspecific auditory cues (Boatright-Horowitz and Simmons 1995; Horowitz et al. 2001).

Tadpoles and metamorphs will be tested in core tray arenas (as for the experiment previously described), and juveniles will be tested in larger arenas (Figure 13).

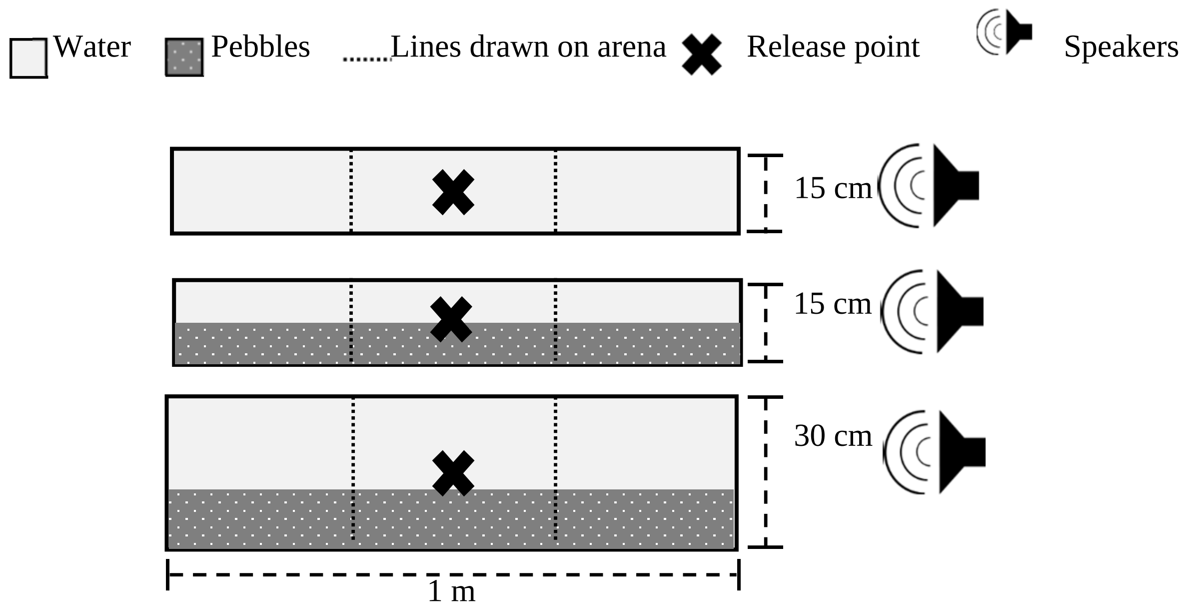

Figure 13. Experimental arenas for tadpoles, metamorphs and juveniles. Testing individual are released is at the centre of the arena (black cross), and the position of the animals will be scored.

Pilot trials using 18 tadpoles (Gosner stage 27 to 33, body size 11.7 to 17.8 mm) were conducted, and analyses are being adjusted for the full experiment. Results indicate that the position of the tadpoles did not differ among the manipulative control (static), the treatment (*L. aurea* calls) and control (no sound). For all conditions, distribution indicated a preference for the edges of the arena, closest to the speaker side (Figure 14). Because this directional bias was detected in the treatment, control and manipulative control, we suspect it was potentially caused by a small amount of light coming from a window, in the side of the room where the speakers were placed, and towards which tadpoles moved. We are currently developing ways to contour this bias, and a full experiment will be conducted after this year breeding. Experiments on metamorphs and juveniles begin after the first clutches reaches metamorphosis, probably from the next summer to the start of autumn.

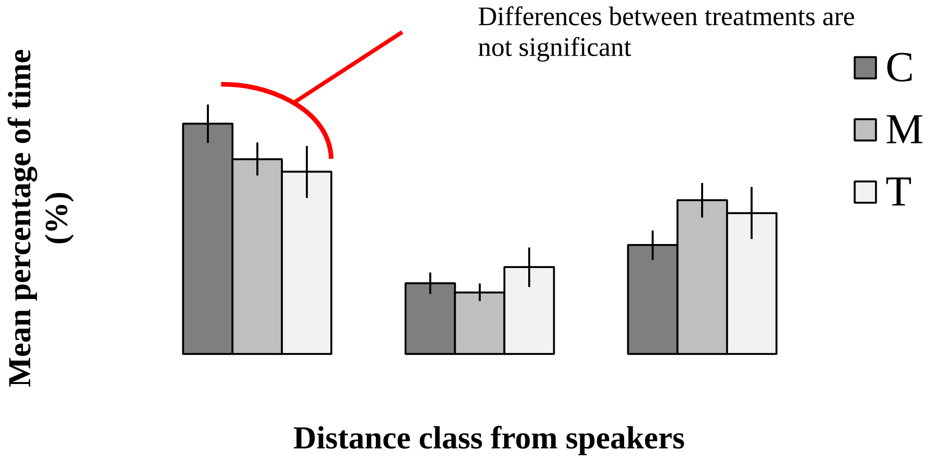

Figure 14. Mean time spent in the sections closest speakers, centre of the arena and furthest from the speakers, for conditions of no sound in control (C), static in manipulative control (M) and *Litoria aurea* calls treatment (T). Bars represent standard error.

4.3. Field Study

Do green and golden bell frogs use habitat features to select ponds where they call?

Habitat features are being sampled in ponds where frogs are seen calling and ponds with no calling detected and will be compared to determine if there is selectivity. Surveys started in the 2012-2013 breeding season, mostly in Sydney Olympic Park, as we failed to detect calling in Koorangang Island. The surveys will continue from September 2013 in the island.

5. NCIG Compensatory Strategy

It was mentioned in the previous Quarterly Report that the NCIG Compensatory Habitat and Ecological Monitoring Program (CHEMP) was being updated for submission to both DoPI and OEH, as a condition of the Rail Flyover Modification Approval. The CHEMP was submitted to both government departments on 7 June 2013. A follow-up meeting was held with representatives of DoPI, OEH and NPWS on 21 June to go through the details of the CHEMP (see attached minutes from meeting). The meeting did not identify any impediments for the approval of the Green and Golden Bell Frog components of the updated CHEMP, which now includes 78Ha of GGBF habitat.

However, there was discussion around approval of the Shorebird component, specifically relating to protection of the habitat in perpertuity. Area E, flagged as the preferred habitat location, currently lies within the boundary of the Infrastructure SEPP. The Infrastructure SEPP was zoned to facilitate the development of industrial infrastructure for a proposed Steel Mill. The steel mill development is no longer viable, and therefore the relevance of the infrastructure zoning for this land is arguably no longer valid. If NCIG, with the assistance of DoPI, could ensure the protection of any habitat developed in perpetuity in light of the infrastructure zoning, then OEH would agree to the proposal of Area E as Shorebird habitat. It was also noted in themeeting that NPWS would need to consider the utilisation of Area E as compensatory habitat, based on internal offsetting policy.

The DoPI provided a letter to NCIG on 7 August 2013, recognising that the CHEMP has been updated to satisfy the conditions of approval for the modification. DoPI recognises that NPWS policy does not normally allow offsetting within National Park. However, as opportunity had been provided to industry to utilise areas on Ash Island for GGBF offsets as part of a Memorandum of Understanding (MoU) with the then Department of Environment and Climate Change (DECC), the CHEMP is now approved by the Director-General insofar as it relates to Green and Golden Bell Frogs. The GGBF component in its updated form complies with the “in-perpetuity” requirement of Condition 2.20A.

Regarding Migratory Shorebirds, the letter states that the Department and OEH support the strategy outlined in the CHEMP. NPWS are willing to provide access to NCIG to Area E for offsetting purposes, as this area had been identified as the most suitable location for restoration of saltmarsh and shorebird habitat through previous discussions with DECC. This was stated in a letter from NPWS on 19 July 2013.

The Department provided contact details for a representative from the Sector Strategies and Systems Innovation Branch within the Department to discuss the prospect of ensuring in-perpetuity conservation within the Infrastructure SEPP. The department recognises that while Director-General approval would be granted in the event that in-perpetuity is secured, NCIG is encouraged to explore other options for Shorebird habitat in parallel.

A Conservation Bond is also required to satisfy Condition 2.20A of the Approval. The Department recognises that formulation of the bond is inherently tied to approval of the CHEMP. NCIG is currently working with DoPI to ensure that an appropriate bond value is calculated, with the Shorebird component of the CHEMP remaining unapproved.

Timing of delivery of compensatory habitat as outlined in the updated conditions remains on target. This includes delivery of 75ha of bell frog habitat before 31 December 2016 and 8ha of migratory shorebird habitat before 31 December 2014, as outlined in Condition 2.20(i). Compensatory, or offset, locations are to be secured by 31 December 2013.

6. Green and Golden Bell Frog Compensatory Habitat

As outlined in the previous Quarterly Report, NCIG has developed a GGBF Master Plan with the assistance of Dr Arthur White (Figure 15). The Master Plan forms a critical part of the CHEMP. As NCIG has now received approval for the

GGBF component of the CHEMP, work is now commencing on appropriate environmental assessment of the area and potential impacts from construction methodologies. This will form a Review of Environmental Factors (REF), to be submitted to NPWS. Aspects to be covered in the REF include Flore, Fauna, Soil, Surface Water and Groundwater. These issues will be fully identified in a meeting with NPWS, scheduled for the week of 16 September 2013.

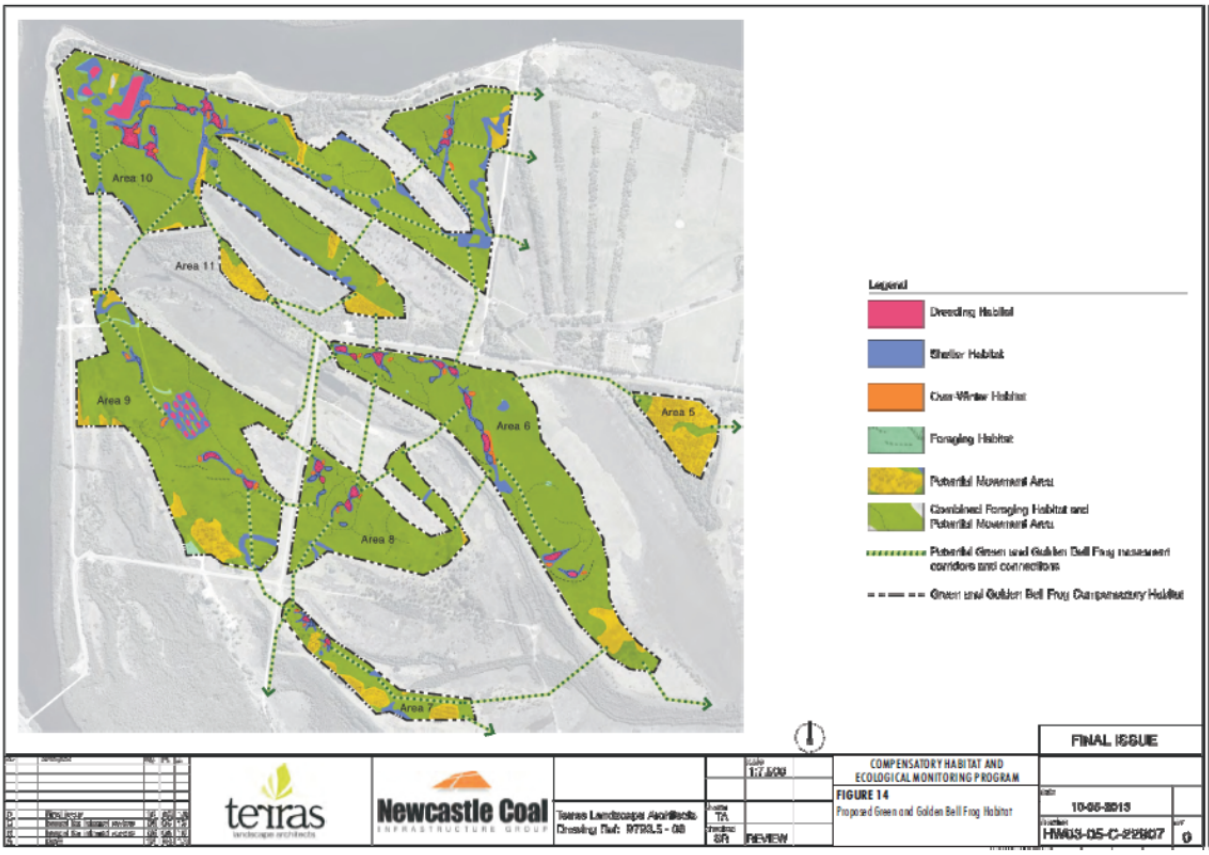

Figure 15. Proposed Green and Golden Bell Frog Concept, Ash Island, Hunter Wetlands National Park

In addition, a meeting was held with representatives of both NPWS and Hunter Central Rivers CMA (KWRP) on 2 September. Specific locations proposed for GGBF habitat were visited as part of this meeting, to identify opportunities and constraints for detailed design of ponds and associated habitat. In particular, previous rehabilitation and revegtation work conducted by KWRP were identified during the meeting, to ensure protection during construction of GGBF habitat. There were no major conflicts identified through this meeting and a subsequent site inspection and NCIG will make minor localised modifications to proposed habitat areas. Consultation with both NPWS and KWRP will be ongoing during the implementation of construction and management of habitat.

Construction of GGBF habitat is scheduled to commence in Quarter 4, 2013. NCIG will form a dedicated team for implemention of compensatory habitat, including areas for Shorebird habitat. The team will include an Area Manager, responsible for implementation of the program.

7. Shorebird Compensatory Habitat

As outlined in Section 5, the Shorebird component of the CHEMP is not yet approved. However, NCIG continues to plan for development of habitat. This includes investigation of construction and mangrove removal techniques. The outcomes of this will form a key part of any future Shorebird habitat development program.

In anticipation of commencing shorebird habitat development, NCIG has requested that two additional members be admitted to the CHEMP Consultative Board. These members are Mr Phil Straw (Shorebird Specialist) and the President of the Hunter Bird Observers Club (HBOC). The DoPI gave approval for these additions, outlined in a letter on 16 August 2013. NCIG welcomes these members to the Board and looks forward to working with them in the future.

8. Hydrodynamic Management, Fish Fry Creek

Kooragang Wetlands Rehabiliation Project continues to utilise the drop board structure at Fish Fry Creek (Creek 5) constructed by NCIG, for the purpose of hydrological management of Area E. The purpose of this is to manage mangrove expansion in the area through water level manipulation.

The management regime has been in place for approximately 12 months. The project encompasses an adaptive management philosophy, where alterations may be made to the regime based on monitoring results and changes in the distribution of mangroves.

NCIG recognises that this program aims to limit the expansion of mangroves in Area E. The proposal for physical removal of mangroves in this area complements the aims of the KWRP project, through removing future sources of mangrove propagules.

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Compensatory Habitat and Ecological Monitoring Program – Quarterly Report

DATE: *9 December 2013*

AUTHOR: Philip Reid, Dr Ligia Pizzatto (Uni of Newcastle), Melanie James (Uni of Newcastle), Alex Callen (Uni of Newcastle)

APPROVAL: Nathan Juchau

INTRODUCTION

This report provides an update of activities relating to the NCIG Compensatory Habitat and Ecological Monitoring Program since the previous Quarterly Report from 13 September 2013. The report aims to provide information on key components of the program and how these are being implemented. An update will be provided to members of the Consultative Board every 3 months, in the form of a Quarterly report and presentations (every 6 months) coinciding with Board Meetings.

1. Compensatory Habitat Bond

NCIG submitted a compensatory habitat bond value to the NSW Department of Planning and Infrastructure (DoPI) on 11 September 2013, for the value of $10,095,030. This was to cover the entire value of the NCIG compensatory habitat works including construction, value of the land, management, monitoring and research. DoPI accepted this value on 1 October 2013, confirmed by letter. NCIG subsequently submitted the bond to DoPI by 14 October.

The bond is to satisfy the requirement of Condition 2.20A of the Project Modification (MOD2), and will be returned to NCIG on the successful completion of objectives as outlined in the NCIG CHEMP and the Project Approval and Rail Flyover Modification.

2. Research Area Ponds and Associated Monitoring

2.1. Research and Monitoring

In the previous quarter it was reported that day monitoring of the introduced population of frogs at the NCIG trial site commenced in winter once night temperatures dropped. Day surveys continued until early spring and night surveys recommenced on 4 September due to unseasonably warm weather conditions. Monitoring records the distribution and abundance of frogs across the trial site, their growth and potential chytrid infection load. The switch back to night surveys and warmer temperatures has coincided with a reduced detection of chytrid-infected individuals, and no deceased or unwell individuals have been recovered from the field since the recommencement of night surveys. The 16 pond environment provides a pond choice experiment for the introduced bell frog population using a 2x2 factorial design of pond depth and salinity. Pond depth treatments were deep – permanent water (1.5m) and shallow – ephemeral water (0.5m). Salinity treatments comprised dosed ponds - to 3‰ using naturally derived sea salt and not dosed ponds – background salinity levels of ponds remained unmanipulated)

Pond water levels have receded due to unseasonably low spring rainfall. Rainfall across the region is substantially lower than the historical average (BOM, 2013) and this has resulted in five of the eight shallow ponds completely drying out (Figure 2-1) and a general increase in pond salinity levels (including in non-dosed ponds Figure 2-2). These results are based on weekly water quality data taken from each pond using a hand held YSI water quality meter. Images of deep pond water contraction and shallow pond drying are illustrated in Figure 2-3 and Figure 1-4. As a result of the lack of rainfall, most deep dosed ponds have now reached the critical 3‰ threshold while shallow dosed ponds have exceeded this threshold with a mean level of almost 7‰. Salinity concentrations above 7.4‰ are considered beyond the threshold tolerated for frogs (ie – there may be a drop in occupancy of these ponds as frogs disperse in search of less saline ponds) and concentrations above 4.4‰ are considered detrimental to tadpole development and survival (Stockwell, 2011). If this dry climatic condition holds then weekly surveys may collect robust data on the habitat preference for frogs during such extreme conditions which will provide important insight to habitat requirements for the species during drought. Water monitoring continues weekly to ensure ponds do not evaporate to levels where salinity within them becomes toxic to tadpoles should a breed and release event occur in the summer of 2013/2014. Contingency water supply is available if required to supplement pond water to avoid this scenario.

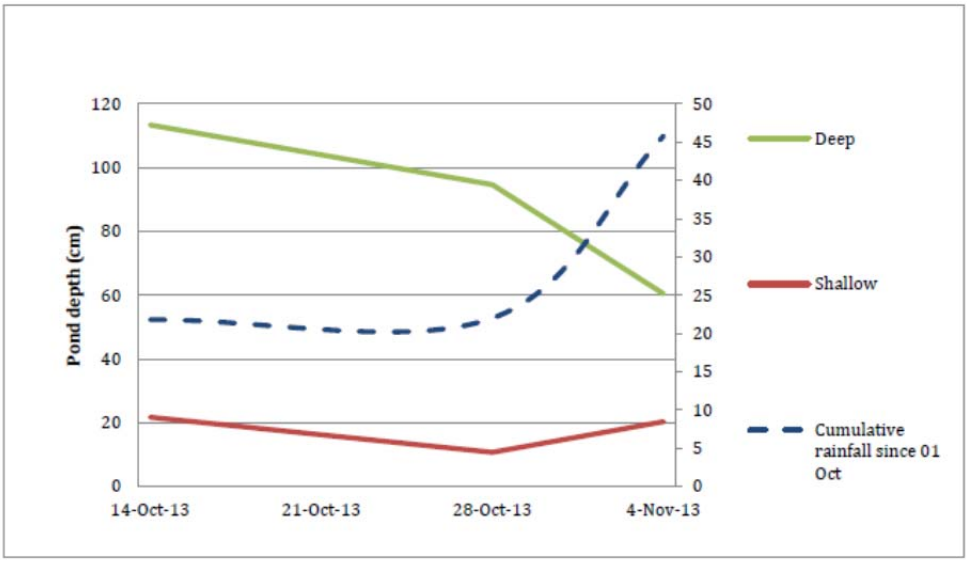


Figure 2-1 Mean pond depth over time and cumulative rainfall. Deep ponds = approximately 1.5m deep (permanent), shallow ponds = approximately 0.5m deep (ephemeral). Cumulative rainfall data obtained from the Australian Government Bureau of Meteorology

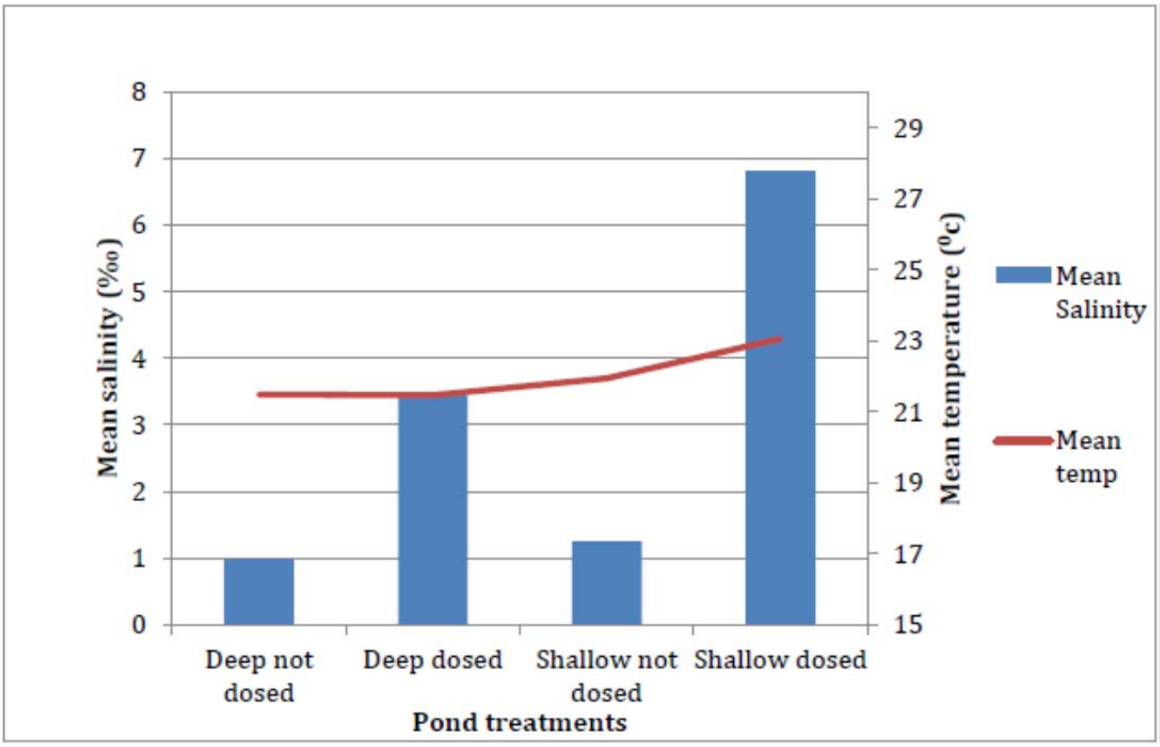


Figure 2-2 Mean salinity and water temperature for pond treatments for October – November 2013

Figure 2-3 Water level contraction at Pond 4 (deep) at the NCIG trial site due to lack of rainfall, 14 October 2013

Figure 2-4 Drying out of pond 1 (shallow) at the NCIG trial site due to low rainfall, 14 October 2013

2.2. Preliminary Data Analysis

Preliminary analyses of datasets relating to the research at the trial site were undertaken during October 2013 at the request of NCIG to supplement their existing green and golden bell frog compensatory habitat and ecological monitoring program (CHEMP). This supplementary report was provided to NCIG on 8 November 2013 and encompassed research findings from regional reintroduced and wild populations of the species in relation to the habitat requirements of the species.

The preliminary analyses was undertaken to test the following research questions:

2.2.1. Is pond occupancy explained by pond traits of salinity, depth and temperature?

Data on the density of frogs sampled during the visual encounter surveys around the ponds in the trial site from March to September was subjected to a preliminary analysis to investigate the effects of pond traits (salinity, temperature, and depth) and Pond ID (pond number). For this analysis a generalized linear model (glm) with negative binomial distribution was fitted using the software R. Data on the number of frogs encountered in the surveys were limited to juveniles as they were the major representatives of the current population. Search effort during the surveys in each pond was incorporated into the analyses using the offset function. Because pond temperature could be an effect of depth a non-parametric Wilcoxon test was used to compare water temperature in deep and shallow ponds.

Results:
Water temperature did not differ between deep and shallow ponds (X2= 0.28, df= 1, p= 0.594), however variances were higher in the shallow ponds.
Frog density around the ponds is explained by the interaction of pond water temperature and salinity (X2= 6.9, df= 1, p= 0.0085), and pond ID (X2=36.8, df= 15, p= 0.0014). Frog density increased sharply when water was warmer and saltier, than in cooler and less salty ponds (Figure 2-5).

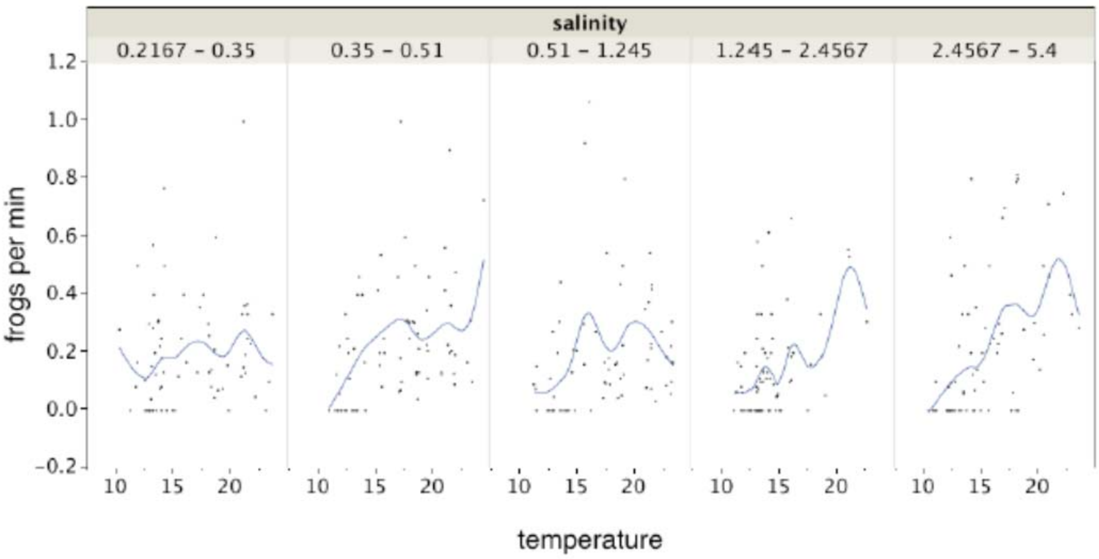


Figure 2-5 Effects of pond salinity (‰) and temperature (oC) on the number of frogs recorded per minute in visual surveys in the NCIG trial site.

Conclusions:
Based on the survey data from the last seven months since release of tadpoles and metamorphs, juvenile frogs seem to prefer ponds with combined higher water

temperature and salinity. In addition, the significant influence of pond ID on frogs' density may suggest that the presence of a conspecific in a particular pond attracts more frogs (conspecific attraction), boosting frog density. Alternatively other non-identified traits of specific ponds could be leading to this pond ID effect. As ponds were built to be identical, it is suspected that any naturally caused differences (e.g. vegetation propagation, prey abundance) would have minor effects on frog attraction. Given the results of experimental trials showing juvenile frogs prefer habitats where conspecifics exist (L. Pizzatto, unpublished data), the conspecific attraction hypothesis to explain pond ID preference should be given further consideration. As a result, song meters were installed in eight ponds across the site to record incidence of frog chorus. This issue will be further investigated with the help of a statistician.

2.2.2. Does microhabitat use vary with frog body size?

Nominal logistic regression was applied to the microhabitat and snout-vent length (SVL) recorded for each frog during visual encounter surveys from May to September to determine whether micro-habitat use across the site varied with frog body size (a proxy for age).

Results:
Micro-habitat use depended on body size (X2= 15.4, df= 6, p= 0.0173). Frogs found on rocks were on average larger than those found on grass, mud, or on the water (Figure 2-6).

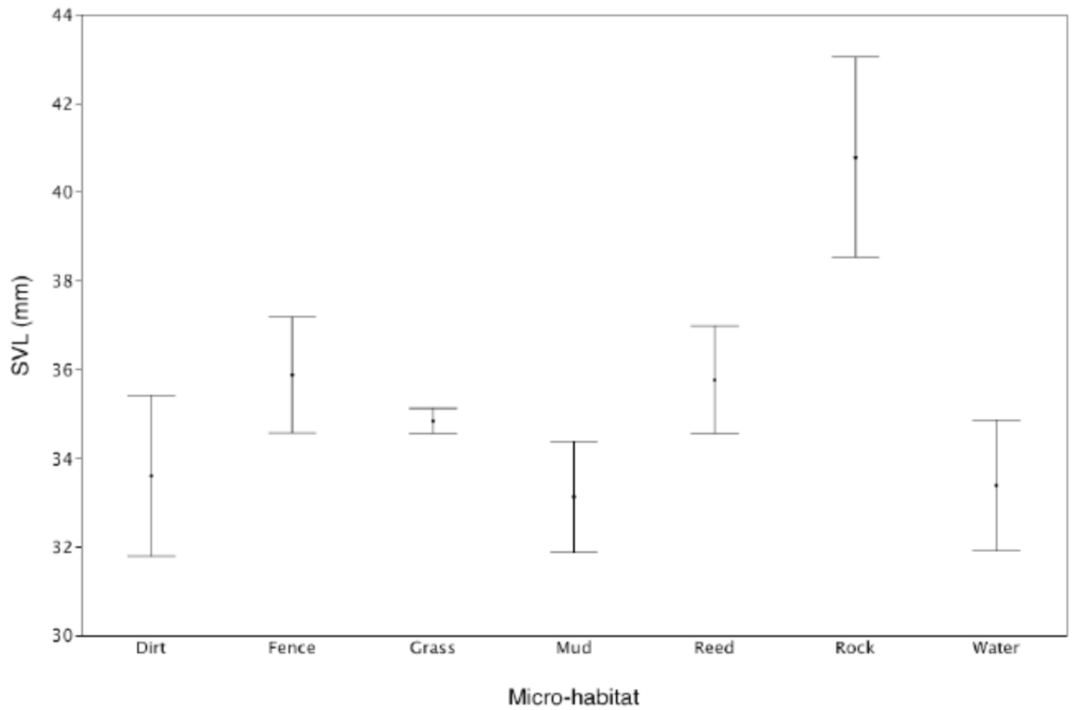


Figure 2-6 Micro-habitat use according to frog snout-vent length (SVL). Circles represent averages and whiskers represent standard error.

Conclusions:

Based on the survey data from the last seven months since release of tadpoles and metamorphs, juvenile frogs appear to have no defined preference for micro-habitat at the trial site. Data collection on frog use of microhabitat will continue with each weekly survey to see if the preference of rock use by larger individuals becomes a trend irrespective of environmental variables.

2.2.3. What is the rate of recapture of frogs and is there any preference for pond treatment?

The proportion of recaptured individuals was compared with the total number of individuals caught in each survey period since the last release of tadpoles in March 2013 up to October 2013 (Figure 2-7). Mean number of recaptures by pond treatment over the entire survey period was also calculated (Figure 2-8).

Results:

Recapture rates varied between survey periods and mean recapture values for autumn and spring generally comprised a recapture rate greater than 20 % of the total number of individuals caught in each survey. Mean recapture data showed no specific preference by the introduced population to a particular pond treatment.

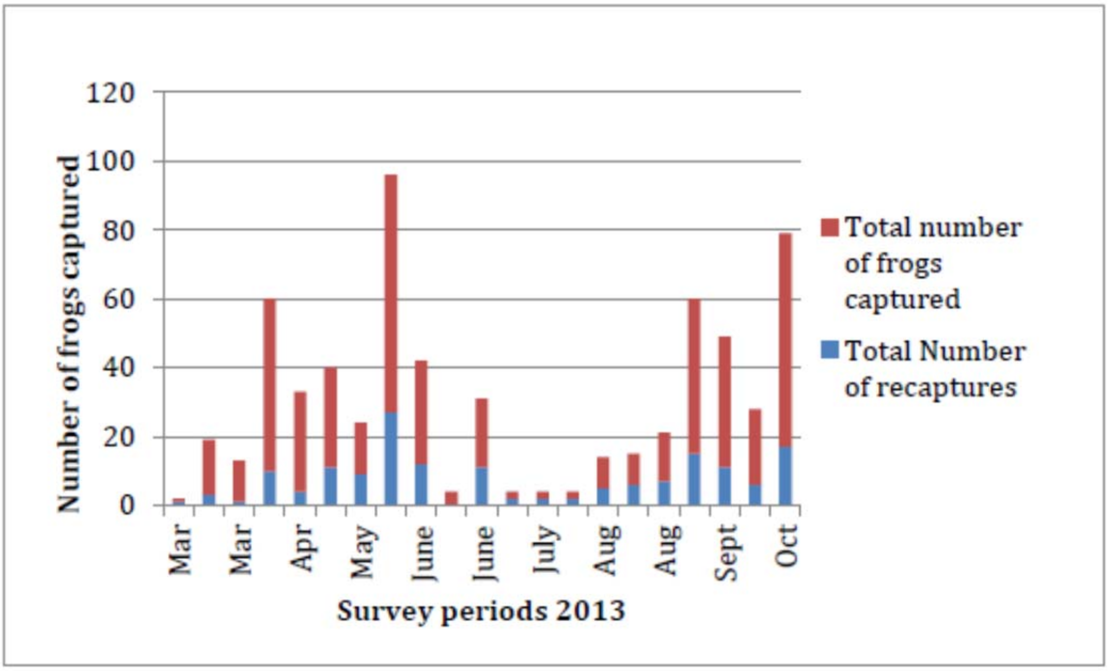


Figure 2-7 Total number of frogs captured per month and the proportion of recaptured individuals across the trial site.

Conclusions:

Based on the recapture survey data from the last seven months since release of tadpoles and metamorphs, juvenile frogs appear to have no defined preference for pond treatments at the trial site. Recapture surveys will continue fortnightly to see if pond preference shifts as a result of life stage (as juveniles mature to adults) or climatic variables (as shallow ponds continue to dry out in the absence of rainfall).

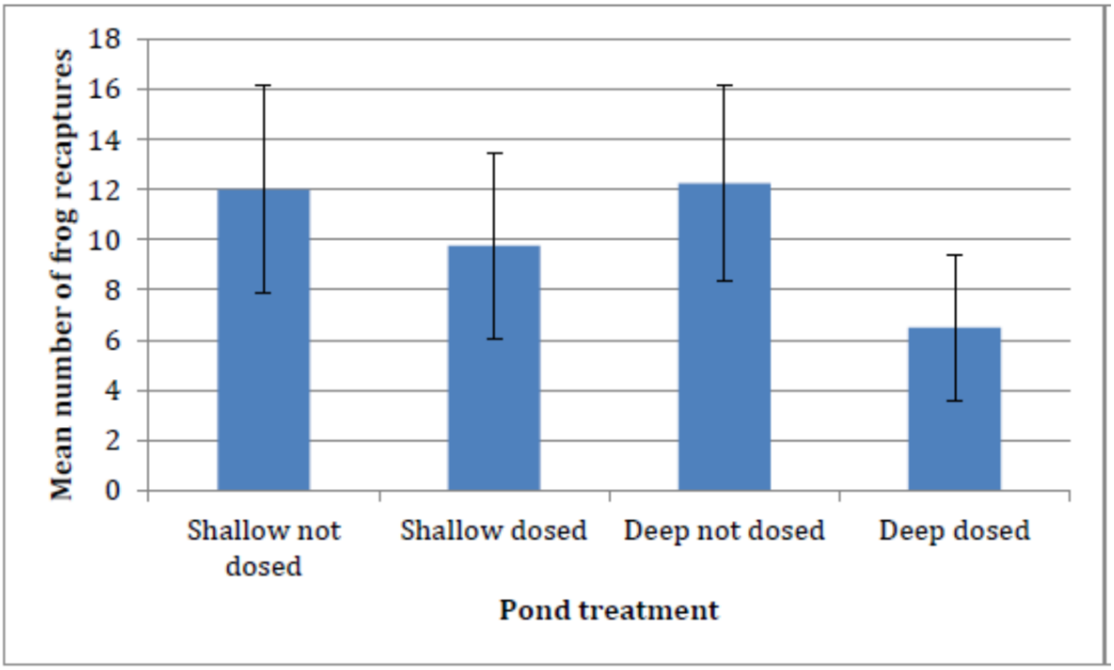


Figure 2-8 Mean number of frog recaptures by pond treatment from March to October 2013. Whiskers represent standard error. Pond treatments are shallow=0.5m, deep = 1.5m, dosed = treated with naturally derived sea salt to approximately 3‰ and not dosed = pond water

2.2.4. Do water quality parameters differ among pond treatments?

Water quality parameters have been taken weekly with an YSI handheld meter between March and October. Data from May to October was compared by pond treatment (data between March and May was pre-treatment) using Anova or equivalent non-parametric test (Kruskall-Wallis). Effect of time on water temperature was analyzed by linear regression.

Results:
Water temperature increased positively with time (R2= 0.14, t= 12.28, $p < 0.001$; Figure 2-9). Warmer waters were recorded at nighttime probably because water reached the maximum temperature absorption and ponds were not yet losing heat when measurements were taken.

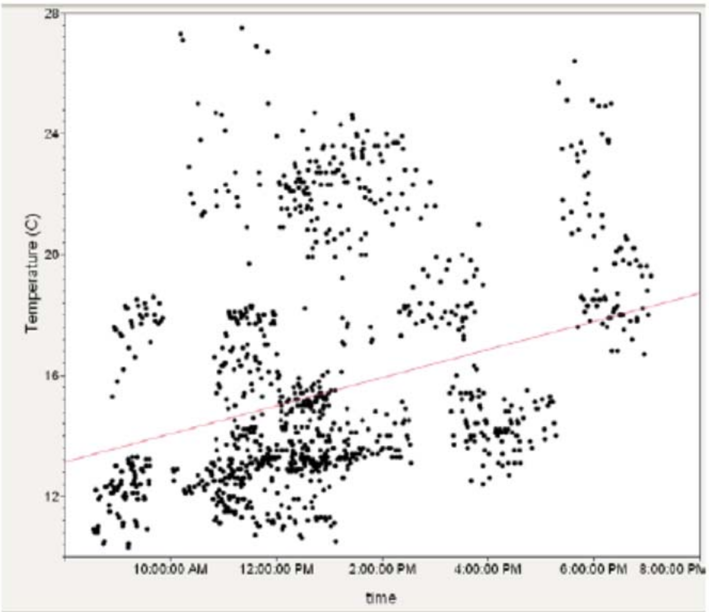


Figure 2-9 Pond water temperature in relation to time for all treatments combined. Red line represents a trendline from the linear regression.

pH increased positively with temperature ($F_{1,899}$= 38.57, p< 0.0001) and depended on the interaction of pond treatment and month of the year ($F_{12,899}$ = 5.37, p < 0.0001) (Figure 2-10). In general, pH values tended to increase from August through to October, with the exception some higher pH values in June in the low salt ponds In most cases, pH values within salt treatments were similar by month irrespective of pond depth.

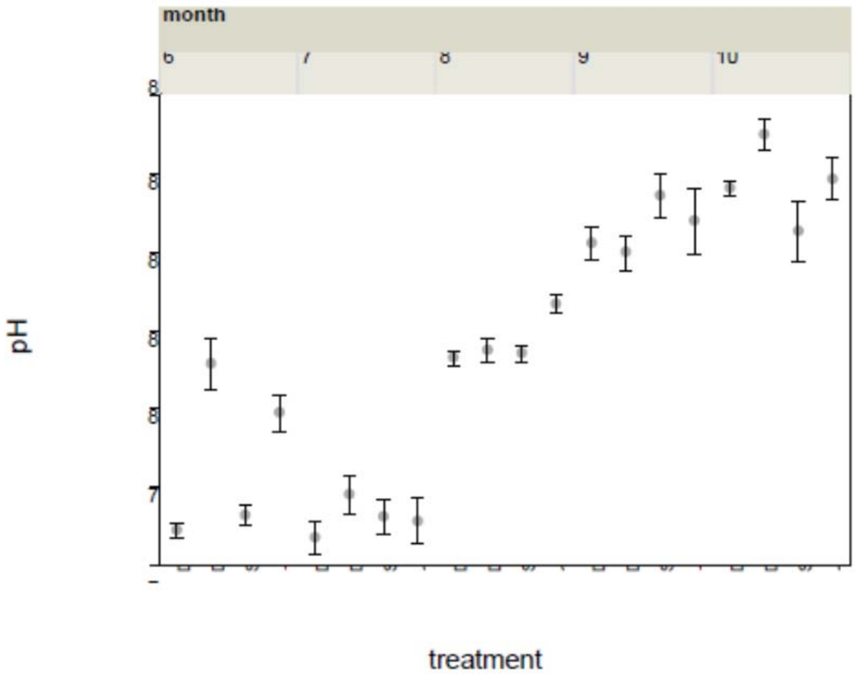


Figure 2-10 Monthly variation of pond water pH according to pond treatments. D = deep (1.5m), S = shallow (0.5m), HS = high salinity (dosed with sea salt approx. 3‰), LS = low salinity (not dosed with sea salt). Circles represent means and whiskers are standard deviation.

Dissolved O2 depended on the interaction of pond treatment and month of the year ($F_{12,833} = 5.11$, $p < 0.0001$), and tended to increase with temperature (marginally significant: $F_{1,833} = 3.22$, $p = 0.073$; Figure 2-11).

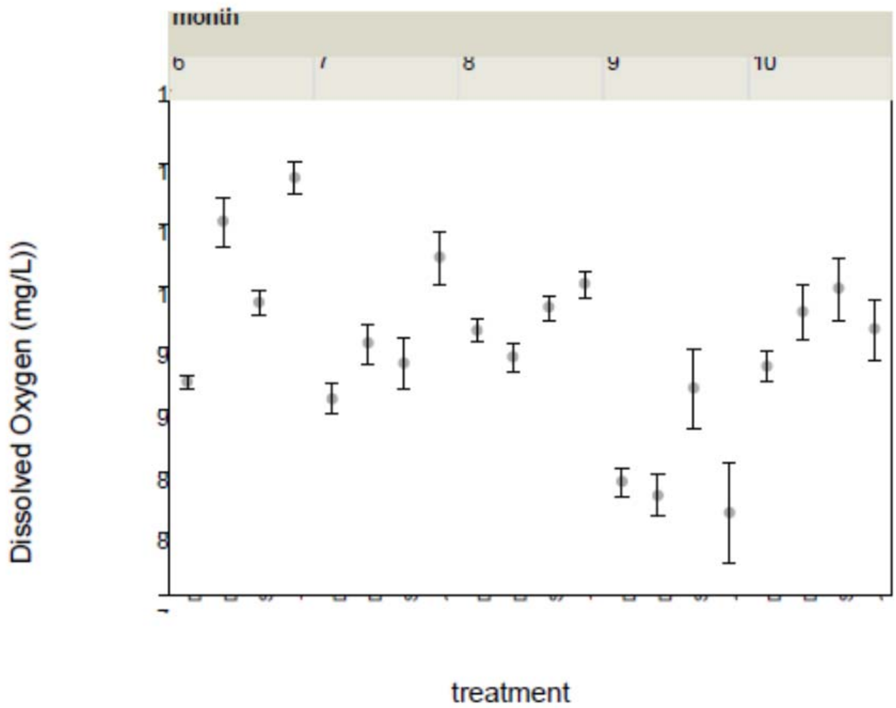


Figure 2-11 Monthly variation of pond water dissolved oxygen according to pond treatments. D = deep (1.5m), S = shallow (0.5m), HS = high salinity (dosed with sea salt approx. 3‰), LS = low salinity (not dosed with sea salt). Circles represent means and whiskers are standard deviation.

Water turbidity, measured as total dissolved solids, also depended on the interaction of month and pond treatment ($F_{12,853} = 20.36$, $p < 0.0001$). Turbidity was significantly higher in salt dosed ponds, independently of the depth (Figure 2-12).

Conclusions:

Water quality parameters require further consideration and analysis in relation to temporal and treatment trends and such analysis will benefit from a larger data set collected over a 12 month timespan. Importantly, it is well known that some phsyio-chemical water quality parameters such as dissolved oxygen are heavily influenced by salinity and while the current data does not show any trends regarding salinity this relationship will continue to be explored.

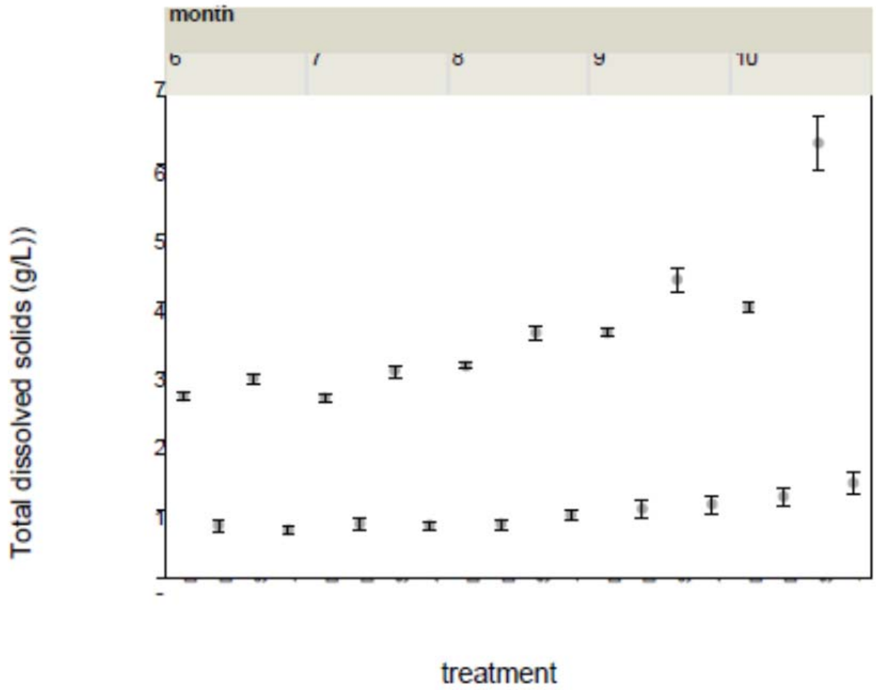


Figure 2-12 Monthly variation of total dissolved solids in pond water according to pond treatments D = deep (1.5m), S = shallow (0.5m), HS = high salinity (dosed with sea salt approx. 3‰), LS = low salinity (not dosed with sea salt). Circles represent means and whiskers represent standard deviation.

Table 2-1 The threshold range of water quality variables (shaded grey) determined as the range found suitable for survival in the literature cited and from occupied habitat on Kooragang Island and Sydney Olympic Park, with a 5% buffer for pH and 10% for all other (from Stockwell, 2011).

Water Quality Variable	Suitable range for survival		References	Threshold Range	
	Tadpoles	Frogs		Tadpoles	Frogs
Water Temperature (°C)	16-31	4-35	(Hamer 1998; Penman 1998; Browne and Edwards 2003)	14.4 - 34.1	3.6 - 38.5
Salinity (ppt)	< 4*	< 6.4	(Werkman 1999; Stockwell 2011).	< 4.4	< 7.04
pH	4-9	4-10.2	(Penman 1998)	3.5 – 9.5	3.5 – 10.7
Dissolved Oxygen (mg/L)	4.1 – 17.1		No references available. Range from known habitat alone.	3.7 – 18.8	

* In the references provided, tadpole survivorship was not affected up to 4 ppt. However, in one study, tadpole survivorship was reduced at 2 ppt (Christy and Dickman 2002).

While understanding the response of water quality parameters in relation to the salinity treatments being conducted at the NCIG trial site is important, the measurements of temperature, DO and pH recorded from the site are within the threshold range to continue to support aquatic life, and the bell frog (Table 2-1 from Stockwell, 2011). Salinity levels increase as pond water decreases and this variable continues to be monitored closely. Intervention to reduce pond salinity concentrations may occur if a breed and release event progresses this summer, or in future seasons when females are shown to be sexually mature, as tadpoles have a lower salinity threshold than that currently measured in many shallow dosed ponds.

3. Behavioural Ecology Research

Dr. Ligia Pizzatto is conducting research on conspecific attraction in Green and Golden Bell frogs, as accepted in the original research programme proposal. Research question 1 in the proposed Research Program asks if green and golden bell frogs (*Litoria aurea*) are attracted to areas occupied by conspecifics.

Dr Pizzatto conducted experiments using Green and Golden Bell frogs for testing kin and familiarity preference among schooling tadpoles (experiments 1-3 from previous report). A re-analyses of the data were presented in the last report with promising results, and we stated that a new clutch would be included in the experiment for strengthening the results. One clutch has already been obtained from captive breeding, eggs were split in different tubs, and tadpoles are being raised to the size of testing.

Progress of other questions being investigated:

3.1. Do Green and Golden Bell Frog tadpoles recognise alarm pheromones from conspecific?

This experiment aimed to test if tadpoles avoid a macerate of conspecifics, which in some species works as an alarm pheromone. The pheromone alerts for danger of predators feeding on conspecifics and can result on decreased activity or avoidance of the area where it is present by other tadpoles. If *L. aurea* presented a defensive behaviour in the presence of conspecific macerate we could use it in association with mosquito fish scents to create an associative learning on the tadpoles. Specifically, this associative learning can be obtained by presenting the alarm pheromone (conspecific macerate) together with the predator scents and the naïve tadpoles associate the fish scent with the pheromone and develop defensive behaviour towards the fish scent even when presented along (without the alarm pheromone). The result would be then, a creation of mosquito-fish smart tadpoles that would recognize and avoid *Gambusia* as a predator.

Methods: Three clutches of captive bred *Litoria aurea* were used. Trials were run in plastic core trays (1 m length x 0.1m width) with fly screen mesh fixed at 10cm from both ends to form two compartments, and filled with rain water to a 5cm depth. The top of the tray was marked with black lines to visually divide it into three 10 cm sections (two adjacent to each end compartment and one middle). Water was completely changed for each trial. Tadpoles were randomly assigned to pheromone or control treatments. For the pheromone treatment, we prepared the stimulus solution (presumably an alarm pheromone) by macerating 0.7 g of euthanized *L. aurea* tadpoles in 50 mL. The macerate was passed through filter paper to remove any solids, and further diluted in water, and dyed with green food colouring (Hagman & Shine 2009) to allow visualization. 50 ml of stimulus solution was added with plastic pipette to one of the end compartments and manually mixed until the green dye colouration was present throughout half of the tray (Crossland et al 2011). 50 ml of rain water was added to the opposite end; the testing tadpole was released at the centre of the tray and filmed for 35 minutes. For the controls, the stimulus solution was replaced by green dyed water, and the experimental procedures followed what described for the pheromone treatment. We used a total of 30 tadpoles per treatment. From each tadpole recording we scored (1) the first reaction when it encountered the dyed solutions, (2) the total time each tadpole spent in each section of the tray during 30 minutes (the first 5min was discarded as acclimatization period). We also used a software (JWatcher) to score duration of and frequency of specific behaviours during 10 minutes after the acclimatization period.

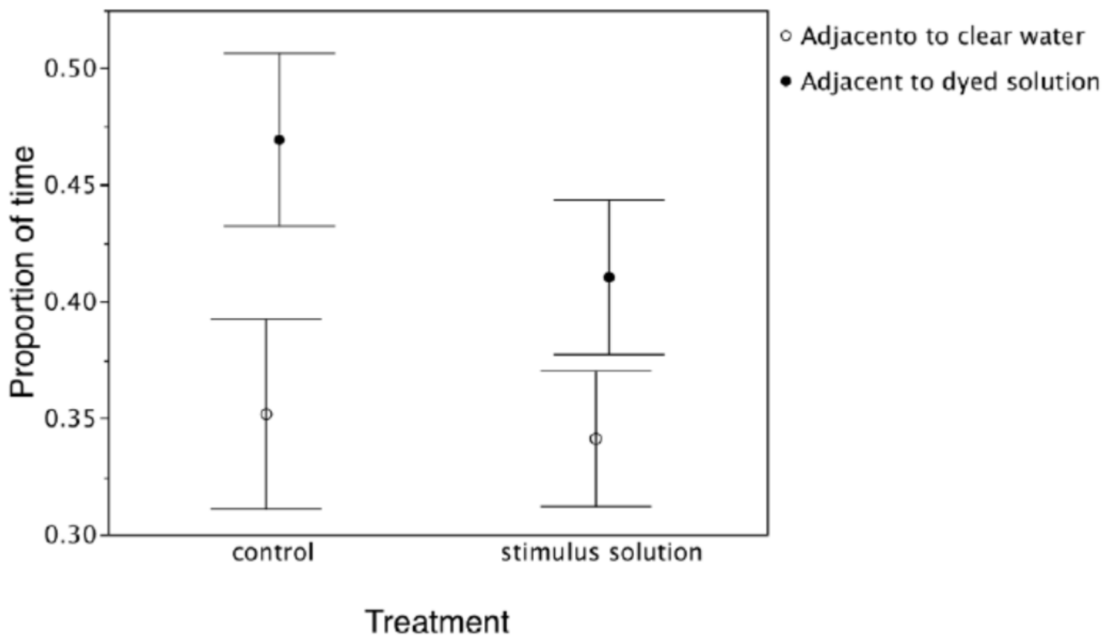


Figure 3-1. Proportion of time *Litoria aurea* tadpoles spent in the sections adjacent to compartments where dyed solutions were added and adjacent to compartments where only water was added, in both stimulus solution and control treatments. Circles represent means and bars represent standard errors.

Analyses and Results: We compared the proportion of time the tadpoles spent adjacent to the compartment with dyed solution and adjacent to compartment with non-dyed solution by repeated-measures ANOVA. The proportion of time tadpoles spent performing each specific behaviour was compared between treatments by ANOVA. The reaction of tadpoles when they first encountered the dyed solutions in the pheromone and control treatments was analysed using Chi-Square test.

Tadpoles tend to spend less time in the section near the dyed solution than adjacent to only water. However, the time tadpoles spent adjacent to dyed solution did not depend on treatment ($F_{1,57} = 0.25$, $p = 0.618$; Fig. 3-1).

Tadpoles spent significantly more time swimming in the non-dyed water ($F_{3,240} = 7.85$, $p < 0.0001$), but the proportion of time tadpoles spent performing each specific behaviour did not significantly differ between treatments (interaction: $F_{3,240} = 0.135$, $p = 0.998$, Fig. 3-2), neither the reaction of tadpoles when they first encountered the dyed solutions ($X2 = 1.66$, df = 3, $p = 0.618$, Fig. 3-3).

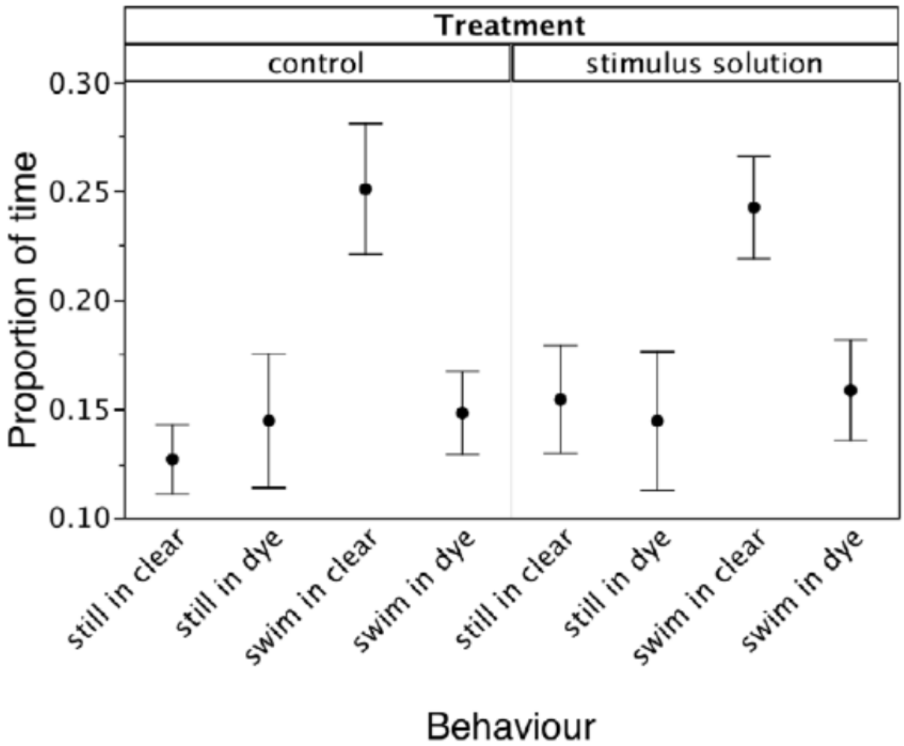


Figure 3-2. Proportion of time *Litoria aurea* tadpoles spent performing specific behaviours in both stimulus solution and control treatments. Circles represent means and bars represent standard errors.

General interpretation: Tadpoles did not present any defensive behaviour (avoidance and decrease in activity) when encountered chemical cues of dead conspecifics. Thus, in *L. aurea* macerate of conspecifics do not work as alarm pheromones. Unfortunately this renders the proposed methods for teaching tadpoles to recognize mosquito fish not possible.

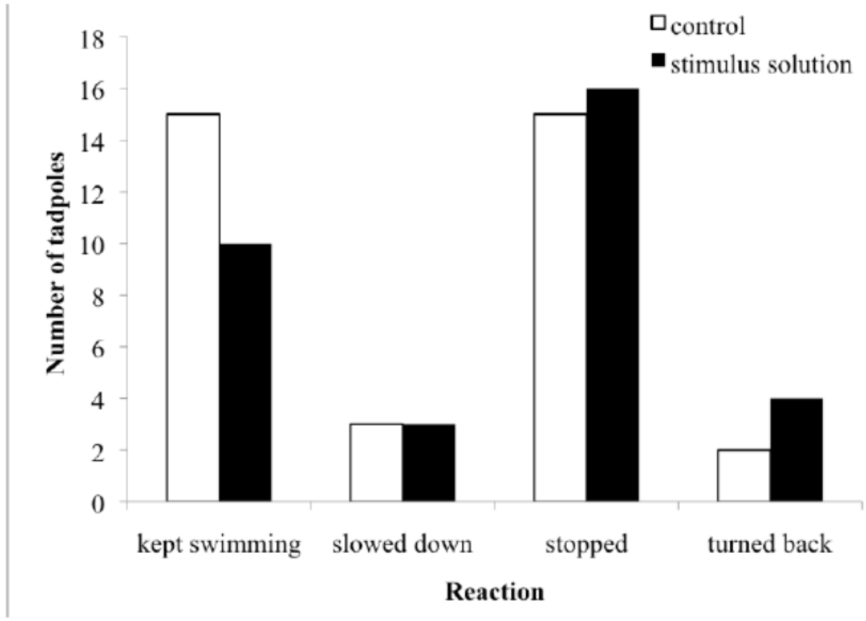


Figure 3-3. Reaction of *Litoria aurea* tadpoles when first encountered the dyed solutions in the stimulus solution and control treatments.

3.2. Do Green and Golden Bell Frogs choose a 'poor habitat' where conspecifics are present over a 'rish habitat' where there are no conspecifics?

This experiment was planned to addresses the research question 2 in the original proposal: Do green and golden bell frogs use the presence of conspecifics (social information theory) to determine habitat suitability? In the previous report we showed that *L. aurea* juveniles had no preference for a poor habitat with conspecifics or a good habitat without conspecifics. At the present control trials are being run for this experiment to confirm that in the absence of the conspecific the testing frogs would prefer the good habitat.

3.3. Do Green and Golden Bell Frogs choose a habitat based on conspecific?

This experiment still addresses the research question 2 in the original proposal: Do green and golden bell frogs use the presence of conspecifics (social information theory) to determine habitat suitability? We have already shown that juvenile *L. aurea* do prefer habitats where conspecifics are, but this response can differ according to age, sex, and breeding status.

At the present we are running experiments in which we test the preference of adult breeding males and gravid females for habitat containing (1) scent of breeding males and (2) presence of breeding males. These ongoing trials will be presented in full in coming reports.

3.4. PhD fellowship partially funded by NCIG GGBF Research Programme

Melanie James has been preparing her documents and presentation for PhD confirmation – a requirement of her first year. She has produced a 20 page literature review and 19 page research proposal to be presented on 19th November 2013.

Melanie's project addresses conspecific attraction/ repulsion based on auditory cues (calls). She is investigating the role of calls on the distribution of green and golden bell frogs in different life stages, under laboratory and field conditions.

Progress of current questions being investigated:

3.4.1. Are adults attracted to the calls of conspecifics (adult breeding males and gravid females)? Do non-gravid females avoid calling males?

To answer these questions animals will be experimentally exposed to the sound of calling adult males in laboratory. The response of the testing animals to calling will be compared to a control (no sound) and manipulative control (static).

Currently, the animals planned to be used in this experiment were from the breeding program. However, synchronizing the experiments with the breeding without compromising breeding was proven quite challenging due to the duration of the experiments. Also, in preliminary experiments we have detected a low rate of response of the captive animals towards the calling treatment, and we suspect that habituation of the animals may be influencing their behaviour. Habituation is a decrease in and animal's response to a stimulus after being exposed to the stimulus for a long period of time. For example, animals kept in confined conditions may not display behaviour typical of that species, due to extended time in captivity. Consequently, in order to remove any potential effect of habituation we have changed the protocol to use animals from the wild, and this change is being accessed by the ethics committee.

3.4.2. Do early life stage L.aurea (juveniles, metamorphs, tadpoles) avoid calling adults?

Twenty four juveniles (≤ 35 mm SVL) have been obtained from the 2012-2013 breeding season and were kept over winter. Arenas for experiments are set up (Figure 3-4), and experiments are planned to be conducted between 18th November and 20th December 2013. A clutch of tadpoles have already been obtained in captivity by Dr L. Pizzatto and are being raised until they reach an appropriate size for the experiment.

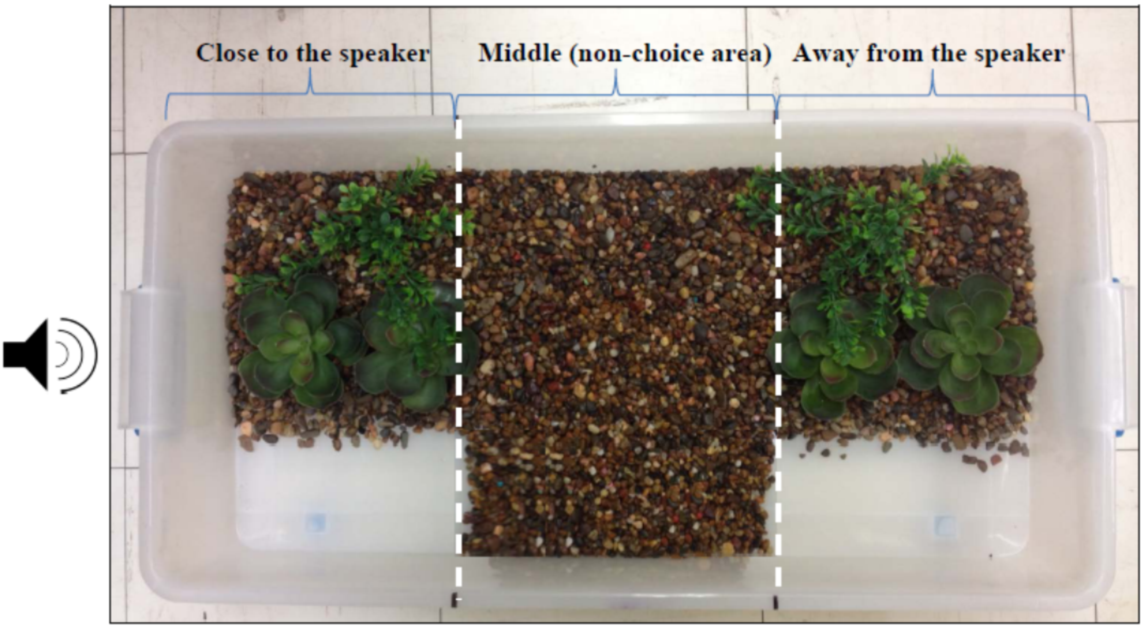


Figure 3-4: Experimental arena for juvenile and metamorph exposure to conspecific calls. Each side of the container holds plants for reguge and one pool of water. 🔊 Represents the speaker.

The preliminary results of this study will be presented at the 2014 conference of the Australian Society of Herpetologists in Canberra in early February (Australian National University).

3.4.3. Do Green and Golden Bell Frogs use the presence of conspecifics (social information theory) to determine habitat suitability?

This study aims to determine if male *L. aurea* from natural populations choose to call in specific sites based on habitat features. Features from sites where males were calling will then be compared to the availability of habitat within ponds to determine if there is selectivity. This study is currently underway and replicates are being increased through the inclusion of ponds on Kooragang Island. Currently K22 and 23 have had six nights of data collection, and throughout November and December ponds on the industrial side of Kooragang Island will be surveyed.

4. Annual Green and Golden Bell Frog Monitoring

As part of Project Approval 06_0009, NCIG are required to undertake monitoring of Green and Golden Bell Frogs in locations around the NCIG Terminal on Kooragang Island. PWCS monitored this area for Green and Golden Bell Frogs in 2012/13 as part of the T4 pre-feasibility study. Data for this season will soon be made available to NCIG.

Moving forward, NCIG is establishing a monitoring and research sharing agreement with PWCS. The results of research being conducted by PWCS at the University of Newcastle will be made available, including the effect of solutes on bell frogs. There will be an opportunity for Newcastle Port Corporation (or the private entity that will lease the port) to join the information sharing agreement, as they will have bell frog impacts resulting from capping works of the Kooragang Island Waste Emplacement Facility (KIWEF). To date, BHP Billiton has not entered an information sharing agreement with NCIG.

The Monitoring for season 2013/14 has commenced and results for this will be available at the end of the season.

5. Breeding Program

The breeding pairs utilised for NCIG's Research Area are being retained at the University of Newcastle, with the intent of utilising these either for experimental pursposes and for re-populating the NCIG Research Area in the coming season.

Future generations may be released into NCIG or PWCS compensatory habitat developments or into existing habitat with the potential to support the local Green and Golden Bell Frog population. Costs for managing the breeding individuals are currently assumed by both NCIG and PWCS.

6. Green and Golden Bell Frog Compensatory Habitat

NCIG has developed a Master Plan to guide the construction and implementation of the Green and Golden Bell Frog compensatory habitat. This was included in the bell frog component of the CHEMP, which was approved on the 7 August 2013. The Master Plan identifies areas for development of breeding, sheltering and overwintering habitat and areas that will be retained as foraging and movement areas. This plan was developed with the assistance of Project-approved Ecologist, Dr Arthur White, and landscape architects, Terras.

To enable the construction of ponds and associated habitat components, NCIG must prepare an environmental assessment for determination by NPWS, the owners and managers of the land. A Review of Environmental Factors (REF) is currently being prepared. A meeting was held with NPWS on 19 September 2013 to establish what issues are to be covered in the assessment. Specific issues that are being assessed include:

- Existing biodiversity, including listed flora and fauna species
- Existing and proposed revegetation work, completed by environmental groups such as the Kooragang Wetlands Rehabilitation Project (KWRP)
- Water impacts
- Heritage impacts, both aboriginal and non-aboriginal
- Acid sulphate soils
- Additional construction traffic

Extensive consultation has also been held with stakeholders, in particular KWRP and the Hunter Central Rivers CMA to discuss interaction with restoration activities in the National Park. This included a site meeting with KWRP, NPWS and NCIG representatives on 2 September 2013 to visit each location for pond development and discuss potential issues. It has been established through this consultation process that liaison will be ongoing between NCIG, NPWS and KWRP regarding works relating to compensatory measures and other environmental/restoration works. A consultation process will be developed and included in a management plan for NCIG compensatory habitat post-construction.

The REF is scheduled for submission in early January 2014. Based on standard assessment and determination periods, approval will likely be provided in later February/early March 2014.

A dedicated team for implemention of compensatory habitat has been built, including an Area Manager and HSE Coordinator. This team is managing the civil and landscape design process, which is being run concurrently with the environmental assessment process. This captures changes to the design developed for the CHEMP which reflect opportunities for larger ponds and utilisation of existing surface contours, and constraints such as existing vegetation, known locations of heritage items and other planning constraints.

In addition, NCIG held a workshop on 25 November 2013 including the University of Newcastle, Terras Landscape Architects and ADW Civil Engineers to identify opportunities for incorporation of learnings from the university's various research programs. The main outcome from this was to merge ponds and excavate shallow surface scrapings to achieve greater pond surface areas under high pond level conditions resulting from significant rainfall. A schematic of the updated broad-scale design can be seen in Figure 6-1 below. The updated design will form the basis for the drawings that will form part of the tender br

Construcability is being considered as part of engineering and project management for the habitat. Items such as access tracks, order of works and handling of materials including acid sulphate soils have been reviewed to gain an understanding of the schedule for the construction works.

An Expression of Interest (EOI) has been sent to a number of civil contractors for development of the GGBF habitat. Responses to the EOI have been received and these are currently being reviewed. Tender documentation is being developed and this is scheduled for release in January 2014. Awarding of the contract is scheduled to coincide with determination of the works by NPWS in late February/early March 2014.

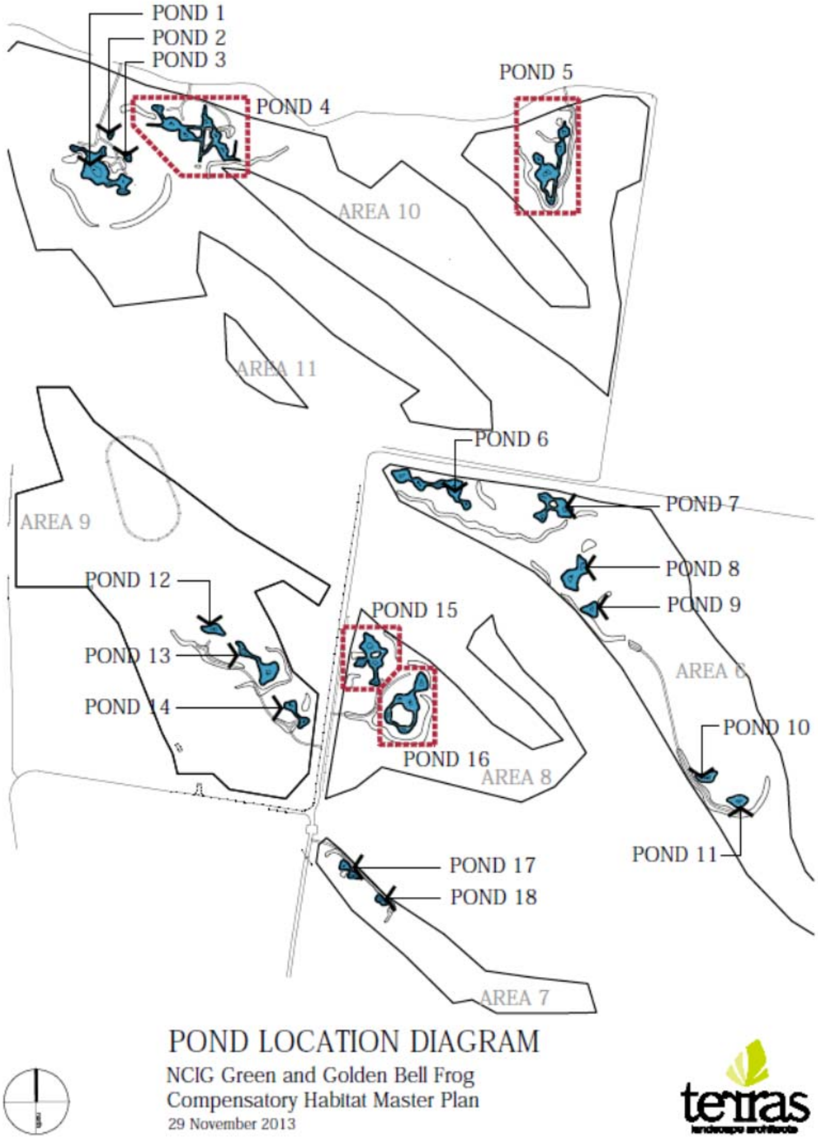


Figure 6-1. Updated GGBF Masterplan, incorporating constraints, opportunities and research learnings

7. Shorebird Compensatory Habitat

As mentioned in the previous quarterly report, the Shorebird component of the CHEMP has been provided in principle support by DoPI and OEH (NPWS). This is in regnition of the suitability of the land for shorebird habitat and the close proximity to the disturbance area. Full approval is pending resolution of the land use zoning for Area E and assurance of "in perpetuity" protection. This area is currently subject to the operation of the Infrastructure SEPP. NCIG is currently in discussions with DoPI and NPWS to define an acceptable mechanism to allow adequate security for shorebird offsets in the Infrastructure SEPP within Area E.

NCIG has requested that two additional members be admitted to the CHEMP Consultative Board. These members are Mr Phil Straw (Shorebird Specialist) and the President of the Hunter Bird Observers Club (HBOC). The DoPI gave approval for these additions, outlined in a letter on 16 August 2013. NCIG welcomes these members to the Board and looks forward to working with them in the future.

8. Hydrodynamic Management, Fish Fry Creek

Kooragang Wetlands Rehabiliation Project continues to utilise the drop board structure at Fish Fry Creek (Creek 5) constructed by NCIG, for the purpose of hydrological management of Area E. The purpose of this is to manage mangrove expansion in the area through water level manipulation.

The management regime has been in place for over 12 months. To date, there has already been an impact on existing mangrove trees adjacent to the water level control structure, with some larger trees having died. The aim of the program aims to limit the expansion of mangroves in Area E. The proposal for physical removal of mangroves in this area complements the aims of the KWRP project, through removing dead trees to create shorebird habitat and reducing future sources of mangrove propagules.

9. NCIG Compensatory Habitat Schedule

A copy of the NCIG Compensatory Habitat Schedule of Works is provided on the following page.

References

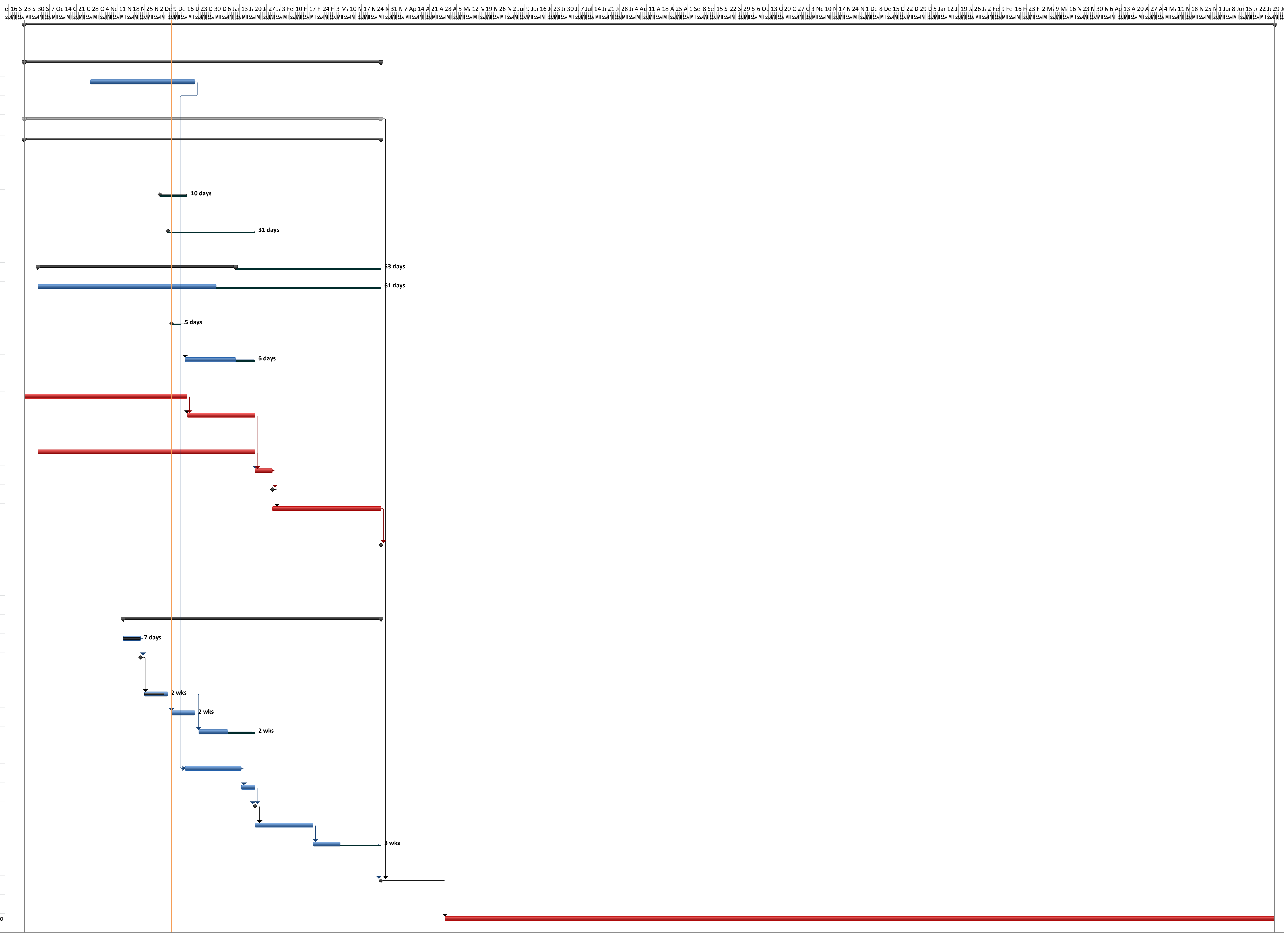
Australian Government Bureau of Meteorology Monthly Weather Review, New South Wales, October 2013.

Crossland, M., Brown, G. & Shine, R. 2011. The enduring toxicity of road-killed cane toads (*Rhinella marina*). Biological Invasions 13: 2135-2145.

Hagman, M. & Shine, R. 2008. Understanding the toad code: Behavioural responses of cane toad (*Chaunus marinus*) larvae and metamorphs to chemical cues. Austral Ecology 33: 37-44.

Stockwell, M. P. (2011). "Impact and mitigation of the emerging infectious disease chytridiomycosis on the endangered green and golden bell frog." PhD Thesis, The University of Newcastle.

ID	Task Mode	Name	Duration	Start	Finish	Predecessors
1		**GGBF Habitat**	**441 day**	**Tue 24/09/13**	**Tue 30/06/15**	
2						
3		**Detailed Design**	**124 day**	**Tue 24/09/13**	**Wed 26/03/14**	
4		Detailed Design	8 wks	Mon 28/10/13	Fri 20/12/13	
5						
6		**NCIG Shorebird Schedule**	**132 day**	**Tue 24/09/13**	**Wed 26/03/14**	
1		**Green and Golden Bell Frog Compensatory Habitat Review of Environmental Factors [REF]**	**132 days**	**Tue 24/09/13**	**Wed 26/03/14**	
2		Confirm final pond designs for inclusion/assessment in the REF.	0 days	Tue 3/12/13	Tue 3/12/13	
3		NPWS to confirm approvals pathway (i.e. REF)	0 days	Fri 6/12/13	Fri 6/12/13	
4		**Prepare and finalise specialist studies**	**74 days**	**Tue 1/10/13**	**Fri 10/01/14**	
5		Prepare surface water, groundwater and soil study	66 days	Tue 1/10/13	Tue 31/12/13	
6		Commission Aboriginal cultural heritage assessment visual inspection	0 days	Mon 9/12/13	Mon 9/12/13	
7		Prepare Aboriginal cultural heritage assessment	20 days	Mon 16/12/13	Fri 10/01/14	6
8		Prepare draft 7-Part Tests of Significance	60 days	Tue 24/09/13	Mon 16/12/13	
9		Finalise 7-Part Tests of Significance (including specialist review)	25 days	Tue 17/12/13	Mon 20/01/14	2,8
10		Prepare draft REF	80 days	Tue 1/10/13	Mon 20/01/14	
11		Finalise REF	7 days	Tue 21/01/14	Wed 29/01/14	10,3,9,7
12		Lodge REF with NPWS for determination	0 days	Wed 29/01/14	Wed 29/01/14	11
13		NPWS to assess REF (including 40 calendar day guideline assessment period)	40 days	Thu 30/01/14	Wed 26/03/14	12
14		OEH Administering Authority to issue determination notice	0 days	Wed 26/03/14	Wed 26/03/14	13
7						
8						
9		**Commercial**	**87 days**	**Thu 14/11/13**	**Wed 26/03/14**	
10		Identify potential tenderers	7 days	Thu 14/11/13	Fri 22/11/13	
11		Provide tenderers with project description and outline of prequalification process	0 days	Fri 22/11/13	Fri 22/11/13	10
12		Tenderers complete PQ questionnaire	2 wks	Mon 25/11/13	Fri 6/12/13	11
13		Safety and Environmental Audit conducted	2 wks	Mon 9/12/13	Fri 20/12/13	12
14		Evaluate responses and determine prequalified tenderers	1 wk	Mon 23/12/13	Mon 6/01/14	12,13
15		Preparation of tender package	3 wks	Mon 16/12/13	Mon 13/01/14	4FS-1 wk
16		Legal review of tender package	1 wk	Tue 14/01/14	Mon 20/01/14	15
17		Provide tender package to prequalified tende	0 days	Mon 20/01/14	Mon 20/01/14	14,16
18		Tender period	4 wks	Tue 21/01/14	Wed 19/02/14	17
19		Tender Assessment and Contract Preparation Period	2 wks	Thu 20/02/14	Wed 5/03/14	18
20		Contract Award	0 days	Wed 26/03/14	Wed 26/03/14	19,6
21						
22		**Construction**	**297 day**	Tue 29/04/14	Tue 30/06/15	20FS+1 mo

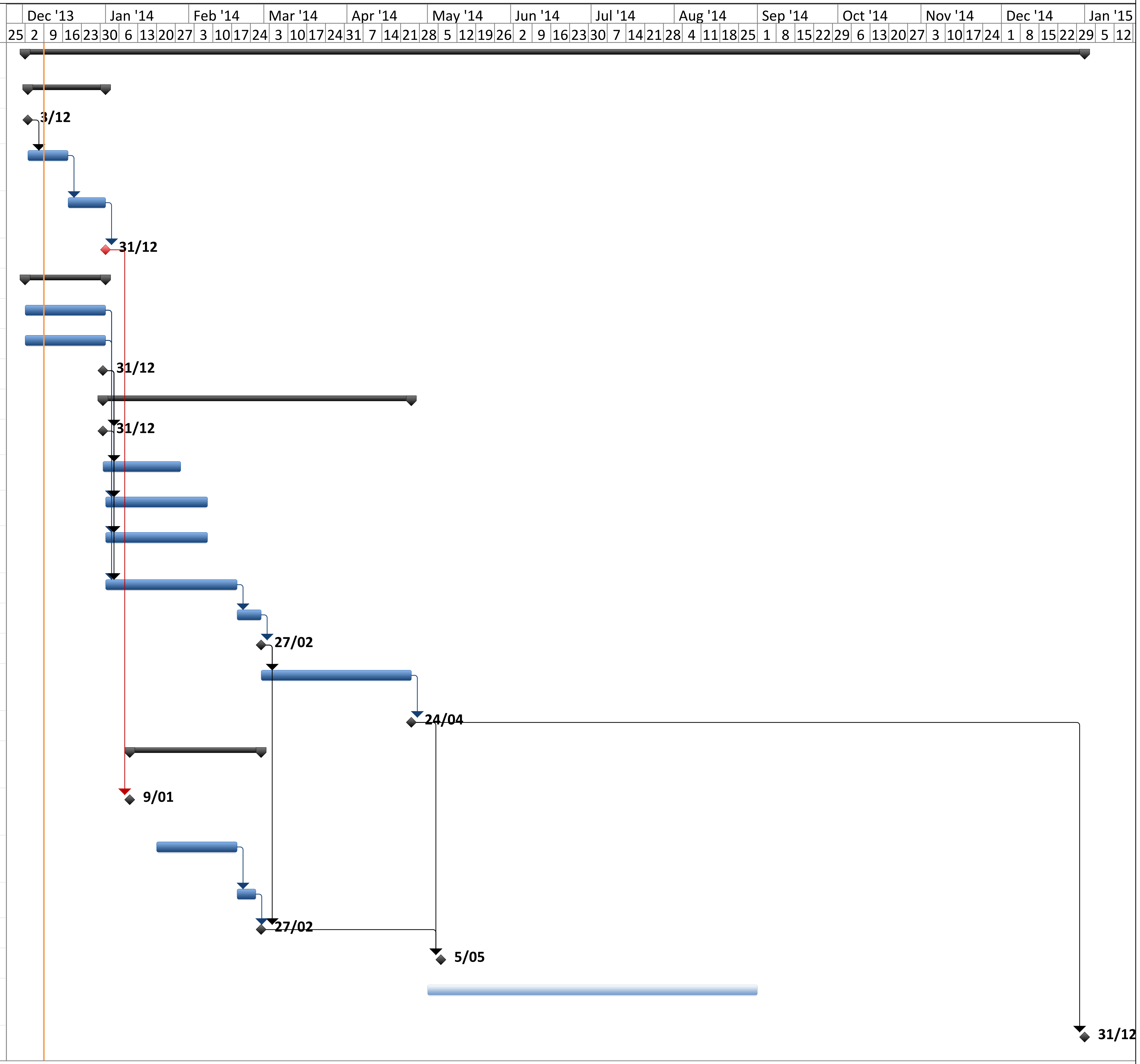


Task	Milestone	Slippage	Project Summary	Rolled Up Critical Split	External Milestone	Inactive Milestone	Manual Task
Split	Slack	Summary	Rolled Up Critical	External Tasks	Inactive Task	Inactive Summary	Duration-only

Manual Summary Rollup	Start-only	Deadline	Critical Split	
Manual Summary	Finish-only	Critical	Progress	

NCIG Compensatory Habitat and Ecological Monitoring Program [Green and Golden Bell Frog and Shorebird Components] Environmental Approvals Schedule DRAFT

ID	Task Name	Responsible
1	**Shorebird Compensatory Habitat**	
2	Security of Shorebird Compensatory Habitat Location at Area E	
3	Meeting with NPWS, DP&I and CMA to discuss habitat security	NCIG
4	Liaison with NPWS and DP&I to place legal restriction on habitat site at Area E	NCIG/RS
5	Preparation of conveyance documentation to secure habitat location at Area E	NCIG/Legals/NPWS
6	Security of the Shorebird Compensatory Habitat Location at Area E	NCIG/NPWS
7	Preliminary Works Prior to Confirmation of REF Process	
8	Commence preparation of figures to support REF	RS
9	Scope and commission specialist studies	RS/NCIG/Specialists
10	NPWS to confirm approvals pathway (i.e. REF)	NPWS
11	Shorebird Compensatory Habitat REF	
12	Confirm Project Description.	Terras/NCIG
13	Coordinate required field surveys (flora and fauna)	RS/Specialists/NCIG
14	Prepare specialist studies	RS/Specialists/NCIG
15	Prepare and finalise 7-Part Tests of Significance (including specialist review)	RS/Specialists/NCIG
16	Prepare draft REF	RS/NCIG
17	Finalise REF	RS/NCIG
18	Lodge REF with NPWS for determination	NCIG
19	NPWS to assess REF (including 40 calendar day guideline assessment period)	NPWS
20	OEH Administering Authority to issue determination notice	NPWS[OEH]
21	Application to obtain permit for mangrove removal under the NSW Fisheries Management Act 1994 (FM Act)	
22	Meeting with Industry and Investment NSW regarding the removal of mangroves	NCIG/RS
23	Prepare permit application form to harm marine vegetation under Part 7 of the FM Act	NCIG/RS
24	Finalise permit application	NCIG/RS
25	Lodge permit application form with final REF to I&I NSW for assessment	NCIG
26	I&I NSW to issue permit prior to commencment of works	I&I NSW
27	Mangrove clearing to be undertaken between May and August in accordance with CHEMP	NCIG
28	Completion of shorebird compensatory habitat works at Area E	NCIG



Note 1: Many tasks in this schedule are at the discretion of the NPWS and I&I NSW and therefore cannot be controlled by NCIG or RS.

Newcastle Coal
INFRASTRUCTURE GROUP

Compensatory Habitat and Ecological Monitoring Program – Quarterly Report

DATE: *31 March 2014*

AUTHOR: Philip Reid, Dr Ligia Pizzatto (Uni of Newcastle), Melanie James (Uni of Newcastle), Alex Callen (Uni of Newcastle)

APPROVAL: Nathan Juchau

INTRODUCTION

This report provides an update of activities relating to the NCIG Compensatory Habitat and Ecological Monitoring Program since the previous Quarterly Report from 9 December 2013. The report aims to provide information on key components of the program and how these are being implemented. An update will be provided to members of the Consultative Board every 3 months, in the form of a Quarterly report and presentations (every 6 months) coinciding with Board Meetings.

1. Research Area Ponds and Associated Monitoring

The 16 pond environment at the NCIG trial site ('the trial site') provides a pond choice experiment for a green and golden bell frog reintroduction program using a 2x2 replicated factorial design with pond depth and salinity as treatments to determine pond preference and passive chytrid management. Pond depth treatments were deep – permanent water (1.5m) and shallow – ephemeral water (0.5m). Salinity treatments comprised artificially salted ponds - to 3‰ using naturally derived sea salt and ponds that background salinity levels remained unmanipulated ('non salted'), however some deep ponds have been influenced by background salinity from the groundwater at the site.

This quarterly report provides a summary of investigations over the 2013/14 summer period. Night monitoring of the green and golden bell frog population continues at the trial site, recording the distribution and abundance of frogs across the sixteen ponds, their growth and potential chytrid infection load.

1.1. Climate and Site Conditions

Seasonal summer rainfall across the region was substantially lower than the historical average (BOM, 2013) and this resulted in five of the eight shallow ponds (ponds 1, 3, 8, 9 and 16) completely drying out in early November 2013. Storm events in late November resulted in partial refilling but these ponds dried out once again in January 2014. Water levels in deep ponds across the site also dropped considerably but they have not completely dried.

1.1.1. Water Quality, Water Depth and Rainfall

Pond water levels have receded due to unseasonably low spring and summer rainfall resulting in increases in pond salinity concentrations, including in non-salted ponds where background salinity was presumably a result of surface water/groundwater interactions. Mean salinity concentration of salt treated ponds reached 3.9 ‰ just prior to complete drying of shallow ponds in late October 2013 (Figure 1-1). Non-salted ponds reached a mean salinity concentration of 1.1‰ at the same time. Two rainfall events in November resulted in partial filling of the ponds, however with little groundwater recharge the shallow ponds subsequently dried out once again in January 2014.

As a result of low rainfall, most deep salted ponds maintained the critical 3‰ threshold up to October 2013 while shallow salted ponds exceeded this threshold with a mean level of almost 7‰ over the same period. We recorded a decrease in mean salinity concentrations of salted and unsalted ponds even after two rainfall events in November that replenish the ponds to about 40cm. Thereafter, weekly water quality data taken from each pond using a hand held YSI water quality meter showed a slow increase in salinity concentration towards treatment levels over time, suggesting an incremental environmental release post rainfall (Figure 1-1). Non-salted ponds showed a negligible increase in salinity concentrations over this period. Freshwater lenses and subsequent stratification of salinity in pond water occurred immediately following heavy rainfall and uniform mixing at each pond occurred within about a week of rainfall.

Salinity above 6.4‰ are considered beyond the survival threshold tolerated for frogs (i.e. – there may be a drop in occupancy of these ponds as frogs disperse in search of less saline ponds) and concentrations above 4‰ are considered detrimental to tadpole development and survival (Stockwell, 2011). Section 1-2 describes the relative abundance of frogs by pond type and the tadpole release undertaken in December 2013 – February 2014 in relation to water quality of ponds at the site.

Water depth also continued to drop over time (Figure 1-2). Pond replenishment appears to occur as result of both rainfall (increase in depth for shallow ponds correlated to rainfall), and via groundwater expression in deep ponds, when periods of high rainfall result in substantial aquifer recharge. The latter form of pond replenishment is illustrated in Figure 1-2 by a time lag where pond depth increases can occur up to one month from the initial rainfall event as a result of infiltration of precipitation through the unsaturated zone. Figure 1-3 and Figure 1-4 illustrate the extent of water drop in deep and shallow ponds across the site.

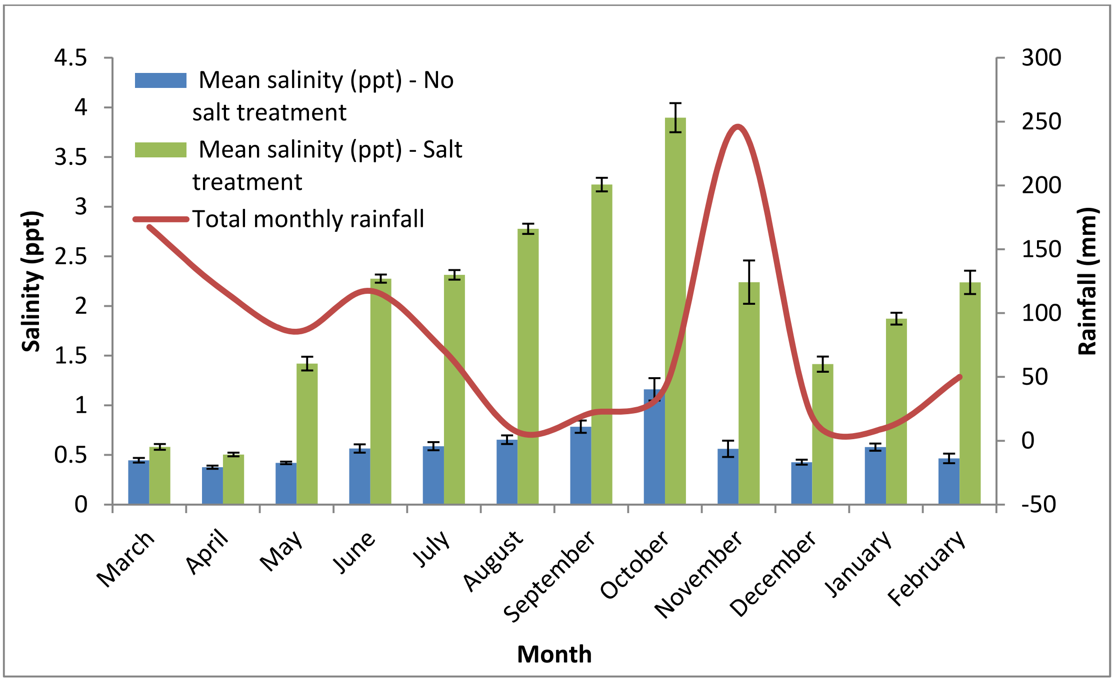


Figure 1-1 Mean salinity over time by salt treatment (‰). Columns represent salinity and the red line represents total monthly rainfall (mm). Whiskers represent standard error. Rainfall data obtained from the Australian Government Bureau of Meteorology.

The three month forecast by the Bureau of Meteorology predicts autumn rainfall and temperatures to be consistent with the median experienced across the lower Hunter over the last 29 years. Should autumn rainfall not reach expected levels then additional salting of ponds may be required to bring salinity levels up to the

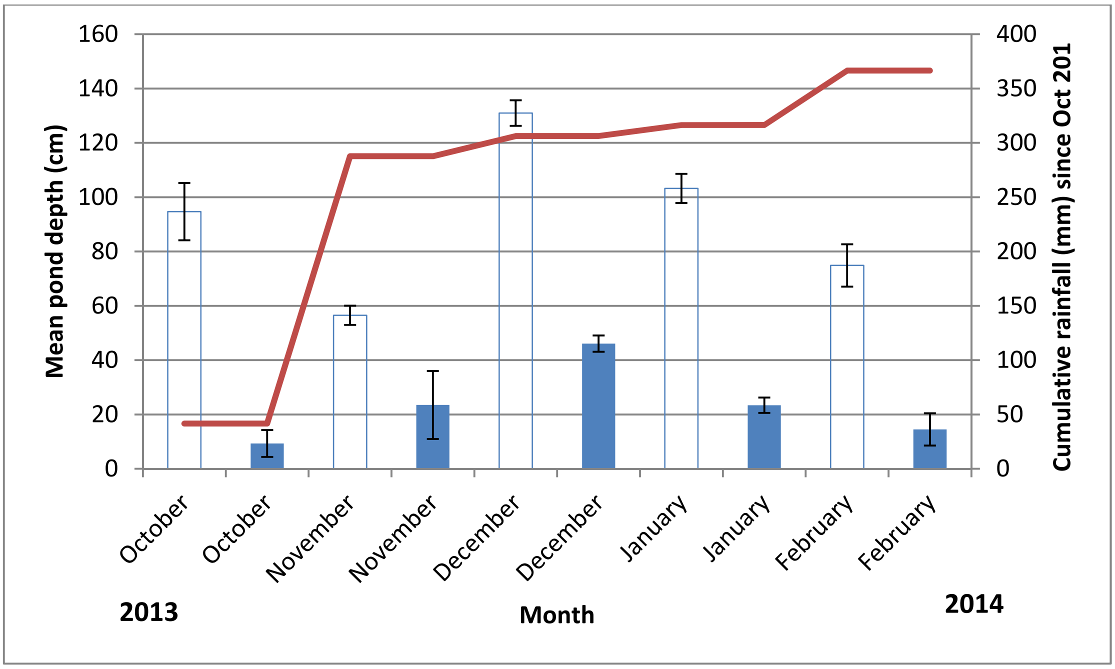


Figure 1-2 Mean pond depth (cm) over time and cumulative rainfall (mm). Open columns represent deep ponds (1.5m, permanent) and closed columns represent shallow ponds (0.5m, ephemeral). Whiskers represent standard error. Cumulative rainfall data was obtained from the Australian Government Bureau of Meteorology.

treatment threshold in order to maintain the experimental design of the project and address the research question. If required, new dosing needs to happen prior to any potential outbreaks of chytrid with the onset of winter, and a decision in regards to this matter will be made in April, or earlier if mean pond water temperatures drop below 20°C.

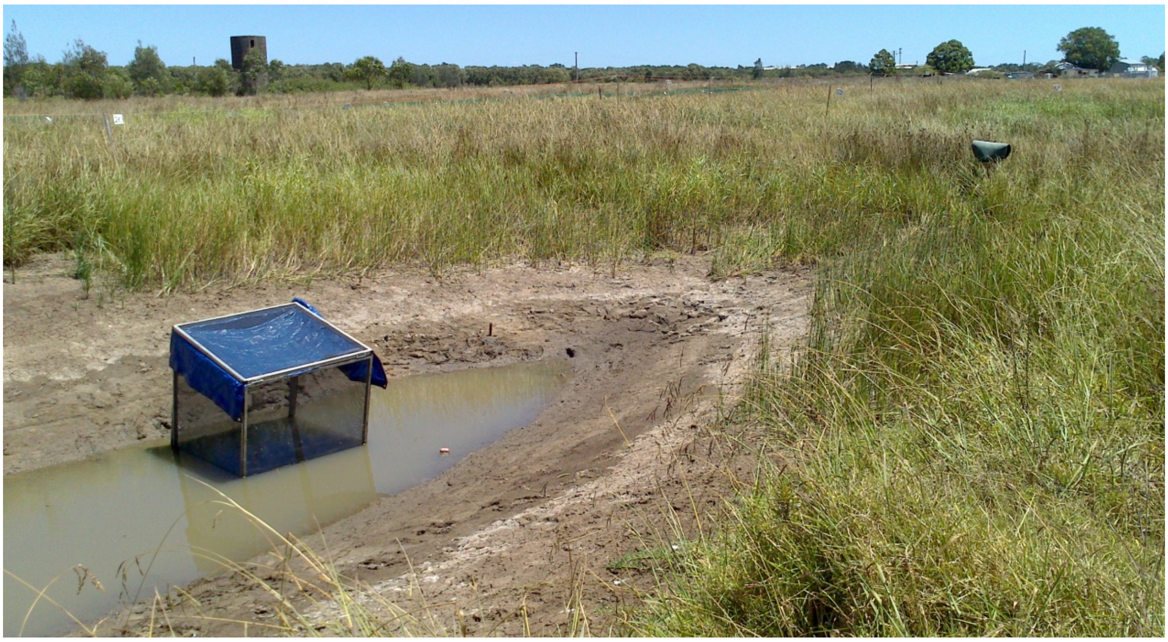


Figure 1-3 Water level contraction at Pond 4 (deep) at the NCIG trial site due to lack of rainfall, January 2014. Pond 4 was a tadpole release site as depicted by the tadpole basket in the foreground.

Figure 1-4 Drying out of pond 1 (shallow) at the NCIG trial site due to low rainfall, January 2014

1.2. Trial Ponds Monitoring and Research

1.2.1. Pond Preference through Visual Encounter Surveys

Visual encounter surveys of all 16 ponds occur fortnightly across the site. Data on the density of frogs sampled during the visual encounter surveys around the ponds was standardized by time and is represented as the mean number of frogs encountered per minute by pond treatment and by season (Figure 1-5). The increasing density of frogs over spring and summer correlates with increasing ambient temperatures and the onset of the breeding season for the species. Lower densities associated with the autumn season in 2013 may be attributed to decreasing ambient temperatures and may also be associated with the rate of metamorphosis of tadpoles released at the trial site as the initial population.

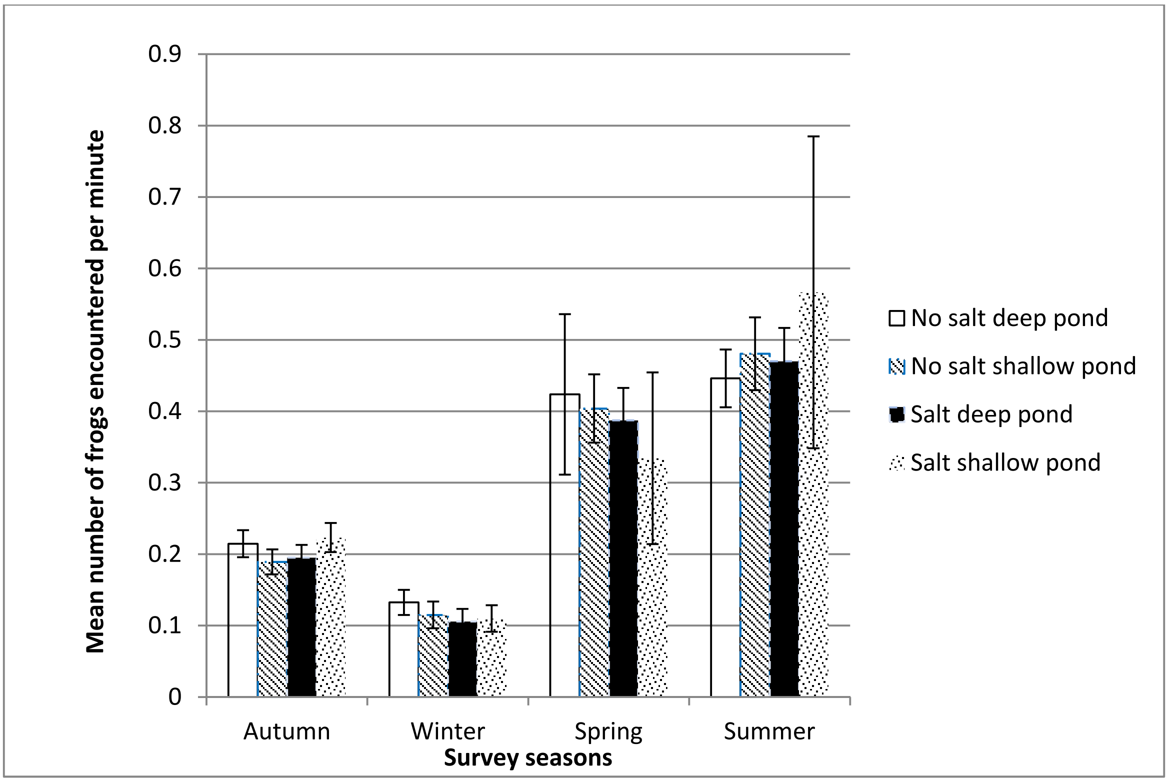


Figure 1-5 Results of visual encounter surveys recorded as the mean number of frogs encountered per minute across all four seasons. Whiskers represent standard error

Standard errors associated with the mean number of frogs encountered per minute by pond treatments and by season confirm the results of previous analysis that suggests that to date there has been no long term trend in frog preference for a particular pond type (shallow, deep, saline or fresh) at the trial site based on the experimental concentrations of salinity at 3‰. Closer analysis of data for the driest and warmest months at the trial site to date suggests some short term dispersal away from shallow salted ponds where individual pond concentrations exceeded 7‰. This is discussed in further detail below.

Stockwell (2011) summarised the range of water quality variables suitable for all life stages of the green and golden bell frog (Table 1-1), suggesting salinity less than 4‰ as suitable for tadpole survival and concentrations less than 6.4‰ suitable for frog survival. Salinities greater than the suitable survival range for frogs were exceeded in October and November 2013 after prolonged drought.

This occurred in three of the treated shallow ponds where salinity reached as high as 8‰, and remained that high over a two week period. Subsequently the ponds dried out completely or were replenished by November rainfall.

Table 1-1 The threshold range of water quality variables (shaded grey) determined as the range found suitable for survival in the literature cited and from occupied habitat on Kooragang Island and Sydney Olympic Park, with a 5% buffer for pH and 10% for all other variables (from Stockwell, 2011).

Water Quality Variable	Suitable range for survival		References	Threshold Range	
	Tadpoles	Frogs		Tadpoles	Frogs
Water Temperature (°C)	16-31	4-35	(Hamer 1998; Penman 1998; Browne and Edwards 2003)	14.4 - 34.1	3.6 - 38.5
Salinity (ppt)	< 4*	< 6.4	(Werkman 1999; Stockwell 2011).	< 4.4	< 7.04
pH	4-9	4-10.2	(Penman 1998)	3.5 – 9.5	3.5 – 10.7
Dissolved Oxygen (mg/L)	4.1 – 17.1		No references available. Range from known habitat alone.	3.7 – 18.8	

*** In the references provided, tadpole survivorship was not affected up to 4 ppt. However, in one study, tadpole survivorship was reduced at 2 ppt (Christy and Dickman 2002).**

Figure 1-6 illustrates the mean number of frogs encountered by pond treatment by month relative to salinity concentrations of each treatment during the driest period of the study so far – October 2013 to February 2014. Averages and standard error bars associated frog densities per month show little difference among treatments, with the exception consistently lower number associated with shallow salted ponds in October, November and December. However, mean salinities associated with salt-dosed ponds (shallow and deep) were high in October and showed a trend of rapid decrease after heavy rainfall in November with no major shift in frog densities in deep salted ponds. Additionally, mean salinity of deep salted ponds shows a trend of increasing since December, while the shallow salted ponds are showing a decrease in mean salinity since January. The decrease in mean salinity across shallow salted ponds may be associated with several ponds drying out in January (resulting in no water in which to measure salinity) or the dilution factor associated with pond replenishment to maintain tadpole habitat (in ponds 6 and 14). Given that shallow salted ponds have presented more variable salinities between October and February with no substantial change in the mean density of frogs, it is possible that pond preference by frogs in this period has been driven by the presence of water rather than salinity concentrations.

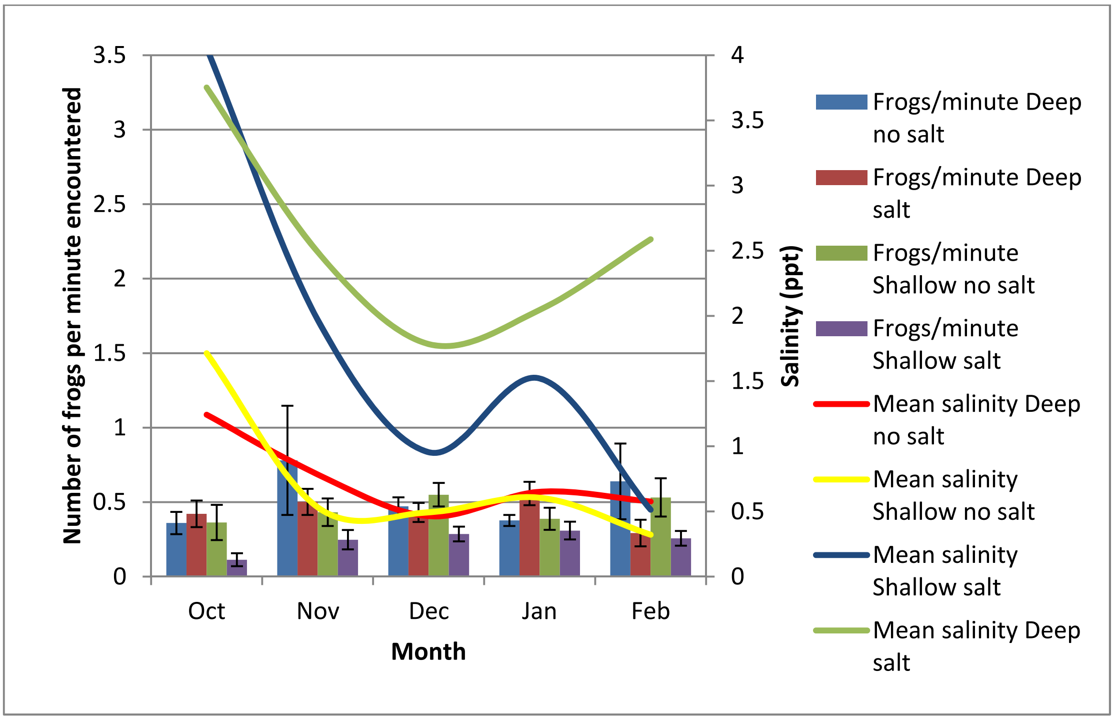


Figure 1-6 Mean number of frogs encountered per minute by pond treatment and mean salinity by pond treatment since October 2013. Whiskers represent standard errors.

The mean number of frogs encountered at deep and shallow ponds between October 2013 and February 2014 suggests a more stable mean density of frogs associated with the water permanence of deep ponds, than the mean monthly densities associated with shallow ponds that seem to fluctuate with depth (Figure 1-7). Further analysis of the role of pond permanency, water temperature and salinity concentrations will be undertaken on an annual data set.

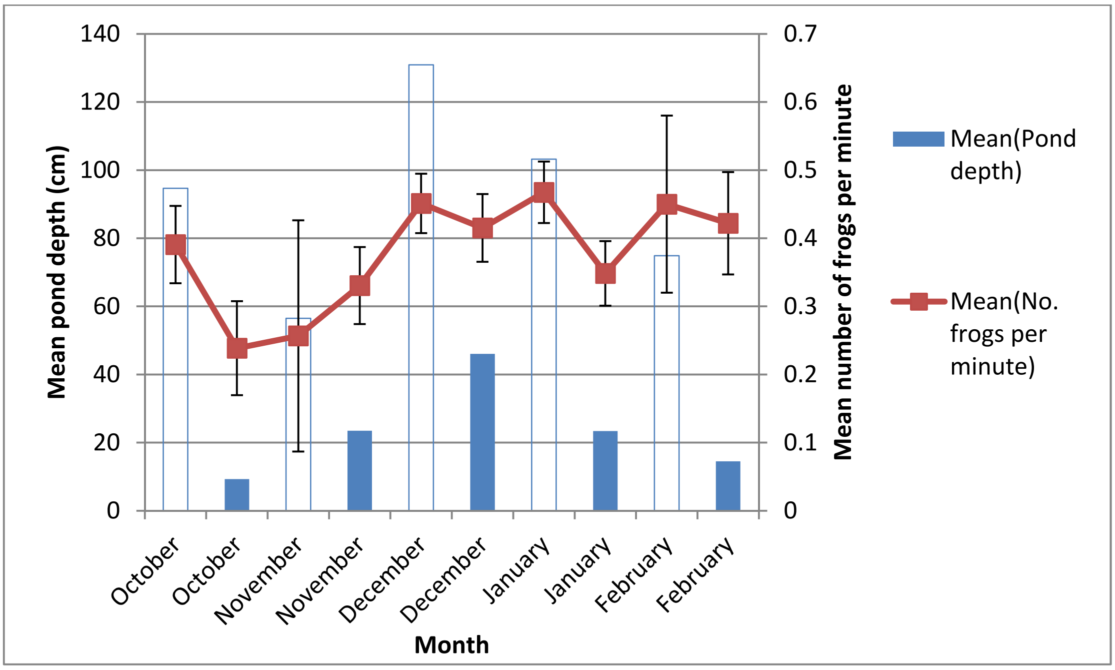


Figure 1-7 Mean number of frogs encountered per minute by pond depth (deep - 1.5m permanent open bars, shallow - 0.5m ephemeral closed bars). Whiskers represent standard errors

1.2.2. Mean Morphometrics

Individual body mass (M) and snout urostyle length (SUL) are measured each time a frog is captured. On average frogs are caught from each pond once per month, weighed, measured, swabbed and recapture status is recorded. Almost twelve months of data has been collected in relation to M and SUL of individuals sampled from the trial site population (Figure 1-8). Mean body mass and length are closely related in juvenile frogs captured between March and July 2013. Trends in body mass and length post-overwintering continued to correlate as juveniles matured into adulthood.

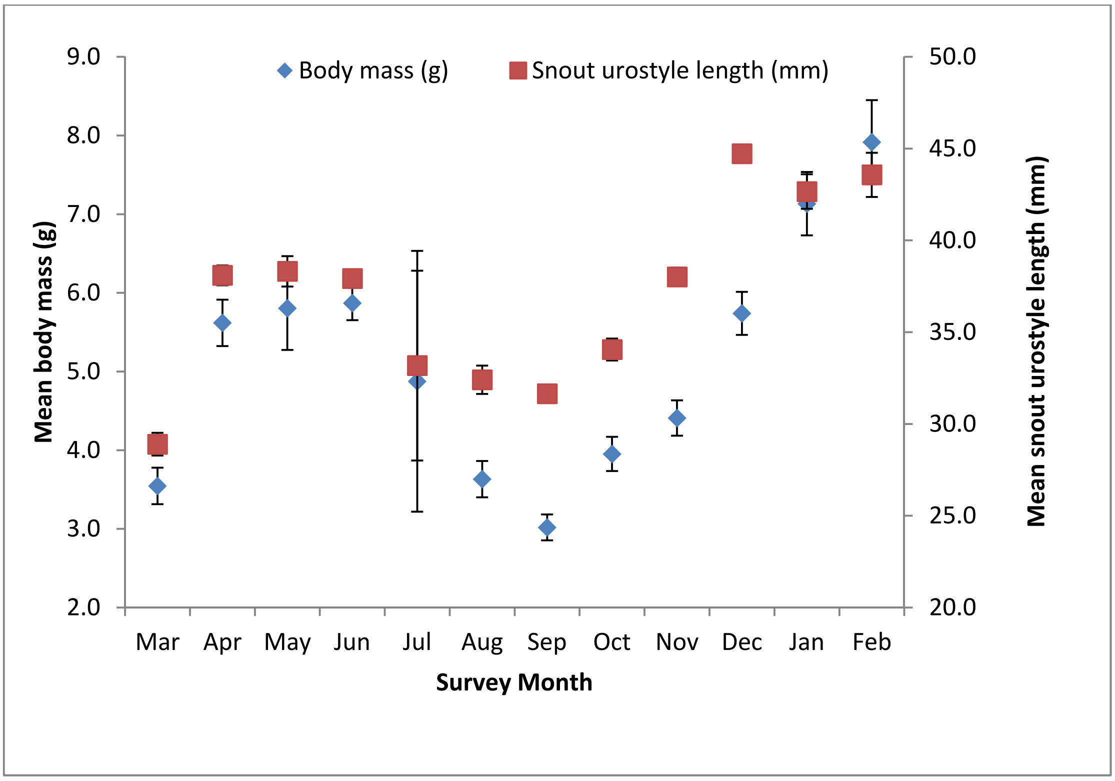


Figure 1-8 Mean morphometrics of captured individuals by month. Whiskers represent standard error.

1.2.3. Population Demographics

Population demographics at the trial site are still heavily biased by juveniles as expected in the first year of a single-age biological re-introduction (Figure 1-9). Juveniles comprised 100% of the sampled population over autumn and winter, with a small cohort of adults (males) and sub adults (females) emerging into spring. The proportion of metamorphs recorded in spring relate to a single release of individuals that had over-wintered as tadpoles at the breeding facility at the University of Newcastle and were then released. Summer surveys recorded a greater number of adults, with some males reaching sexual maturity in November, as evidenced by the presence of nuptial pads and commencement of calling. Calling by males was recorded in one pond in early November, with subsequent calling events occurring in up to five ponds in the same month post-rainfall (irrespective of pond treatment). Calling frequency and distribution diminished in

February regardless of rain events, and is currently confined to Pond 12. The presence of metamorphs in the summer population is a result of the second breed and release event undertaken between December and February at the site.

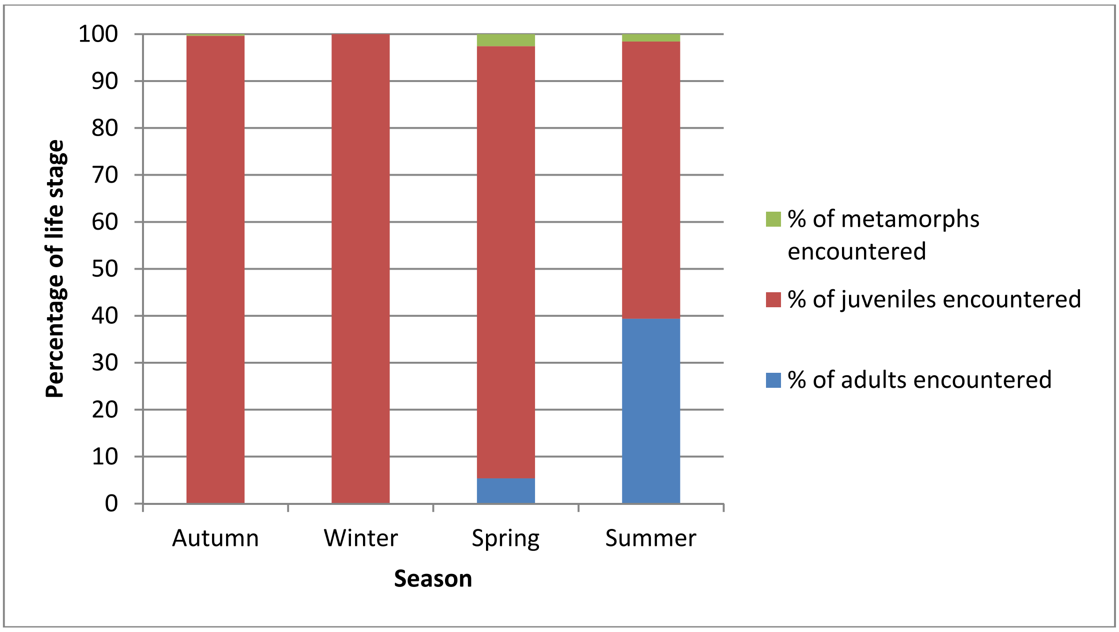


Figure 1-9 Trial site population demographics represented by percentage of life stage by season

1.2.4. Recapture History

Over 600 individuals have been micro-chipped at the trial site to provide data on pond choice and pond shifting in response to life stages and environmental conditions. The proportion of recaptures in any given survey event remains less than half of the total number of individuals captured (with the exception of winter surveys which are represented by a very small catch size and every individual caught (N=7) was a recapture). Low recapture rates are expected to continue as tadpoles from the second breed and release event in summer metamorphose and join the frog population (Figure 1-10). The low and consistent rate of recapture suggests a significant proportion of the trial site population is never captured (often characteristic of large population or re-capture shyness) or there is high apparent mortality (real mortality + emigration). Apparent mortality has not been observed in high numbers at the trial site and emigration, while observed, is also unlikely to be high.

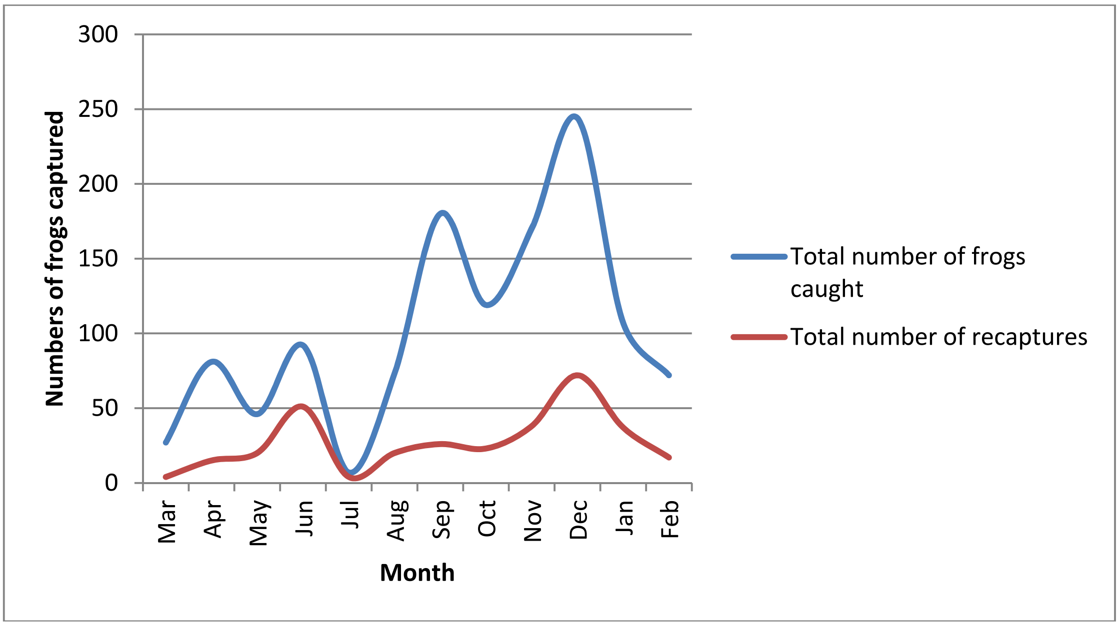


Figure 1-10 Total number of recaptures and total number of frogs caught by month at the NCIG trial site

1.2.5. Tadpole Releases

During the spring and onset of summer 2014 tadpoles were released in eight ponds at the trial site. As five of these ponds started to dry out they were replenished using the potable water supply available at the site. This intervention was necessary for complying with animal welfare and as an attempt to maintain a viable population. Ponds were maintained at or near a 30cm depth to provide optimum conditions for the development and metamorphosis of these tadpoles. Approximately 12 000 tadpoles were released to eight ponds at the trial site in this period, topping up the original translocation of approximately 8000 tadpoles in February 2012. The highest rate of metamorphosis for all ponds was recorded in January (Figure 1-11).

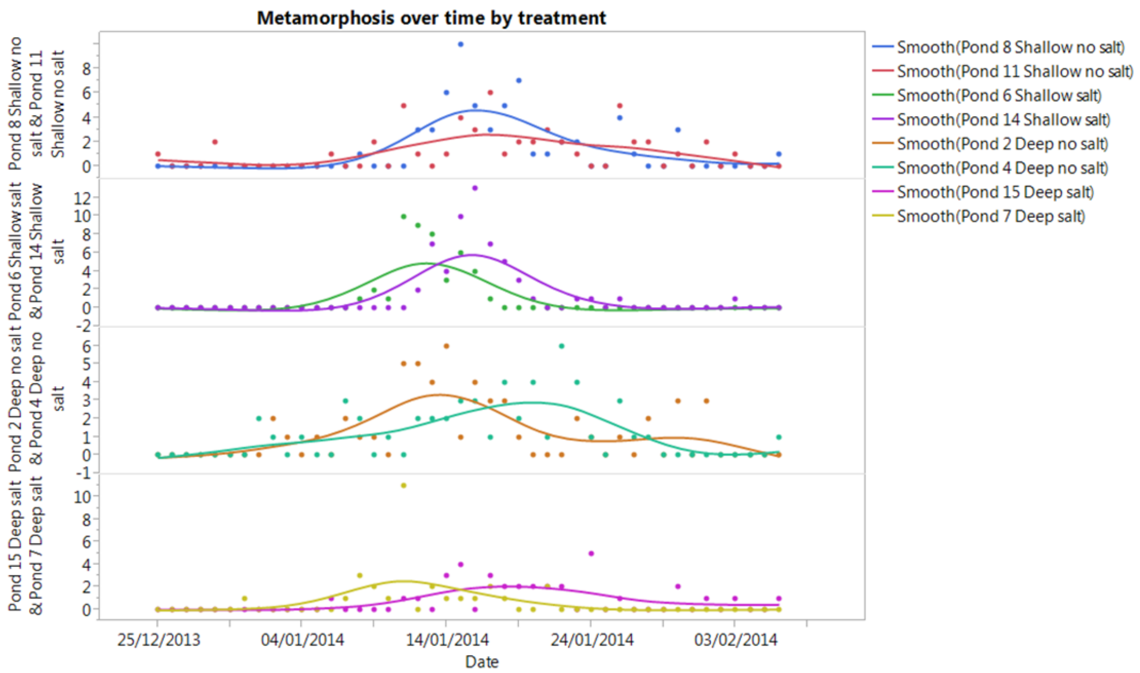


Figure 1-11 Time to metamorphosis of tadpoles associated with the 2013-14 breed and release event at the trial site. The x axis represents the total duration of metamorphosis by pond and the y axis represents number of metamorphs by pond treatment.

1.3. Future Site Investigations

A number of ancillary investigations are planned for the trial site in 2014. These include a formal population estimate, understanding the interactions between groundwater, pond permanency and salinity and the recommencement of the overwintering habitat investigation which was undertaken on the site in 2013.

1.3.1. Population Estimate

A formal population estimate will be conducted in 2014, with an intensive mark-recapture program started in February to collect robust data for the estimate. This initial estimate will provide the foundation for a probable estimate of survival analysis which could be determined if an additional intensive mark-recapture program is undertaken in early 2015.

1.3.2. Groundwater Characterisation

The effects of tidal regime of the Hunter River on groundwater, and interactions between surface pond water and the aquifer require characterisation. These relationships are essential to understand whether the trial design (specifically pond depths in relation to groundwater location) can provide pond permanency and a salinity gradient (to inhibit chytrid) to sustain a bell frog population without ongoing management.

This investigation is in the planning stage and will be scoped in greater detail once an analysis of existing data has been undertaken.

1.3.3. Overwinter Habitat

The thermal gradients of potential overwintering habitats on the site in comparison with ambient air temperatures will recommence in May. Temperatures will be recorded in rock crevices and pond vegetation and compared with ambient air temperatures to determine whether these habitats do provide a micro-climate that reduces the impacts of winter temperatures on frogs. Artificial overwintering habitats which were installed at the site last year will also be monitored for temperature and humidity. A fibre optic scope will be used to randomly sample vegetation and rock habitats for the presence of hidden frogs.

1.4. Site Maintenance

Several site maintenance activities have occurred over the 2013/14 spring-summer. These have included mowing to prevent bell frog emigration and non-target frog immigration, fence patching for similar purposes and pond replenishment to maintain suitable aquatic habitat for the tadpole breed and release event.

1.4.1. Mowing

Prolific growth of exotic grasses (particularly Paspalum) to heights greater than 1.5m near the fence formed an escape route for bell frogs. A clearance area of about one metre wide is now maintained on the inside of the fence using a mulching mower and whipper snipper. This has occurred four times since early December, and will likely continue as a site maintenance requirement until growth slows in late autumn/winter. A wider buffer on the outside of the fence has been created by NCIG as a firebreak, and is intended to be maintained by them using glyphosate.

1.4.2. Maintaining Fence Integrity

A number of holes continue to be observed in the shadecloth fence for the site. These have been patched on an ad-hoc basis by both the University and NCIG personnel and with a focussed effort covering more than 20 holes in January 2014. Fence inspections will continue weekly by researchers working on the site.

1.4.3. Pond Replenishment

The translocation of approximately 12 000 tadpoles to eight ponds at the trial site commenced in December and was completed in February. Replenishment of some of those ponds with potable water was required due to rapid drying as a result of low rainfall, high summer evaporation and strong winds. Pond levels are being maintained as close to 30cm deep as possible to ensure appropriate habitat for the development and metamorphosis of these individuals. Due to the volume of water required to fill these ponds, supply is run continuously under hydraulic pressure from the tank at the site to the ponds via hoses once critical depths are reached.

2. Behavioural Ecology Research

2.1. Post-Doctoral Fellowship Funded by NCIG

Dr. Ligia Pizzatto is conducting research on conspecific attraction in Green and Golden Bell frogs, as accepted in the original research programme proposal. Research question 1 in the proposed Research Program asks if green and golden bell frogs (Litoria aurea) are attracted to areas occupied by conspecifics.

Research question (1) is being addressed using field and laboratory experimentation. PhD candidate Alex Callen conducts visual surveys and mark-recapture of frogs in the NCIG trial site. In collaboration with Alex, data on pond occupancy and distribution of the frogs in the site will be analysed to reveal the spatial pattern in a site that excludes potential effects of micro-habitat availability (because each pond in the trial site are similar in habitats). Pattern of distribution of frogs and its relationship with habitat traits is also being investigated in collaboration with PhD candidate Melanie James.

In the laboratory, Dr Pizzatto is conducting a set of experiments to test conspecific attraction in tadpoles, juveniles and adult frogs, focusing on visual and chemical attraction, while Melanie James focuses on auditory (call attraction).

2.1.1. Do Schooling Tadpoles of Green and Golden Bell Frog prefer to aggregate to Kin and Familiar Conspecific?

As stated in the last report (November 2013), preliminary data based on two clutches suggested kin and familiarity attraction, but also revealed the need to include another clutch for robustness of the results. A new clutch was obtained and tested in December 2013, videos were scored and analysis is in progress.

2.1.2. Do green and golden bell frog tadpoles recognize alarm pheromones from conspecific?

Full results of this trial were presented in the previous report and are now being prepared for publication in a scientific journal.

2.1.3. Do green and golden bell frog juveniles select their habitat based on conspecific cues?

Full results of this trial were presented in the previous report and are now being prepared for publication in a scientific journal.

2.1.4. Do breeding males of green and golden bell frogs attract other breeding males and females?

We have already shown that juvenile L. aurea do prefer habitats where conspecifics are, but this response can differ according to age, sex, and breeding status. Male frogs form calling aggregations in the breeding season to attract gravid females. How these aggregations are formed and attract females is unknown. In this experiment we tested (1) the role of chemical cues of breeding males and (2) the presence of a breeding male in the attraction of (a) another breeding male and (b) a breeding female.

Figure 2-1 Arena used in trials to test the effect of the presence of adult males in breeding habitat selection of males and females. One stimulus breeding male is placed in one of the dark screened basket and the other is left empty. A testing individual is released from the white basked in the centre of the arena, and the time it spends in each side is recorded.

Figure 2-2 Arena used in to test the effect of scent of adult males in breeding habitat selection of males and females. The photo shows half of the arena where five stimulus breeding males are placed let to use it for 24h. Then, stimulus frogs and the white middle barrier are removed, one testing individual is released in the centre of the arena, and the time it spends in each side of the arena is recorded. The opposite side (not shown in this photo) is equal to this one but do not house stimulus frogs.

Adult frogs from the breeding colony showed signs of being ready to breed in late September 2013 (females had increased body weight and males had dark nuptial pads and started to call). Trials started at that time and lasted until early January 2014 when nuptial pads started to fade. A total of 15 males and 15 females were tested in both chemical and presence trials. Trials followed the same design as for those using juveniles. Videos were scored and the preliminary data do not show any attraction or repulsion of conspecifics, but sample sizes is still small and will need to be increased in the next breeding season when more animals (currently sub-adults) will be mature.

Still related to the above question, additional field work was conducted in the NCIG trial site from early November to January (roughly twice a week) when males were detected calling in the ponds. During that period the location of calling aggregations were recorded from visuals and auditory surveys, a behaviour record protocol was established, and observations of the breeding behaviour were conducted to improve our understanding of the conspecific attraction of breeding adults and the mating system of the bell frogs. Six sound recording devices (sound meters) were placed in the edge of randomly selected ponds to record 24h data on bell frog calls from November to December. This data will inform us about the pattern of pond occupancy for calling activity. From December to the present sound meters were placed in ponds where calling activity to focus data collection on the circadian cycle of the calling activity.

Behaviour observations followed two standard methods: scanning and focal behaviour. First, an initial night of observations established and ethogram with the range of behaviours displayed by calling males. Then, in following nights I used the scanning method to record the behaviour (established from the ethogram) of up to seven individuals in the chorus, every 20 seconds for 10 minutes. Each 10 minutes session had a10 minutes interval during which I focused in describing the nature, and recording frequency and duration of agonistic interactions among males in the chorus. The 10 min section of scanning behaviour followed by 10 min focal behaviour observations were repeated for up to 2h.

The gathered data on breeding behaviour is currently being computed to follow analyses. It is intended that breeding behaviour observations will continue in the next breeding season when we expect to have breeding females in the site. Sound meter recordings are currently being stored for posterior analyses.

Research question (2) of the Research Program asks if Green and Golden Bell frogs (Litoria aurea) use the presence of conspecifics to determine habitat suitability. This question is being addressed in two similar experiments in which the describer of a “rich habitat” is varied.

2.1.5. Do green and golden bell frogs choose a ‘poor habitat’ where conspecifics are present over a ‘rich habitat’ where there are no conspecifics?

In a first experiment the ‘rich habitat’ was characterized by the presence of shelter (artificial plants in one side of the arena). In the treatment trials frogs were let to choose from the half of the arena containing shelter but no conspecifics or the other half without shelter but adjacent to conspecifics. Control trials were run to test if in the absence of conspecifics the frogs would choose the rich habitat. Both control and treatment trials are concluded for 25 individuals, and videos are being scored to allow data analyses.

In the second experiment ‘rich habitat’ was characterized by the presence of food (crickets), and trials were conducted as above. Both control and treatment trials are concluded for 24 individuals, and videos are to be scored to allow data analyses.

2.2. PhD fellowship partially funded by NCIG GGBF Research Programme

Melanie James has been approved in her PhD presentation and is confirmed as a candidate. Melanie’s project addresses conspecific attraction/repulsion based on auditory cues (calls), as part of the research questions 1 and 2 of the Research

Project. She is investigating the role of calls on habitat selection of green and golden bell frogs in different life stages, under laboratory and field conditions.

2.2.1. Are adults attracted to the calls of conspecifics (adult breeding males and gravid females)? Do non-gravid adult females avoid calling males?

To answer these questions animals will be experimentally exposed to the sound of calling adult males in laboratory. The response of the testing animals to calling will be compared to a control (no sound) and manipulative control (static).

As previously reported (November 2013) this experiment required some alterations that are now approved by the ethics committee, and will either commence after the completion of the juvenile study (see next experiment) or may occur over September – February in the next L. aurea breeding season.

2.2.2. Do early life stage L. aurea (juveniles, metamorphs and tadpoles) avoid conspecific calling or change their behaviour in the presence of those calls?

This study aims to determine whether the calls of conspecific males act as a mechanism driving early life stage behaviour and habitat selection. Similar to the conspecific chemical cues and presence trails conducted by Dr Pizzatto, in this experiment individuals have the choice of using two sides of an arena that are equal in habitat features (thus equal quality), but one has acoustic (call emissions) cues of conspecifics and the other does not. It also includes testing individuals under control conditions (no sound) and manipulative control (static sound) which allows us to understand change in behaviour (e.g. increase or decrease of activity) in the presence of the stimulus (call).

The experiment was conducted using large juveniles from 35 mm to 45 mm snout vent length (SVL). Preliminary statistical analysis was done as a full factorial comparison between location and treatment, and number of movements and treatment.

In the treatment trials (L. aurea calls), juveniles spent similar percentage of time in each side of the arena, with only a minor, non-significant, increase in use of areas away from speakers (Figure 2-3: See red circles, $P > 0.7181$). This indicates that juveniles did not have a preference for habitats containing or not conspecific calls.

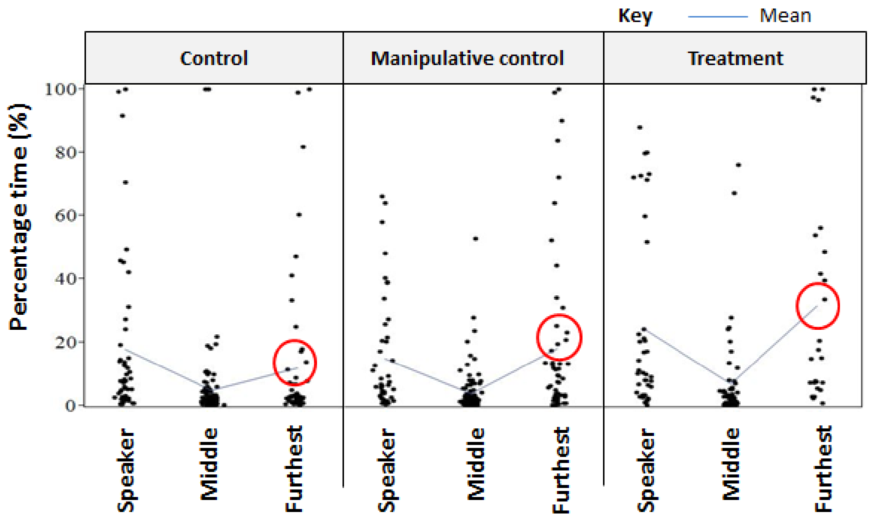


Figure 2-3 Percentage time spent at each section of the arena (furthest from speaker, in the middle or closest to speaker) on control (no sound), manipulative control (speaker static) and treatment (playing Litoria aurea calls from speakers) trials using juvenile frogs. The red circle evinces a slight, but non-significant, increase in use of the section furthest of the calls (call avoidance).

The total number of movements (proxy for activity) among arena sections was slightly lower in the treatment trials (L. aurea calls; Figure 2-4) than in controls or manipulative controls. However, this difference was not statistically significant (P > 0.2718).

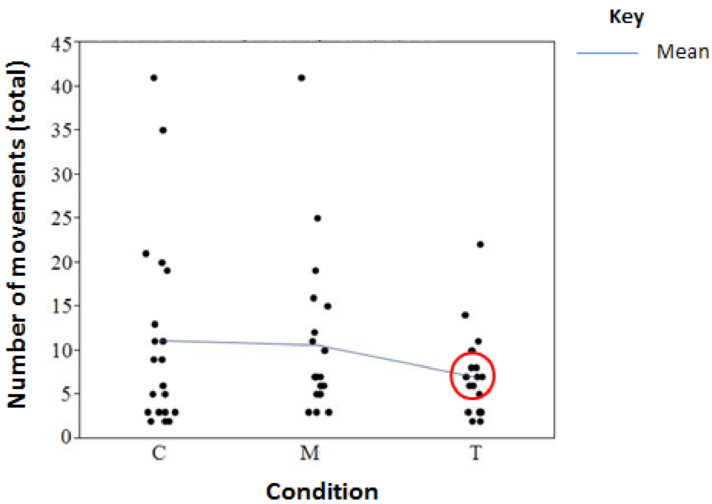


Figure 2-4 Total number of movements between each side of the arena on control (C = no sound), manipulative control (M = speaker static) and treatment (T = playing Litoria aurea calls from speakers) trials using juvenile frogs. The red circle evinces a slight, but non-significant, low number of movements (activity decrease) in treatment trials.

Currently a more sophisticated analysis is being organised to incorporate possible effects of temperature, day of testing, and order of conditions as co-variables. Trials using small juveniles (≤ 35 mm SVL) and late stage development tadpoles are planned to commence.

2.2.3. Do adult green and golden bell frogs use the presence of conspecifics (social information theory) to determine breeding habitat suitability?

This study aims to determine if male L. aurea from natural populations choose to call in specific sites based on habitat features by comparing features from sites where males are calling with the availability of habitat within ponds to determine if there is selectivity. This study is ongoing and replicates are being increased through the inclusion of ponds on Kooragang Island.

3. Annual Green and Golden Bell Frog Monitoring

As part of the NCIG EPBC Act Particular Manner Decision (2006-2987), NCIG are required to undertake monitoring of Green and Golden Bell Frogs in locations around the NCIG Terminal on Kooragang Island. PWCS monitored this area for Green and Golden Bell Frogs in 2012/13 as part of the T4 pre-feasibility study. Data for this season has been provided to NCIG, which has been incorporated into the 2012/13 Annual Environmental Management Report.

In addition to this, NCIG is establishing a monitoring and research sharing agreement with PWCS. The results of research being conducted by PWCS at the University of Newcastle will be made available, including the effect of solutes on bell frogs. There will be an opportunity for Newcastle Port Corporation (or the private entity that will lease the port) to join the information sharing agreement, as they will have bell frog impacts resulting from capping works of the Kooragang Island Waste Emplacement Facility (KIWEF). While BHP Billiton has not entered an information sharing agreement with NCIG and PWCS, discussions have commenced regarding how an information sharing agreement can be arranged.

The Monitoring for season 2013/14 has commenced and results for this will be available at the end of the season, i.e. April/May 2014.

4. Breeding Program

The breeding pairs utilised for NCIG's Research Area are being retained at the University of Newcastle, with the intent of utilising these either for experimental pursposes or for populating the NCIG Green and Golden Bell Frog Compensatory Habitat, which will be completed prior to the 2014/15 Summer.

The breeding facility may also be used to populate PWCS compensatory habitat developments or existing habitat with the potential to support the local Green and Golden Bell Frog population. Costs for managing the breeding individuals are currently assumed by both NCIG and PWCS.

5. Green and Golden Bell Frog Compensatory Habitat

5.1. Review of Environmental Factors and Land Access

The previous quarterly report stated that a Review of Environmental Factors (REF) was being developed to identify potential environmental issues and mitigation and management measures when constructing and managing the proposed Green and Golden Bell Frog compensatory habitat on Ash Island. This was submitted to NPWS for review on 24 January 2014. A Determination on the activity was provided by NPWS on 28 February 2014, which found that the activity was permissible within the Hunter Wetlands National Park subject to the conditions detailed in Schedule 1 of the Determination Notice. These conditions cover a number of key environmental management measures, development of relevant management plans and entering into a licence agreement with NPWS for land access.

The licence was provided to NCIG on 27 March 2014, specifically a Section 151A Licence for Minor Operations. This is currently being reviewed internally by NCIG and is likely to be signed and handed back to NPWS prior to the end of April 2014.

5.2. Civil and Earthworks Package

The NCIG Compensatory Habitat Team is progressing the civil earthworks package in preparation to commence habitat construction works in Quarter 2. The tender process was opened on 25 February 2014, with a site meeting held on 4 March and tender responses received by 14 March. Three (3) tender responses were received and an evaluation process has been conducted with a preferred tenderer chosen. NCIG is currently in contract negotiations with the preferred tenderer, and agreement on conditions is expected to be reached in the coming weeks.

Development of specific management plans, eg. Public Safety Management Plan, Incident Management Plan and Dilapidation Report, are currently underway with the preferred tenderer. First versions of the plans will be submitted to NPWS for approval prior to commencement of construction. Based on the likely time required to develop these plans and sign the s151 Licence, the successful contractor is scheduled to mobilise to site around the first week of May 2014.

As mentioned in the previous quarterly report, constructability is considered a significant part of the project. For this reason, the construction schedule will allow for no more than two (2) work fronts at a time to limit the amount of construction plant present in the national park, and will provide dedicated acid sulphate soil treatment areas and cut/fill balance within each area/work front to avoid transport of material along the national park road network. Based on tenderer submissions, the construction schedule for Green and Golden Bell Frog habitat is likely to take approximately 16 weeks, pending weather.

5.3. Successful Breeding and Viable Population

MOD 2 of Project Approval 06_0009, Condition 2.20 requires that NCIG are to have a viable breeding population of Green and Golden Bell Frog established as part of compensatory habitat works. If this is not achieved, then an equivalent area of habitat which is known to contain the species is to be purchased by 31 December 2019 and managed in perpetuity. According to the Modification Approval:

- A Breeding population (in relation to *Litoria aurea*) is defined as '*Evidence of natural breeding events occur in two seasons (September to March) and include the presence of eggs, tadpoles and/or metamorphs that were not released from captive breeding stock in at least one pond. The breeding events do not have to be recorded over two consecutive seasons*'.
- A Viable population (in relation to *Litoria aurea*) is defined as '*Evidence of at least five reproductively mature individuals are identified within new aquatic and/or terrestrial habitat in each of the two seasons when breeding events occurred. Such evidence will include presence of calling males with nuptial pads and gravid females*'.

There is no date specified in the Modification Approval for when a viable breeding population must be confirmed or established. However, as an equivalent area of habitat is to be purchased by 31 December 2019 in lieu of this, then a viable breeding population must be established no later than the 2018/19 Summer. With this as a target final date for establishing a successful population, there will be a total of five (5) seasons after the completion of habitat construction in which to attain this.

It has been recognised by ecologists and academics in discussions in the previous Consultative Board meeting that achieving two breeding events in the constructed habitat by 2018/19 will be difficult. Historical evidence that the species only breeds in a small portion of available habitat, as well as climatic events and environmental conditions may greatly affect the outcome of any successful breeding by a wild population.

In order to provide the best chance of wild breeding in the constructed habitat, NCIG propose to utilise the breeding facility at the University of Newcastle to translocate captive-bred animals into the habitat. As there is still only limited evidence of naturally-occurring bell frogs in the northern portion of Ash Island, there is little chance that constructed habitat will be populated through natural migration from an existing wild population. By introducing captive-bred animals (similar to the Research Ponds site), there will be a greater chance of breeding in subsequent seasons. Alternatively, animals from the Research Area or wild populations on Ash Island can be directly translocated in the constructed habitat. These options as well as appropriate monitoring and survey methodologies for identifying breeding events are currently being discussed with Dr Arthur White and the University of Newcastle.

6. Shorebird Compensatory Habitat

As mentioned in the previous quarterly report, the Shorebird component of the CHEMP has been provided in principle support by DoPI and OEH (NPWS). This is in recognition of the suitability of the land for shorebird habitat and the close proximity to the disturbance area. Full approval is pending resolution of the land use zoning for Area E and assurance of "in perpetuity" protection. This area is currently subject to the operation of the Infrastructure SEPP

NPWS has requested that a Deed of Agreement be entered into between NCIG, NPWS and NSW Office of Environment and Heritage to allow Area E to be utilised for migratory shorebird compensatory measures and ensure that NCIG manages the land for the life the NCIG Terminal. DoPI has indicated that this, coupled with recognition of the shorebird offset in the Hunter Wetlands National Park Plan of Management (PoM), would be appropriate in-perpetuity protection of the offset. This agreement is expected to be formalised in the coming period prior to the next Board meeting.

In parallel with facilitation of accommodating the offset, NCIG is conducting preliminary investigations of Area E to gain a clear understanding of the environmental constraints and issues that are present on the land and in the water. Preliminary investigations include flora, fauna and aquatic fauna surveys. These will be used to develop an appropriate environmental assessment document to identify management and mitigation measures in removing the mangroves and submit to NPWS for determination. The environmental assessment will also include appropriate consultation with stakeholders such as Kooragang Wetlands Rehabilitation Project (KWRP) and NSW Department of Primary Industries – Fisheries.

Additionally, consideration is being given to defining the optimal methodology for undertaking the proposed mangrove removal. A desktop search was conducted to identify if there were any similar projects being undertaken elselwhere that could provide an insight into the merits of various mangrove removal methodologies. Out of this process it was identified that a number of comparable projects had been completed or were proposed in the Auckland region of New Zealand. After initial discussions with project personnel, an inspection of the mangrove removal project areas was undertaken. This three-day trip was able to provide valuable information relating to the manner in which the projects were completed. It also provided a great learning opportunity through discussion of elements of the projects that worked well or could be inproved.

7. Shorebird Monitoring

Shorebird monitoinrg in the lower Hunter estuary continues to be routinely undertaken by the Hunter Bird Observers Club (HBOC). This monitoring is conducted in a number of areas in the vicinity of the proposed NCIG offset area (ie Swan Pond, Wader Pond and Deep Pond). The general indication from this monitoring is that shorebirds (both migratory and resident) continue to utlise this area to a varying degree which is often in response to prevailing conditions both at the site and elsewhere in the vicinity /region.

NCIG is currently considering an appropriate scope for shorebird monitoring of the area to include the area of compensation.

8. Hydrodynamic Management, Fish Fry Creek

Kooragang Wetlands Rehabiliation Project continues to utilise the drop board structure at Fish Fry Creek (Creek 5) constructed by NCIG, for the purpose of hydrological management of Area E. The purpose of this is to manage mangrove expansion in the area through water level manipulation.

The management regime has been in place for almost 18 months. To date, there has already been an impact on existing mangrove trees adjacent to the water level control structure, with some larger trees having died. The aim of the program is to limit the expansion of mangroves in Area E. The proposal for physical removal of mangroves in this area complements the aims of the KWRP project, through removing dead trees to create shorebird habitat and reducing future sources of mangrove propagules.

9. NCIG Compensatory Habitat Schedule

A copy of the NCIG Compensatory Habitat Schedule of Works is provided on the following page. The Migratory Shorebird schedule accounts for the extension in delivering the shorebird compensatory habitat provided by DoPI (i.e. 6 months).

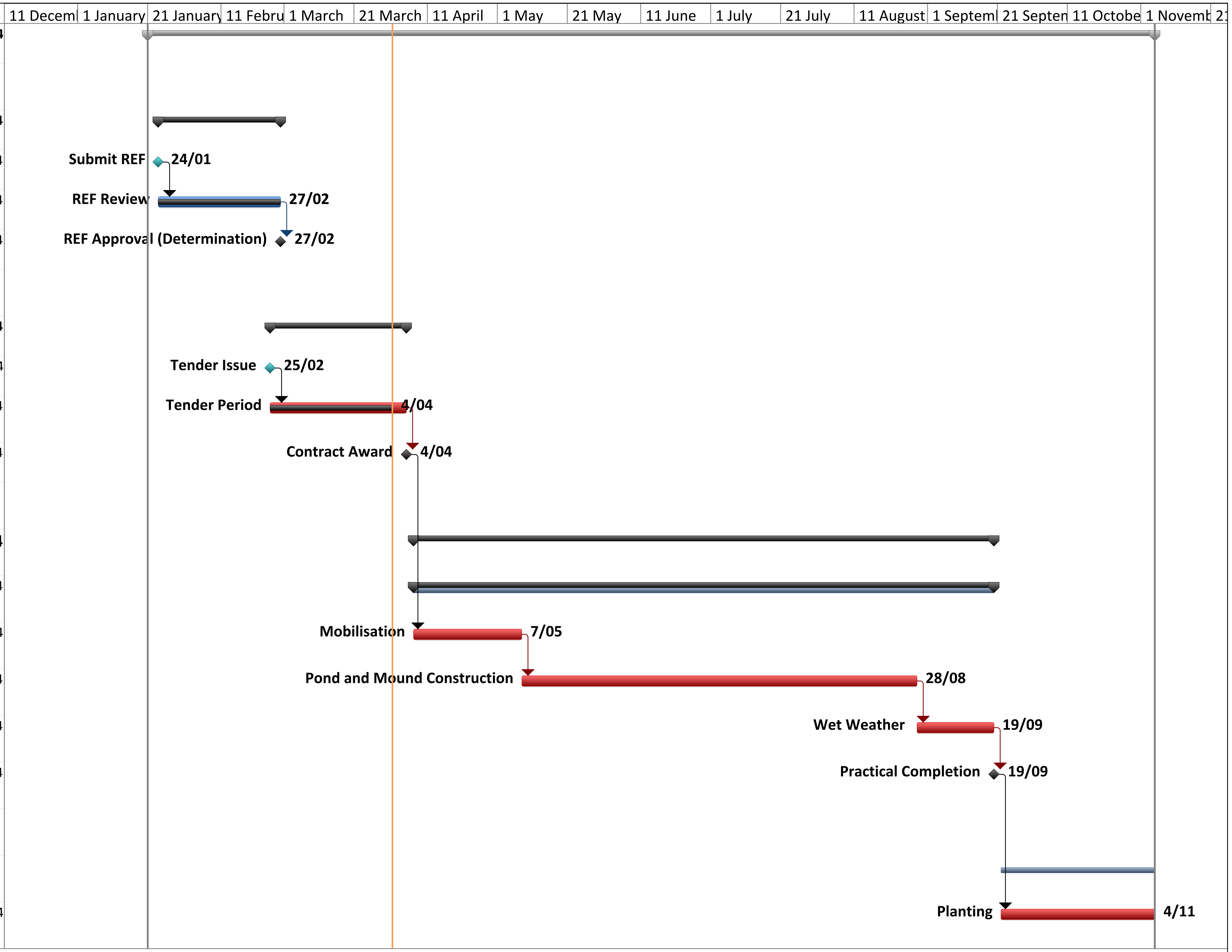
References

Australian Government Bureau of Meteorology Monthly Weather Review, New South Wales, February 2014.

Modification of Minister's Approval – MP 06_0009, 13 May 2013.

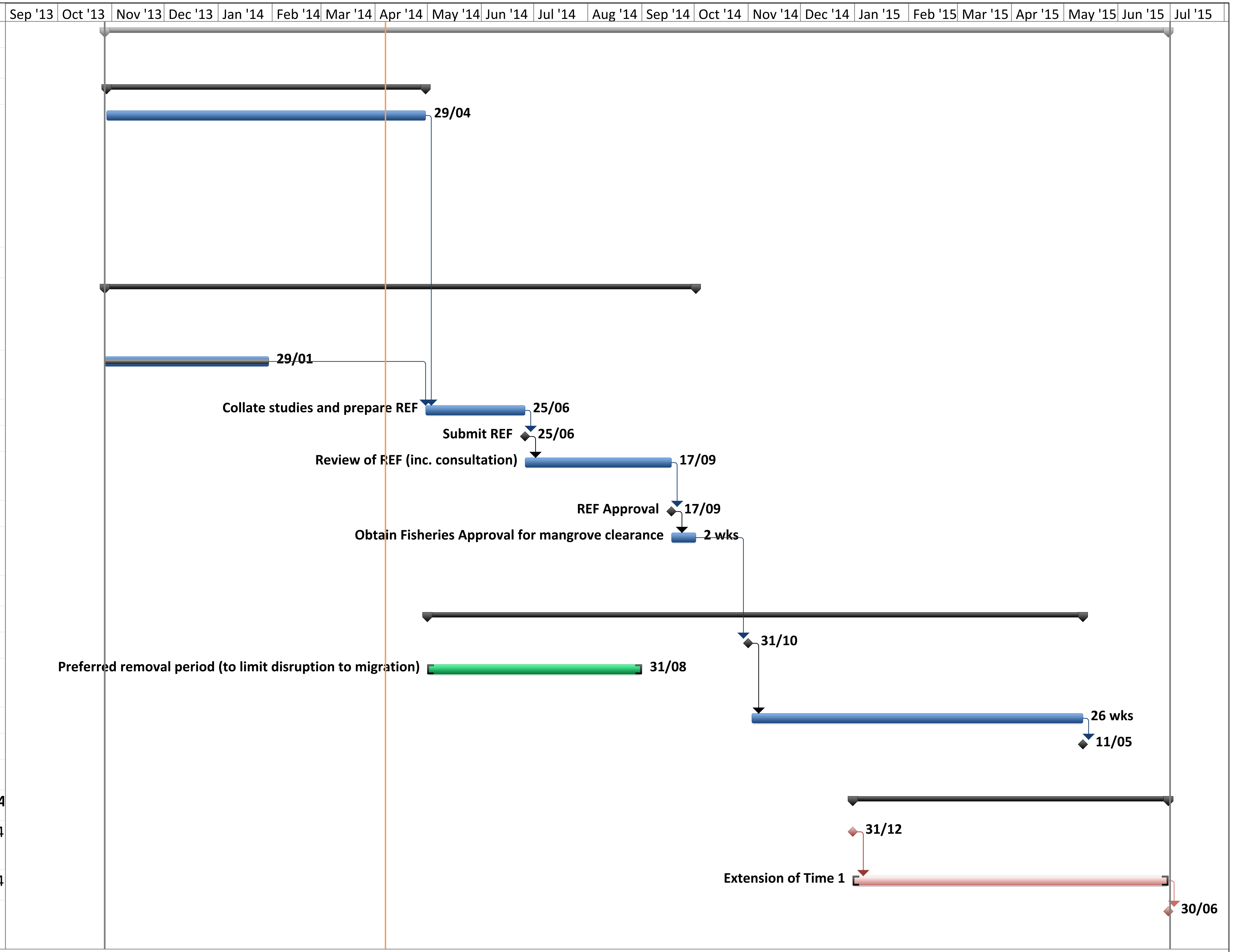
Stockwell, M. P. (2011). "Impact and mitigation of the emerging infectious disease chytridiomycosis on the endangered green and golden bell frog." PhD Thesis, The University of Newcastle.

ID	Name	Duration	Start	Finish
0	**GGBF Habitat - Construction Program**	**198 days?**	**Tue 21/01/14**	**Tue 4/11/14**
1				
2	**Approvals**	**23 days**	**Fri 24/01/14**	**Thu 27/02/14**
3	Submit REF	0 days	Fri 24/01/14	Fri 24/01/14
4	REF Review	23 days	Fri 24/01/14	Thu 27/02/14
5	REF Approval (Determination)	0 days	Thu 27/02/14	Thu 27/02/14
6				
7	**Commercial (Civil)**	**29 days**	**Tue 25/02/14**	**Fri 4/04/14**
8	Tender Issue	0 days	Tue 25/02/14	Tue 25/02/14
9	Tender Period	29 days	Tue 25/02/14	Fri 4/04/14
10	Contract Award	0 days	Fri 4/04/14	Fri 4/04/14
11				
12	**Construction**	**116 days**	**Mon 7/04/14**	**Fri 19/09/14**
13	Civil Works	116 days	Mon 7/04/14	Fri 19/09/14
14	Mobilisation	1 mon	Mon 7/04/14	Wed 7/05/14
15	Pond and Mound Constructio	16 wks	Thu 8/05/14	Thu 28/08/14
16	Wet Weather	16 days	Fri 29/08/14	Fri 19/09/14
17	Practical Completion	0 days	Fri 19/09/14	Fri 19/09/14
18				
19	**Landscaping**			
20	Planting	6 wks	Mon 22/09/14	Tue 4/11/14



Critical		Slack		Rolled Up Critical Split		Inactive Summary		Start-only	
Critical Split		Slippage		External Tasks		Manual Task		Finish-only	
Task		Summary		External Milestone		Duration-only		Deadline	
Split		Project Summary		Inactive Task		Manual Summary Rollup		Progress	
Milestone		Rolled Up Critical		Inactive Milestone		Manual Summary			

ID	Task Name	Duration	Start
0	**Shorebirds Compensatory Habitat**	**416 days**	**Mon 28/10/13**
1			
2	**Resolving land tenure**	**120 days**	**Tue 29/10/13**
3	Consult with Department of Planning, obtain approval of Shorebirds component of CHEMP and agreement on appropriate legal mechanism with NPWS.	6 mons	Tue 29/10/13
4			
5	**Project Approval (indicative durations obtained from Resource Strategies)**	**231 days**	**Mon 28/10/13**
6	Undertake specialist studies for inclusion in REF	12 wks	Mon 28/10/13
7	Collate studies and prepare REI	8 wks	Wed 30/04/14
8	Submit REF	0 days	Wed 25/06/14
9	Review of REF (inc. consultation)	12 wks	Thu 26/06/14
10	REF Approval	0 days	Wed 17/09/14
11	Obtain Fisheries Approval for mangrove clearance	2 wks	Thu 18/09/14
12			
13	**Construction**	**259 days**	**Thu 1/05/14**
14	Contractor mobilisation	0 days	Fri 31/10/14
15	Preferred removal period (to limit disruption to migration)	87 days	Thu 1/05/14
16	Remove mangroves	26 wks	Mon 3/11/14
17	Completion	0 days	Mon 11/05/15
18			
19	**NCIG Approval Conditions**	**125 days**	**Wed 31/12/14**
20	MP 06_009 Completion Date	0 days	Wed 31/12/14
21	Extension of Time 1	181 edays	Wed 31/12/14
22	Current MP 06_009 Completion Date	0 days	Tue 30/06/15



Project: Shorebirds Compensator
Date: Mon 7/04/14

Task		Project Summary		Inactive Milestone		Manual Summary Rollup		Deadline	
Split		External Tasks		Inactive Summary		Manual Summary		Progress	
Milestone		External Milestone		Manual Task		Start-only			
Summary		Inactive Task		Duration-only		Finish-only			

Appendix F

GGBF Annual Report on the 2013/14 Field Season

Research Program on the Green and Golden Bell Frog (*Litoria aurea*) on Kooragang Island

Annual Report on the 2013/14 Field Season
For
PORT WARATAH COAL SERVICES

November, 2014

Research project report prepared by:

Simon Clulow, Michelle Stockwell, John Clulow & Michael Mahony
School of Environmental and Life Sciences
University of Newcastle

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Executive summary

In 2010 Port Waratah Coal Services (PWCS) commissioned the University of Newcastle to undertake a research program on the Green and Golden Bell Frog (GGBF) on Kooragang and Ash Islands (KI/AI). This program aimed to investigate specific questions relating to GGBF population ecology on the island, including population size, demographic composition and landscape utilisation. The first year of this program began to build a picture of the GGBF population on Kooragang and Ash Islands, and subsequent years continued it. This program is now in its fourth year and this report outlines the findings on the population demography of the GGBF population on KI/AI for the 2013/2014 season.

It was found that the population estimate ranged from 639 to 1238 individuals with an average estimate across the season of 880 individuals. This is comparable to the three previous seasons and suggests that the population is currently stable, albeit small in size.

Frogs were found at 25 ponds giving naïve pond occupancy of 45.6%. This might be artificially low due to the site-access issues on T4, but is comparable to the prior two seasons nonetheless. Evidence of breeding was found in 5 ponds across KI/AI, including 3 ponds that occur on the T4 site. Calling activity was also widespread and predominately occurred on T4.

Numerous movements were again observed between ponds in the 2013/2014 season, although most of the movement activity was concentrated around K22/K23. Three medium-ranged movements were observed between the K22/23 on Ash Island and ‘the cell’ which suggests that the current rail infrastructure is not a significant barrier to dispersal from Ash Island to T4 and vice versa.

1. Introduction

1.1 Background to the study

In 2010 Port Waratah Coal Services (PWCS) commissioned the University of Newcastle to undertake a research program on the Green and Golden Bell Frog (GGBF) on Kooragang and Ash Islands (KI & AI), which was subsequently continued into the 2011/2012 and 2012/2013 seasons (see Clulow et al, 2012; Clulow et al, 2013). This program aimed to investigate three specific questions relating to GGBF population ecology on the island, including:

1. What is the estimated population size of the green and golden frog on Kooragang Island?
2. What is the demographic composition of the green and golden bell frog population on Kooragang Island?
3. How do green and golden bell frogs utilise the landscape on Kooragang Island?

During the 2010/2011 to 2012/2013 GGBF seasons field surveys were conducted and the techniques of capture-mark-recapture and visual encounter surveys (VES) were employed to collect data to begin to address these questions. Moving into the fourth year of the research program, in addition to expanding the scope of the program to address questions surrounding GGBF persistence in some habitats but not others to inform best habitat creation practice (not the subject of this report, but see Clulow et al, 2014), these techniques were continued to expand the long-term data set on the current status of the GGBF population on KI/AI prior to proposed development.

1.2 Background to the problem

The green and golden bell frog decline

The green and golden bell frog was once common and widespread throughout the east coast of Australia from northern New South Wales to southern Victoria and its adjacent tablelands (Pyke and White 2001). Since the 1960s a decline was observed and the green and golden bell frog is now known to have undergone a dramatic reduction in its distribution and abundance (Mahony et al, 2013; White and Pyke 1996; Pyke and White 2001). Today, the green and golden bell frog persists in less than 10% of its historical distribution, and occupies about 40 known sites today (Mahony et al, 2013; White and Pyke 1996). Populations that were once reported on the Central Tablelands appear to be extinct, having not been observed since the early 1970s (White and Pyke 1996; White and Pyke 1999), and until a recent rediscovery of a small population in Queanbeyan (Patmore 2001; Wassens and Mullins 2001), they were believed to be extinct in the Southern Tablelands, having not been observed there since 1980 (Osborne, Littlejohn et al. 1996). In addition to those in the highlands, many populations have also been lost along the foothills and coastal plain of the Hunter, Sydney and Shoalhaven regions where they were once common (Daly 1995; White and Pyke 1996; Mahony 1999).This reduction has resulted in the species being listed as endangered in New South Wales under the *Threatened Species Conservation Act 1995* and as vulnerable nationally under the *Environment Protection and Biodiversity Conservation Act 1999.* Two key populations are named for the Lower Hunter region, one of which occupies Kooragang Island (DECC 2007, there named Kooragang/Ash Island).

Causes of the decline and disappearance of bell frog populations

There is considerable evidence that the Green and Golden Bell Frog was once common in the Hexham Swamp/Kooragang Island area of Newcastle (Hamer et al., 2004). The species apparently declined rapidly in the 1980s and by the 1990s the only confirmed breeding site south of the Hunter River was in the 2HD wetlands at Sandgate. This population disappeared some time prior to 2006, leaving only the population on Kooragang/Ash Island.

More broadly the range contraction of the threatened bell frog species occurred rapidly, suggesting a causal agent that was able to act over short time periods was involved (Hamer et al., 2009). They disappeared from nearly all inland, high altitude areas of their respective ranges (Courtice and Grigg, 1975, Hamer et al., 2009, Mahony, 1999a, White and Pyke, 2008, White and Pyke, 1996) alongside a suite of co-occurring frog species that did not appear to decline. These consistencies with the disease hypothesis suggest that chytridiomycosis may have played a role in bell frog declines and, if so, that the effects of this disease must be less severe in areas where bell frogs have persisted (Mahony et al, 2013). The NSW National Parks and Wildlife Service Draft Recovery Plans for *L. aurea* lists disease (specifically chytridiomycosis) as a threat to the persistence of these species, and several observations of infection and die-offs are referred to therein (DEC, 2005a, DEC, 2005b, NSW NPWS, 2001).

Bell frogs are highly susceptible to the amphibian chytrid fungus that causes the disease chytridiomycosis. Experimental exposure of *L. aurea* to the chytrid fungus results in 100% of individuals showing terminal signs of chytridiomycosis in captivity (Stockwell et al., 2010). Although the impacts of disease are expected to be more severe in captive environments, such high susceptibility in *L. aurea* hosts suggests that the chytrid fungus has the potential to constrain population size and cause extinctions. Multistate modelling of the Kooragang Island *L. aurea* population supports this, showing significantly lower over-winter survival rates in infected individuals (0.1) than uninfected (0.56) which was predicted to cause the population to decline at twice the rate of an otherwise uninfected population (Stockwell, 2011). These studies indicate that large-scale unobserved seasonal die-offs may occur in bell frog populations during cold periods when both bell frog detectability and survey frequency are low. In addition, the chytrid fungus has been implicated as the causal agent in the overwinter extinction of a reintroduced *L. aurea* population in the Hunter Region of NSW (Stockwell et al., 2008). Such die-offs and extinctions have serious implications for the ability of remaining isolated populations to persist with infection, particularly in the presence of demographic and environmental stochasticity.

The existence of a link between the bell frog persistence in coastal environments and chytrid salt sensitivities has been suggested several times (Berger et al., 2009, Mahony, 1999a, White, 2006) and significant negative correlations have been found in bell frog habitat between infection loads and the salinity of water bodies (Stockwell, 2011). An inhibitory effect of 3-4 ppt sodium chloride on fungal growth and infective capacity has also been confirmed experimentally (Stockwell, 2011). These results suggest that bell frogs may currently persist in areas with a saline influence as they act as environmental refuges from the effects of the chytrid fungus. The addition of salt to water bodies, both in captivity and in an experimental reintroduction site has also been found to increase bell frog survival rates in the presence of chytrid (Stockwell, 2011), suggesting that this may be used in management.

Apart from chytrid, the two most commonly cited causal agents for the bell frog decline are habitat modification and predation by the introduced mosquito fish *Gambusia holbrooki*. Many historic bell frog sites have been altered, particularly through filling and drainage of wetlands and floodplains for agriculture, trampling of waterways by feral horses and pigs and urban and industrial development (Clancy 1996; Daly 1996; Van De Mortel and Goldingay 1998; Lewis and Goldingay 1999; White and Pyke 1999). Correlations between the loss of suitable habitat and bell frog population extinctions have been made and appear to be exacerbated by the loss of connectedness between habitat and the subsequent impacts of demographic and environmental stochasticity, and low levels of genetic exchange on small populations (White and Pyke 1996; Goldingay 2008; White and Pyke 2008).

The introduced mosquito fish is known to prey upon the eggs and tadpoles of many frog species including the green and golden bell frog (Morgan and Buttemer 1996) and can significantly reduce survivorship, both in laboratory-based experiments (Morgan and Buttemer 1996; Pyke and White 2000) and in the field (White and Pyke 2008). In addition, bell frog tadpoles appear to be completely naïve to the presence of mosquito fish, showing no avoidance or refuge seeking behaviours (Hamer, Lane et al. 2002). The timing of the earliest bell frog declines coincided with the expansion of mosquito fish populations throughout NSW (White and Pyke 1996) and numerous sites where bell frogs remain are associated with an absence of the mosquito fish (White and Pyke 1996; Lewis and Goldingay 1999; Pyke, White et al. 2002).

In addition to the direct effects of predation, the presence of mosquito fish in permanent water bodies may also have resulted in a shift in the type of habitat utilised for breeding. Bell frogs appear to have bred in permanent water bodies more frequently in the past than they do now and this may be because ephemeral water bodies that dry frequently do not sustain populations of mosquito fish (Pyke and White 1996; Hamer, Lane et al. 2002; Pyke, White et al. 2002). However, breeding in ephemeral water bodies carries the risk of pond drying before tadpoles can metamorphose and unlike many other species, bell frog tadpoles do not appear to be plastic in their development rate, being unable to metamorphose more rapidly in response to declining water levels (Hamer, Lane et al. 2002).

1.3 Research objectives

Conservation efforts to mitigate the effects of habitat loss and other pressures causing GGBF decline often involve the management, restoration or creation of habitat, which depends upon a thorough understanding of habitat requirements and population demography. Research efforts have attempted to characterize particular features of bell frog habitat being selected for (Pyke and White 1996; Penman 1998; Christy 2000; Hamer 2002; Pyke, White et al. 2002; Garnham 2009; Pollard 2009; Midson 2010). However, each study found bell frogs to be associated with a different suite of variables, suggesting that it may be a generalist in its habitat requirements. The green and golden bell frog is an opportunistic colonising species with high dispersal ability and fecundity (Pyke and White 2001; Hamer, Lane et al. 2007) which also suggests that it should readily establish populations in suitable habitat. This has caused confusion as to why the species never seems to occupy all seemingly appropriate water bodies in a particular area where it is present, and why occupancy of ponds (presence/absence) can change regularly both within a season and from season to season.

Five attempts have been made to create bell frog habitat to date, using similar habitat templates (Mahony et al, In Press; Pyke and White 1996), and only one has resulted in the establishment of a breeding population (Pyke, Rowley et al. 2008; Stockwell, Clulow et al. 2008; White and Pyke 2008). Although these studies have increased our knowledge of various aspects of bell frog biology and ecology, the low rate of success in establishing populations illustrates our current lack of understanding regarding the habitat preferences and requirements of this species. Given the development pressures placed on much of the existing bell frog habitat, this urgently needs to be resolved. Despite the intensive research effort that has gone into understanding bell frog habitat requirements, very little has included a temporal (across time) component and this may prove to be vitally important in this understanding. Similarly, the unit of study focused upon in these investigations has consistently been the individual water body. However, bell frog habitat selection may be based on smaller or larger scales than this. Therefore, an understanding of how bell frogs utilize a landscape temporally and spatially is required if their distribution is to be understood and habitat effectively managed or created.

The specific objective of the research program in 2013/2014 that this report addresses is to build upon the population demographic data gathered through field surveys in the 2010/2011 to 2012/2013 GGBF seasons by conducting further surveys in the 2013/2014 season. This enables us to begin to build a picture of the GGBF population on KI/AI both spatially and temporally, which in turn help us to understand the dynamics that might be driving the population, and provide an aid as to how best to manage the population moving into the future, considering the need to balance future developments on KI and maintain a resilient population of GGBFs.

In particular, to make the proposed 'habitat corridor' work for the bell frog it is necessary to have a detailed understanding of the structure of the bell frog population as it currently exists on KI/AI. This required repeated surveys similar to the past two years and involves a combination of mark-recapture and visual encounter survey (VES) techniques. In addition to the surveys that were carried out in water bodies over the first two seasons, the BHP wetlands and the two recently created clusters of ponds were included this year's surveys (as with last year). Investigations of the 'BHP Wetlands' to determine if this large wetland is supporting a population of the frogs is considered very important to the PWCS project. This wetland could be key to the success of the habitat corridor, given its relatively large size and location in the landscape, and construction of wetlands nearby or adjacent to this wetland may be the best strategy to provide for a large population of the bell frog (it is not possible to easily modify this wetland because such an action would require an EIS, and it has other ecological values other than for bell frogs). The site has some logistically important features: there is an ample supply of freshwater, it is nearby to where bell frogs previously occurred, and there is the opportunity to create additional wetlands near to its shore (e.g., to enable habitat features to me managed such as preventing entry of Gambusia, providing increased salt levels, and temperature). The addition of the recently created clusters of ponds will allow determination of their success (as assessed by occupancy) as newly created habitat.

2. Methods

2.1 Population size and apparent survival estimates using mark-recapture and visual encounter survey data

Estimates of population size and survival provide a biologically relevant measure that allows population persistence to be predicted and dynamics monitored (Krebs 2001). The conservation of threatened species requires a focus on preventing reductions in population size as small populations are more vulnerable to extinction. Small populations are particularly vulnerable to demographic and environmental fluctuation, inbreeding depression, loss of genetic diversity and stochasticity (i.e. unpredictable catastrophes) (Primack 1998; Krebs 2001). Population size estimates are a first step but only population viability analyses (PVA) can determine whether a population is viable and will persist over time. Important measures include recruitment, mortality, immigration and emigration. However, these data are often lacking and stakeholders and managers require information quickly. An approach to bridge this gab is meta-analysis. Meta-analyses have shown that an applicable rule of thumb for wildlife populations independent of species could be that a minimum of 500 adult individuals is required to prevent the effects of inbreeding and a minimum of 5000 individuals is required to retain evolutionary potential via genetic diversity and to protect against stochastic events (Traill et al. 2010). However, such a rule of thumb cannot substitute the value of understanding the relevant parameters that drive the population dynamics of a particular species.

We used a combination of two methods; visual encounter surveys (VES) and capture-mark-recapture surveys to determine population size and apparent survival of the green and golden bell frog on Kooragang & Ash Islands. Both methods have intrinsic advantages and disadvantages. Here, we applied them in combination to achieve a more comprehensive knowledge of the population size than is possible when both methods are used in isolation.

Visual Encounter Surveys (VES)

In order to identify the distribution and abundance of green and golden bell frogs across Ash and Kooragang Islands, standardised auditory and visual encounter surveys were conducted at all accessible fresh water bodies across the landscape in October and December, 2013 and February and March 2014. Each survey started with a green and golden bell frog call auditory survey which involved listening for the call of male bell frogs for 3 minutes, followed by a 1 minute period of imitating GGBF calls to elicit a response, and 3 more minutes of listening for calling males. Estimated numbers of calling green and golden bell frogs were recorded. The total number of bell frogs and other frog species heard calling was then recorded.

Following the auditory survey, VES surveys were carried out. Visual encounter surveys followed the method by Hamer et al. (2002) which involved stratifying the survey effort proportional to the waterbody size (circumference) and vegetation complexity. Each survey involved timed searches of each water body including the emergent and fringing vegetation and terrestrial habitat with 1 m of the water's edge. Surveys were conducted by walking throughout the habitat in a manner that did not overlap with other searchers until all of these areas were thoroughly searched once. We attempted to keep the search effort for each waterbody consistent during all surveys. Frogs were detected during VES by their reflective eye-shine, movement or body shape. Upon detection, frogs were captured by hand where the hand was covered in a disposable plastic bag and the bag inverted to contain the animal. A piece of brightly coloured flagging tape was placed at the point of capture. The number of bell frogs detected at each pond or in the terrestrial areas (including those captured and those that were missed) was recorded, as was the location of each frog found using GPS; the microhabitat they were found in and distance off the ground; and the start and end times of the survey. The snout to vent length (SVL), head width and right tibia of each animal was measured to the nearest 0.1 mm using dial callipers and the body weight measured to the nearest 0.01 g using spring scales. The sex of each individual was determined based on secondary sexual characteristics in individuals greater than 45 mm SVL. The presence of nuptial pads indicated a male and the absence of nuptial pads indicated a female. During the breeding season (October to March), the abdominal cavity of any large females captured were inspected by placing the animal on its dorsal surface over a light source and the presence of eggs in the abdominal cavity recorded. Individuals less than 45 mm SVL were recorded as juveniles. All bell frogs captured during visual encounter surveys were scanned for the presence of a passive integrated transponder (PIT) tag and the unique numeric code recorded, along with the date of capture. If an animal was found without a PIT tag, one was injected subcutaneously into the dorsal lymph space and the tag manipulated so it was positioned away from the insertion site. Following the recording of these measurements all animals were released back at their point of capture.

The air temperature, relative humidity and wind speed were recorded at the start and end of each VES using a Kestrel 3500 weather meter as these variables are known to alter amphibian activity patterns and in turn, detection probability (Crump and Scott 1994). Cloud cover was also estimated at the start and end of each survey, determined visually as the percentage of the sky covered by cloud.

Mark-recapture Surveys

Visual encounter surveys alone are affected by imperfect detection of animals. Imperfect detection has two components, exposure to sampling and detection probability (Dodd 2010). Exposure to sampling describes the ability of an animal of being sampled. For example, an inactive individual is probably sheltering and hence less likely to be detected. Similarly, a frog under water or in the middle of the pond is also less exposed to being sampled. The other component, detection probability, refers to the likelihood of an individual that is exposed to being sampled to actually be detected during the survey. One way of dealing with this is by using capture-mark-recapture surveys. These involve the capture, marking and recapture of animals, and the proportion of recaptured animals that were marked is then used to estimate the population size (Amstrup et al. 2005). Figure 1 illustrates the basic principles of this survey method.

Mark-recapture surveys were conducted at four water bodies on Kooragang Island (K22, K23, K29 and the Rail Loop; see Figure 2) known to have high densities of GGBF, as determined by VES surveys conducted prior to the first mark-recapture period. Surveys were conducted in September & November 2013 and February & March 2014 in K22/23; November 2013 and February & March 2014 in K29 ('The Cell'); and September & November 2013 and February 2014 in the Rail Loop. Surveys involved nocturnal spotlight searches of water bodies and surrounding terrestrial areas for bell frogs. Upon detection, frogs were captured by hand where the hand was covered in a disposable plastic bag and the bag inverted to contain the animal. A piece of brightly coloured flagging tape was placed at the point of capture. All animals that are collected in this investigation are individually marked to enable measurement of survival rates and to detect movement, and to do this each animal has a passive induction transponder tag (PIT tag) placed under the skin. All collected animals were scanned for the presence of a PIT tag and if found, the unique number for that individual recorded. If an animal was found without a PIT tag, one was injected subcutaneously into the dorsal lymph space and the tag manipulated so that it was positioned away from the insertion site. The location of each animal capture was recorded using a GPS; the snout to vent length (SVL), head width, right tibia and body weight measured, and sex determined. The type of microhabitat where the animal was found and the distance off the ground was also recorded. All animals were then released back to their point of capture.

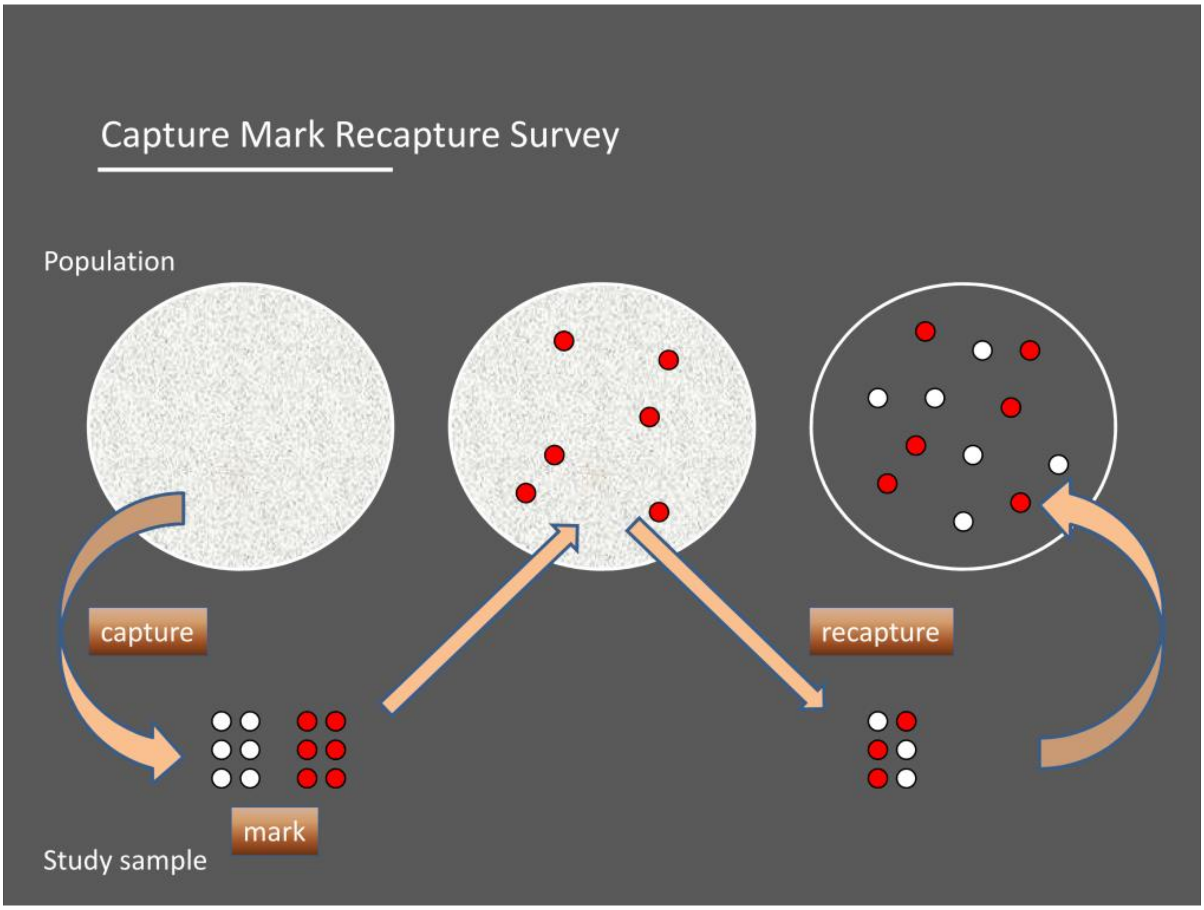

Figure 1. A simple illustration of capture-mark-recapture survey (based on two capture events only).

Left circle: nothing is known about the population size, then during the first capture event animals are caught, marked and released. Middle circle: the number of marked animals within the population is known. During the second capture event marked and unmarked individuals are caught. Right circle: the population size can be estimated based on the proportion of marked individuals caught during the second capture event. *Note that this is an over-simplistic depiction of current mark-recapture methods, with Robust Design allowing far more powerful modelling to be completed by incorporating closed methods (as depicted here) and open methods in conjunction with one another.

Surveys were conducted at two temporal scales in order to estimate population size multiple times within the one breeding season using Pollock's robust design (Amstrup, McDonald et al. 2005). Primary survey periods were conducted in different months, which are separated by long intervals during which migration, mortalities and recruitment within the population may occur. Within each of these primary survey sessions, 3 to 5 secondary surveys occurred with less than 48 hours between them; these shorter periods were assumed to be closed to migration, mortality and recruitment. The number of secondary surveys conducted at each pond within each primary survey period was dependant on the number of recaptures. Surveys were continued until a minimum of 20% recaptures were obtained, but a much higher recapture rate (up to 70%) was ideally sought. By ensuring a minimum 20% recapture rate and incorporating both open and closed periods in the one model, the overall estimates are more robust (Pollock 1982; Amstrup, McDonald et al. 2005; Nichols 2005).

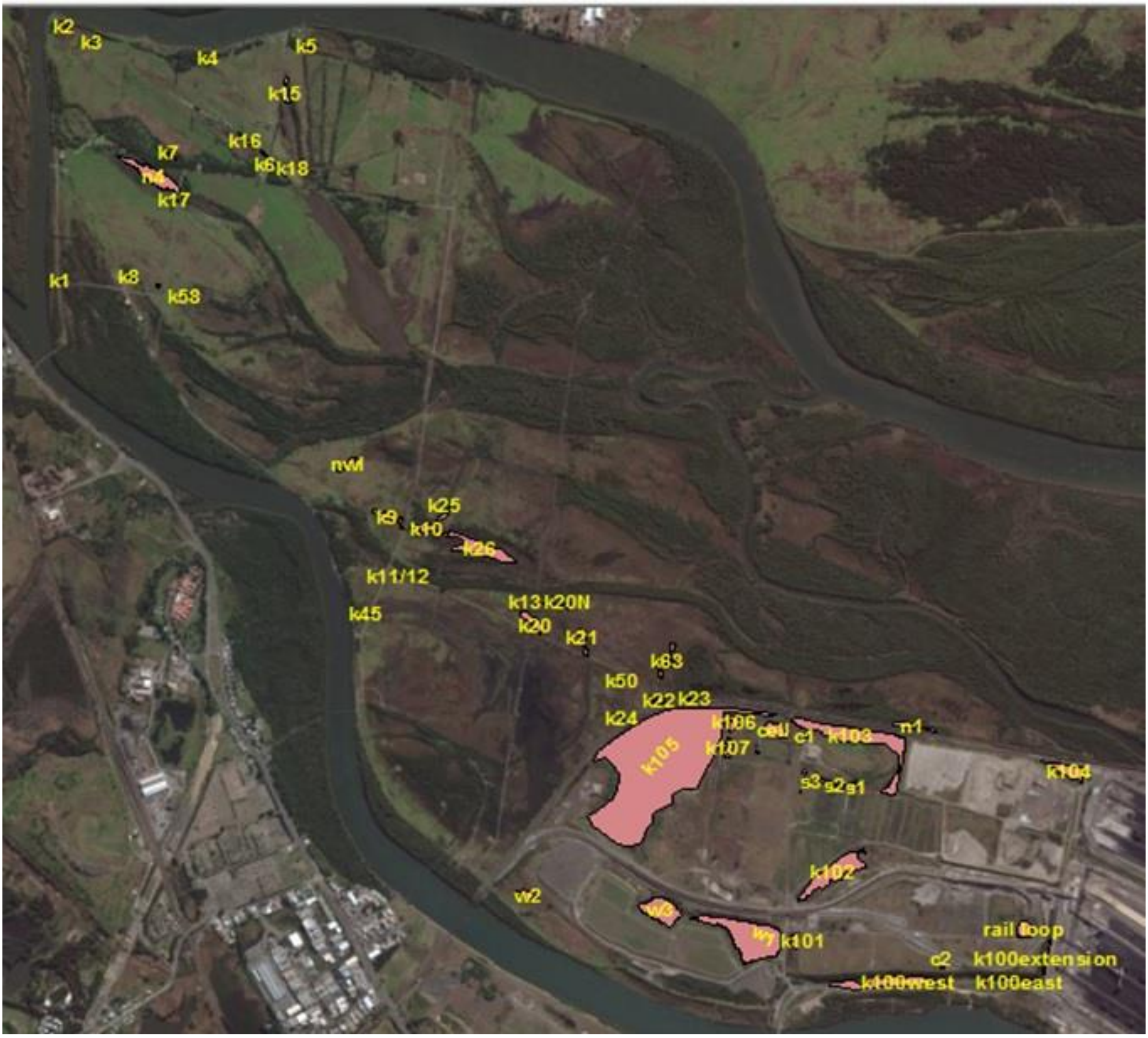

Figure 2. Part of Kooragang Island showing regularly surveyed waterbodies and their identification number.

Modelling population size and apparent survival using mark-recapture data

Apparent survival and population size estimates were modelled using Pollock's robust design. Pollock's robust design is able to 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*). It is important here to understand that apparent survival (φ) is inherently different to true survival. Apparent survival consists of two elements – deaths and emigration – that are not separable without directly measuring emigration or death independently in some way.

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 some models which allowed abundance, survival and recruitment to be estimated for all sampling periods, maximising 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).

Apparent survival across the season was modelled for K29, K22/K23 and the Rail Loop using the above Robust Design approach. 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. Base models were created and the best model selected using Akaike information criterion corrected for small sample sizes (AIC_c) (Burnham and Anderson 2002). 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 were 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).

Extrapolating population size from individual ponds to the whole of Kooragang and Ash Islands using a combination of mark-recapture and VES techniques

Combining visual encounter surveys with capture-mark-recapture survey allows us to extrapolate the number of pond occupants from the high-abundance areas to other low abundance ponds that do not contain enough individuals to successfully model mark-recapture data. This in turn allows us to calculate the green and golden bell frog population size across Kooragang & Ash Islands (at all ponds that were able to be surveyed by VES). The simplest way to do this would be to assume a linear relationship between abundance at any given pond at any point in time, and relative abundance scored as the number of frogs encountered during a VES survey at the same point in time. Using this assumption it would be possible to plot the relationship between the two at all ponds where mark-recapture data was sufficient to estimate abundance (population estimates) and extrapolate this out to all other ponds using the link function of the relationship (y = a+bx). However, if the relationship between abundance and relative abundance is not linear; or the data from multiple ponds used to plot the relationship does not fit the relationship well, the population extrapolations to other ponds will decrease in accuracy and/or precision. Therefore, before simple population extrapolations are conducted it is important to test the relationship and fit of the data, and correct for factors that decrease this relationship where possible.

A regression analysis was performed to determine the relationship and fit of the data between estimated abundances (population estimates using mark-recapture data) and relative abundances (measured as number of GGBFs encountered during VES in the same month as the mark-recapture survey) at multiple ponds and at several points in time (n=5). We tested to see if there was a significant relationship between the two, and measured the fit of the data (expressed as an R^2 value). This then allowed the calculation of a link function expressed as y = a + bx, where y = abundance and x = relative abundance. We also attempted to improve the fit of the data by incorporating detectability as a factor in the analysis.

2.2 Distribution and pond occupancy across Kooragang and Ash Islands

The raw distribution and naïve pond occupancy of GGBFs across Kooragang and Ash Islands was determined through standardised auditory and visual encounter surveys as described in section 4.1. These surveys were conducted at all accessible fresh water bodies across the landscape in October and December, 2013 and February and March 2014.

2.3 Movement and landscape connectivity

Assessing movement and landscape connectivity

All capture data obtained during mark-recapture and visual encounter surveys for the 2010/2011, 2011/2012, 2012/2013 and 2013/2014 seasons was checked to see if there were multiple captures of the same individuals in different ponds. For movements that were observed to occur across Kooragang and Ash Islands, GPS data was were used to plot the movements, and the movement distances were recorded using a GIS mapping tool.

3 Results

3.1 Population size and apparent survival estimates using mark-recapture and VES data

Population estimates using mark-recapture data

Mark-recapture surveys at ponds K22 and K23 found that numerous animals moved between them so data were combined. Sixteen secondary surveys were conducted at these ponds within four primary occasions. A total of 456 captures of 247 individuals were made at ponds K22/23, with individuals recaptured between 1 and 6 times. Ten secondary surveys were conducted at pond K29 within three primary occasions. A total of 203 captures of 116 individuals were made at pond K29, with individuals recaptured between 1 and 5 times. Twelve secondary surveys were conducted at the Rail Loop within three primary occasions. A total of 145 captures of 106 individuals were made in the Rail Loop, with individuals being recaptured between 1 and 5 times.

The survival, capture/recapture probabilities and population size estimates were best represented by the same model at K22/23 and the Rail Loop, but a different model at K29 ('the cell') (**Error! Not a valid bookmark self-reference.**). For all ponds, the best models described apparent survival and immigration/emigration as constant with population size (N) varying as a function of time. Capture and recapture probabilities were best described as equal to one another for all ponds but varied in their consistency. In K22/23 and the Rail Loop these probabilities were found to be constant over time but in K29 they were found to be time varying (Table 1).

Monthly apparent survival estimates were found to be constant across the season for all ponds. Apparent survival probability [95% CIs] was estimated to be 0.70 [0.51 – 0.84]) in K22/23; 0.36 [0.19 – 0.59]) in K29; and 0.17 [0.09 – 0.32]) in the Rail Loop. Deaths and emigration were not separable at any of the ponds and the apparent survival estimates above reflect an unknown combination of the two. Population estimates for the three ponds ranged between 109 [94 – 133; September 2013] and 184 [158 – 223; November 2013] in K22/23; 67 [53 – 92; February 2014] and 82 [66 – 110; November 2013]; and 62 [47 – 90; February 2014] and 97 [76 – 135; September 2013] in the Rail Loop.

Table1. Candidate set of models, ranked by ascending ΔAICc, used to estimate survival probability (φ), and capture/recapture probability (p/c) and population size (N) of green and golden bell frogs captured from ponds K22/K23, K29 and the Rail Loop on Kooragang Island between September 2013 and March 2014. The parentheses indicate the assumptions adopted into the model, where (γ) indicates primary periods, (t) indicates time varying, and (.) indicates constant models. G' = immigration parameter, and G" = emigration parameter.

Model	AIC_c	ΔAIC_c	weight (*w*)	No. of parameters
Pond K22/23				
φ(.) G"=G'(.) p=c(.) N(t)	-391.615	0	0.28869	7
φ(.) G"=G'(.) p(.) c(.) N(t)	-391.405	0.2105	0.25985	8
φ(t) G"=G'(.) p=c(.) N(t)	-390.086	1.5291	0.1344	9
φ(t) G"=G'(.) p(.) c(.) N(t)	-389.922	1.6936	0.12379	10
φ(t) G"=G'(.) p(γ) c(.) N(t)	-388.855	2.7602	0.07262	13
φ(t) G"=G'(.) p=c(γ) N(t)	-387.134	4.4816	0.03071	12
Pond K29				
φ(.) G"=G'(.) p=c(t) N(t)	-119.852	0	0.74557	9
φ(.) G"=G'(.) p(.) c(.) N(t)	-114.555	5.2972	0.05275	7
φ(.) G"=G'(.) p=c(.) N(t)	-114.542	5.3096	0.05242	6
φ(.) G"=G'(.) p=c(γ*t) N(t)	-113.953	5.8988	0.03905	15
φ(.) G"=G'=0 p=c(γ*t) N(t)	-113.953	5.8988	0.03905	15
φ(.) G"=G'(.) p(.) c(t) N(t)	-111.975	7.8775	0.01452	9
Rail Loop				
φ (.) G"=G'(.) p=c(.) N(t)	-60.2405	0.00	0.47681	6
φ (t) G"=G'(.) p=c(.) N(t)	-58.0531	2.1874	0.15972	7
φ (.) G"=G'(.) p(.) c(.) N(t)	-58.0494	2.1911	0.15943	7
φ (.) G"=G'(.) p=c(t) N(t)	-56.1976	4.0429	0.06316	9
φ (t) G"=G'(.) p(.) c(.) N(t)	-55.8306	4.4099	0.05257	8
φ (.) G"=G'=(.) p(.) c(γ) N(t)	-54.1076	6.1329	0.02221	9
φ (t) G"=G'(.) p=c(t) N(t)	-53.9104	6.3301	0.02013	10

Population estimates at low abundance ponds using a combination of mark-recapture and VES data

Determining the relationship between estimated abundance and relative abundance

We plotted the relationship of estimated abundance of 5 ponds from KI/AI (population estimates from mark-recapture data) against relative abundance measured as number of GGBF encountered during full completion off each VES survey (Figure 3). There was a significant linear relationship between the two ($P = 0.038$), with an R^2 value of 0.807. This validates the assumption that the VES surveys were a true reflection of abundance at a given pond at a given point in time. An R^2 value of 0.807 indicates that the data fits the linear regression reasonably well, although there is still an amount of variation that will result in less precise population estimates of low density ponds using this data in its raw form. We therefore also investigated incorporating a factor of detectability, based upon scaling the number of detected frogs during the standardised VES to the speed of the survey into this relationship to see if the fit of the data could be improved. We based this approach on an assumption that at any given abundance of frogs in a pond, more frogs will be detected when an area is searched slowly and thoroughly compared to when it is surveyed more quickly. Hence, we took the size of the ponds (d) that were surveyed using mark-recapture (testing both surface area and perimeter) and the time spent surveying the ponds (t) into account. The resulting, adjusted relative abundance for the regression analysis was calculated as number of frogs*(d/t). In order to keep this approach useful for a wider application we used the simple publicly available measurement tools on Google maps (http://maps.google.com.au/) to determine the perimeter and surface area of each pond surveyed.

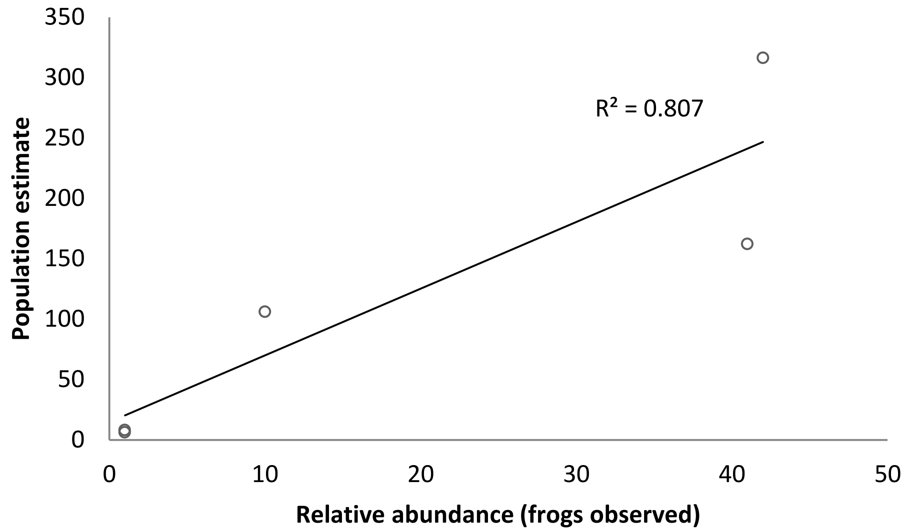

Figure 3. Linear regression between relative abundance (number of frogs observed during VES survey) and estimated abundance (population estimate using mark-recapture data) (n=5; P = 0.038; R2 = 0.807).

Figure 4 shows the relationship between relative abundance (frogs observed*(d[surface area]/t)) and estimated abundance, and Figure 5 shows the relationship between relative abundance (frogs observed*(d[perimeter]/t)) and estimated abundance. By scaling for speed of VES survey and hence incorporating this as a factor of detectability, both the confidence of the relationship and the fit of the data were dramatically improved ($P < 0.005$; $R^2 = 0.951$ for the best model of frogs observed*(d[perimeter]/t)). The best relationship was obtained using relative abundance scaled by speed of VES survey using pond perimeter. This was not unexpected as much of the middle of most ponds is open water where the frogs are not found, and much of the survey takes place around the edge of the ponds and adjoining habitat. The significant improvement in the fit of the data using this approach will result in far more precise population estimates using VES data alone, and was therefore used to calculate the population estimates at all low density ponds.

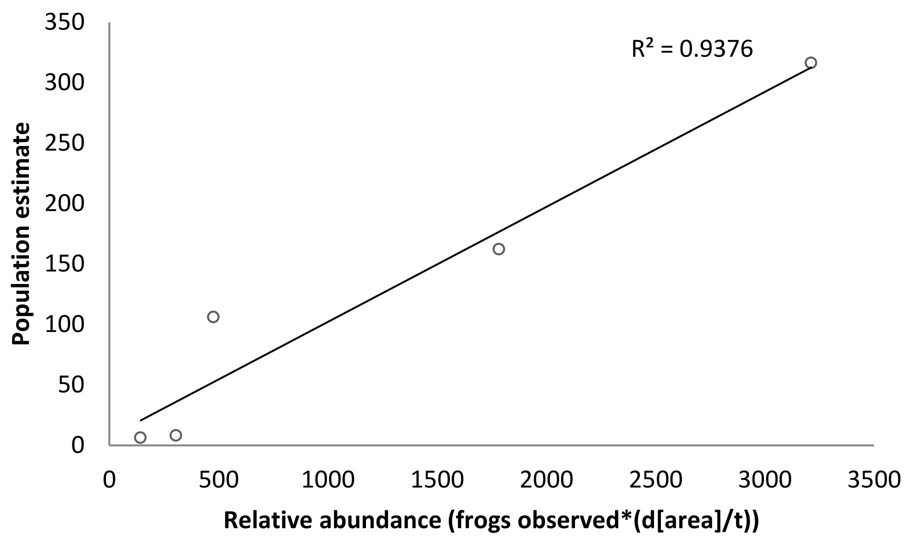

Figure 4. Linear regression between relative abundance (number of frogs observed during VES survey multiplied by pond surface area (m2) divided by person survey minutes) and estimated abundance (population estimate using mark-recapture data) (n=5; P < 0.007; R2 = 0.938).

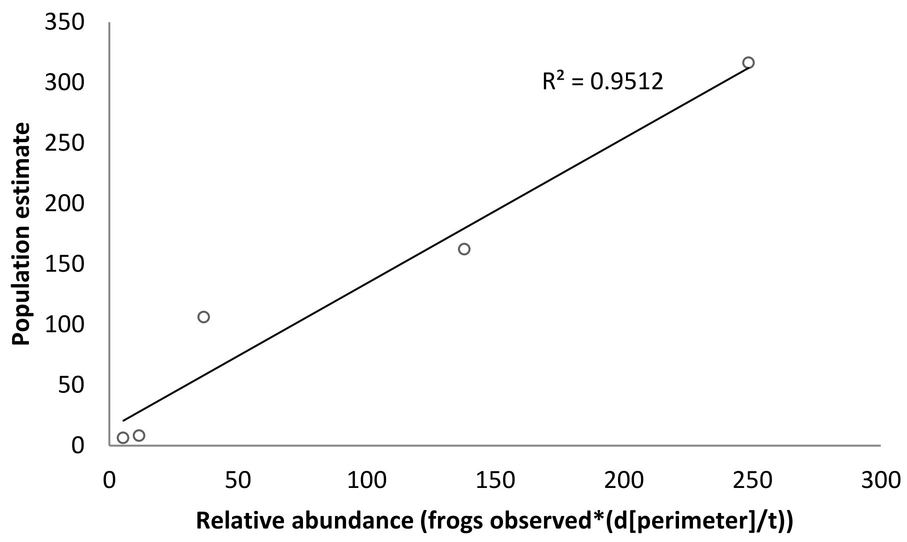

Figure 5. Linear regression between relative abundance (number of frogs observed during VES survey multiplied by pond perimeter (m) divided by person survey minutes) and estimated abundance (population estimate using mark-recapture data) (n=5; P < 0.005; R2 = 0.951).

Estimating population size at low abundance ponds

The link function for the linear regression between estimated abundance and relative abundance for frogs observed*(d[perimeter]/t) was $y = 13.871891 + 1.1996909x$. Based on this function we calculated the estimated abundance (y) and hence population estimate at each surveyed pond for each month using the relative abundance as listed below (x) (Table 22).

Table 2. Estimated abundances calculated for each pond and survey month based on the relative abundance estimated in the respective month (October – March). Relative abundances of zero were not transformed to actual abundances to avoid false positive results. For population estimates: 1 = link function allowed intercepts (y = 13.871891 + 1.1996909x); 2 = link function did not allow intercepts (y = 1.2738776x). NS = not surveyed.

	Relative abundance (frogs/h)				Relative abundance - frogs*(d/t)				Population estimate							
	Oct	Dec	Feb	Mar	Oct	Dec	Feb	Mar	Oct	Oct	Dec	Dec	Feb	Feb	Mar	Mar
Pond									1	2	1	2	1	2	1	2
c1	24.00	36.00	66.00	36.00	18.80	28.20	51.70	28.20	36	24	48	36	76	66	48	36
c2	0.00	0.00	0.00	12.00	0.00	0.00	0.00	9.40	0	0	0	0	0	0	25	12
cell	9.43		4.40	10.00	61.60		28.75	65.33	88	78	82	82	80	80	67	67
k10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0
k100 centre	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0
k100 east	1.15	0.00	0.00	0.00	10.10	0.00	0.00	0.00	26	13	0	0	0	0	0	0
k100 extension	0.00	7.20	0.68	0.00	0.00	74.88	7.09	0.00	0	0	104	95	22	9	0	0
k100 west	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0
k101	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0
k102	NS	2.40	2.26	1.53	NS	46.40	43.77	29.49	NS	NS	70	59	66	56	49	38
k103	0.00	4.00	0.00	0.50	0.00	110.20	0.00	13.78	0	0	146	140	0	0	30	18
k104	20.00	16.46	7.22	7.88	129.67	106.74	46.82	51.08	169	165	142	136	70	60	75	65
k105	1.38	3.41	1.08	1.85	62.31	153.66	48.65	83.08	89	79	198	196	72	62	114	106
k106	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0
k107	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0
k11/12	0.00	0.00	NS	0.00	0.00	0.00	NS	0.00	0	0	0	0	NS	NS	0	0
k13	0.00	0.00	0.00	6.67	0.00	0.00	0.00	24.22	0	0	0	0	0	0	43	31
k15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0
k16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0
k17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0
k18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0
k19	0.00	0.00	NS	0.00	0.00	0.00	NS	0.00	0	0	0	0	NS	NS	0	0

k2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0
k20	0.00	9.23	0.00	6.67	0.00	31.54	0.00	22.78	0	0	52	40	0	0	41	29
k21	0.00	1.43	0.00	1.67	0.00	6.90	0.00	8.06	0	0	22	9	0	0	24	10
k22/23	7.06		7.60		68.94		74.23		109	109	184	184	164	164	131	131
k24	7.50	0.00	0.00	0.00	10.63	0.00	0.00	0.00	27	14	0	0	0	0	0	0
k25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0
k26	0.00	1.94	0.00	0.00	0.00	32.19	0.00	0.00	0	0	52	41	0	0	0	0
k3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0
k4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0
k45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0
k5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0
k50	0.00	0.00	0.00	3.75	0.00	0.00	0.00	5.94	0	0	0	0	0	0	21	8
k58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0
k6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0
k63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0
k7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0
k8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0
k9	0.00	0.00	0.00	0.68	0.00	0.00	0.00	6.66	0	0	0	0	0	0	22	8
n1	0.00	2.57	9.47	6.00	0.00	31.46	115.89	73.40	0	0	52	40	153	148	102	94
n4	0.00	0.00	0.00	1.67	0.00	0.00	0.00	27.92	0	0	0	0	0	0	47	36
Rail loop				NS				NS	97	97	62	62	62	62	NS	NS
s1	0.00	6.67	0.00	2.50	0.00	13.44	0.00	5.04	0	0	30	17	0	0	20	6
s2	4.74	5.45	5.00	2.00	17.37	20.00	18.33	7.33	35	22	38	25	36	23	23	9
s3	0.00	0.00	1.43	0.00	0.00	0.00	2.71	0.00	0	0	0	0	17	3	0	0
s4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0
s5	0.00	7.50	30.00	24.00	0.00	7.00	28.00	22.40	0	0	22	9	47	36	41	29
s6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0
s7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0

w1	0.00	NS	0.00	0.00	0.00	NS	0.00	0.00	0	0	NS	NS	0	0	0	0
w2	0.00	NS	NS	NS	0.00	NS	NS	NS	0	0	NS	NS	NS	NS	NS	NS
w3	NS	NS	0.00	0.00	NS	NS	0.00	0.00	NS	NS	NS	NS	0	0	0	0
TOTAL	**75**	**104**	**135**	**113**	**379**	**663**	**466**	**475**	**676**	**601**	**1303**	**1172**	**866**	**768**	**922**	**731**
AVERAGE ESTIMATE										**639**		**1238**		**817**		**827**

The link function $y = 13.871891 + 1.1996909x$ includes an intercept which results in two implications. First, all visual encounter surveys that did not detect any green and golden bell frog (relative abundance=0 frogs*m/min) are given an estimated abundance of 14 frogs. Therefore, we did not apply the link function at ponds that scored 0 frogs encountered, and instead assumed that these ponds did not have any frogs in them at the time of survey (an assumption that is likely wrong on at least some occasions and thus will result in a slight bias towards an underestimate of the true population). In addition, the link function applied to very low number of observed frogs (less than 1 frog*m/min) can result in an estimate of less than one. As it is not possible to only have a fraction of one frog in a pond, any estimate that was less than 1 was rounded up to 1 individual. The population at these ponds had to be at least one, as the relative abundance calculation was based upon the detection of at least one frog to gain a score above 0, and this is therefore considered to be a reasonable approach.

The second implication is that the relative influence of the intercept is larger for small x-values than for large x-values. This means that visual encounter surveys that only observed a few frogs relative to search effort (m/min) will be more strongly inflated by the intercept value than surveys that observed many frogs. This may result in an overestimation of group sizes particularly at water bodies with a low relative abundance of green and golden bell frogs.

An alternative approach is to not allow intercepts in the linear regression analysis, which means the regression line is forced through the point of origin ($P < 0.001$, $n = 5$). The resulting link function is $y = 1.2738776\mathbf{x}$. However, this approach will result in some false negative determinations of absence. In particular this approach would not allow for the scenario that green and golden bell frogs may not be detected in visual encounter surveys despite their presence. However, this is particularly likely at low abundances. These cases would translate into an actual abundance of zero (absence of the species), which would underestimate the occupancy rate and population size. In summary, below the point of intersection of two regression lines a link function that allows an intercept will result in a larger population size estimate than a link function that does not allow an intercept, and vice versa. Above the point of intersection the relationship is reversed. Hence, both estimates may function as the brackets of a population size interval, with the best population size estimate somewhere within the interval. We therefore calculated the population estimate at all ponds using both approaches, and also calculated the average of these estimates (Table 2).

Estimates across KI/AI ranged from 639 (October 2013) to 1238 (December 2013) with more than 800 individuals estimated to occur in both February and March, 2014 (Table 2).

3.2 Distribution and pond occupancy across Kooragang and Ash Islands

From October 2013 to March 2014, surveys were conducted at a total of 55 freshwater ponds across Kooragang and Ash Islands (although due to access issues some of these were only surveyed on as little as one occasion; Figure 2). Visual encounter and auditory surveys detected post-metamorphic bell frogs at 25 ponds and both males and females were distributed similarly across the landscape (Figure 6). This gives a naïve (not taking probability of detection into account) pond occupancy estimate of 45.6% across the season. Calling was detected at 9 ponds, with evidence of breeding (tadpoles and metamorphs) at five ponds (**Error! Reference source not found.**).

Figure 6. Aerial photograph of Ash and Kooragang Islands showing the cumulative locations of GGBF records between September 2011 and March 2014. Source: Microsoft Bing, March 2014.

Figure 7. Aerial photograph of Ash and Kooragang Islands with the location of calling green and golden bell frogs and evidence of breeding from October 2013 to March 2014. Source: Microsoft Bing, March 2014.

3.3 Movement and landscape connectivity

Assessing movement and landscape connectivity

Unlike previous years, no large range movements were observed to occur across KI/AI in the 2013/2014 season. Numerous short range movements between ponds K22 and K23 were observed (a distance of approximately 80m) along with three moderate movements between ponds K22/23 and K29 i.e. 'the cell' (a distance of approximately 460m in a straight line). These movements all occurred between the 2012/2013 and 2013/2014 seasons. Movements between K22/23 and the cell involve crossing the railway that separates T4 on Kooragang Island from the national park on Ash Island (Figure 2).

4 Discussion

4.1 Population size and apparent survival estimates

Several ponds on KI/AI were not able to be surveyed on every occasion, possibly leading to a slight underestimate of the population size in any given month. With that said, the majority of ponds were able to be surveyed on most (if not all) occasions and the population estimates for the island as a whole are considered reasonably robust. The population estimates ranged between 639 and 1238 with an average estimate across the season of 880 individuals. The largest estimate (1238) was recorded in December, 2013 and is likely attributable to some breeding events that occurred before that time which would have led to recruitment of young individuals into the population.

Previous estimates of up to 967 individuals in 2011 (Leu et al, 2011); 930 individuals in 2011/2012 (Clulow et al, 2012); and 834 individuals in 2012/2013 (Clulow et al, 2013) suggest that the population is relatively stable over the four year study period to date. These numbers are also comparable to previous estimates from Ash and Kooragang Islands, which found a population size of 1995 (±315) males in the year 200 and 905 (±145) in 2001 (Hamer, Lane et al. 2007). Continuation of monitoring which is to occur into a 5th year of the program will paint a clearer picture of the population stability on the island and provide a solid foundation for future changes to be measured against (particularly post-development if it is to occur).

Monthly apparent survival varied greatly between ponds. In K22/23 apparent survival was similar to previous years (Clulow et al, 2012; Leu et al, 2011), although was much lower at K29 'the cell' (estimated to be between 0.19 and 0.59) and at the rail loop (estimated to be between 0.09 and 0.32). These low estimates are likely to be attributable to breeding events that happened around those ponds. There were a large number of tadpoles that had overwintered from the previous season in the rail loop and a breeding event that took place in the current season in the c1 ponds – the constructed cluster of ponds that adjoins 'the cell'. These breeding events likely contributed to a low apparent survival at those two ponds in two ways; the first being that juvenile mortality is usually high, and the second being that juveniles are thought likely to disperse away from natal ponds. Apparent survival is an estimate of both of these parameters together (deaths and emigration) which were not separable at any of the ponds. The apparent survival estimates above thus reflect an unknown combination of the two.

There are several assumptions that need to be met when modelling mark-recapture by robust design, 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). Not meeting these assumptions affects the accuracy of the output from the models.

Violations of these assumptions were reduced where possible throughout the study. PIT tags were used which are easily detectable and do not affect growth or survivorship (Christy 1996; Pyke 2005). The injection of the tag into the lymph sac and manipulation away from the site of insertion reduces tag loss. Secondary surveys were conducted over short periods relative to the interval between monthly primary periods. However, it is important to note that in the system in which this study was carried out, violations of some of the assumptions of the models likely occurred. For example, secondary survey periods are rarely likely to be completely closed. That is, that there is possibility of small amounts of migration in or out of the site (temporary or permanent); and mortalities and recruitment to the site could potentially occur despite the surveys being carried out no more than 48 hours apart. Equal survival probabilities between individuals also rarely exist in nature. Violation of the assumption of closure to migration in secondary periods can also come in difference forms; individuals might physically move into or out of the site being surveyed, or they might simply become 'invisible' to the survey methodology despite remaining in the site, for example by burrowing underground. It is therefore important to take all of these potential violations of the model assumptions into account when considering the meaning of the data output, as any violations of a model's assumptions affects the accuracy of the output (despite some models producing very precise estimates).

4.2 Distribution and pond occupancy use across Kooragang and Ash Islands

Frogs were found to occur in 25 ponds in the 2013/2014 season, with naïve pond occupancy on Kooragang and Ash Islands of 45.6%. This was comparable to previous seasons; in the 2011/2012 season frogs were found in 23 ponds (naïve occupancy of 41.8%; Clulow et al, 2012) and in 2012/2013 frogs were found in 20 ponds (naïve occupancy of 36.4%; Clulow et al, 2013). The ponds in which they have occurred each season, however, have changed over time. The reasons for this remain unknown, although a similar phenomenon has been observed at the Sydney Olympic Park site for many years.

Once again, GGBFs were found to readily inhabit the artificially created cluster of ponds adjacent to 'the cell' known as c1. However, only a very small number of frogs were found on a single occasion in the second cluster (c2), which is located much further away from other inhabited water bodies (Figure 2). This potentially supports the idea that proximity to inhabited ponds is an important factor for the colonisation of created habitats and should be noted for future habitat creation projects. Importantly, cluster 1 was not only found to contain a healthy population of GGBF (with much greater numbers than previous years) it was also found to be a site of breeding for the species (see also Clulow et al, 2014 for a lengthy discussion on the results of the cluster ponds).

No GGBF were found in the BHPB wetlands in the 2013/2014 season. Only a small number (2 individuals) were observed in one of the BHPB wetlands last season (the first season in which they were able to be surveyed. This potentially has important implications for the management of T4 and for the island as a whole, as this area forms a key part of the proposed habitat corridor to move the frogs to the south of the T4 site in the future. It would appear that the BHPB wetlands only support a low density population and might not be suitable for 'seeding' the colonisation of future created wetlands on their own. It is possible that strategies such as translocations might have to be considered, although these would need to be considered carefully and managed well with best-practice and science-driven principals in place.

Evidence of breeding was found in just 5 ponds across KI/AI in the 2013/2014 season, with one of those ponds (the rail loop) believed to have contained tadpoles from the prior season only. This suggests that breeding took place in only a small number of the occupied ponds, similar to previous years. The reasons for this remain unknown. Three of the 5 ponds where tadpoles were observed occur within T4. Calling by males was found to be widespread across the island with calling males observed in 9 ponds. Seven of the ponds containing calling males were located on T4.

Perhaps one of the more interesting observations from the VES surveys in the 2013/2014 season was the detection of two individuals on the west of Ash Island in pond N4. GGBF have not been seen this far west since studies in the late 1990s and early 2000s. However, the most likely explanation for the occurrence of these individuals is not a recent expansion of the range of the KI/AI population back to the west of the island, but rather individuals coming from inside a trial translocation site located nearby to N4. One of the two individuals that were caught in N4 was confirmed as having come from the trial site as identified by a visual implant elastomer (VIE) marker. The other individual was not, however it is possible that it lost its original VIE mark.

4.3 Movement and landscape connectivity

Most movement observed on Kooragang/Ash Islands were concentrated around the K22/K23 area of the island in the 2013/2014 season, although some medium-range movements were also observed across the rail line into T4. These consisted of three movements between the K22/23 ponds into K29 ('the cell'). These movements have been observed numerous times in prior seasons' surveys and involve crossing the rail line between Ash Island and the T4 site. Therefore, these rail lines are likely not a significant barrier to dispersal, although it is not possible to say what effect widening these rail lines would have; or how many frogs might be killed in the process of crossing them due to trains.

While larger movements (greater than 500m) were not directly observed during the 2013/2014 season, longer-ranged movements in the past (e.g. >2km observed in the 2012/2013 season and > 1km observed in 2011/2012 season) suggest that such movement may well have occurred without being picked up.

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