  

Annual Environmental Management Report 2013

Prepared for:
Newcastle Coal Infrastructure Group

Prepared by:
ENVIRON Australia Pty Ltd

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Newcastle Coal Infrastructure Group

ENVIRON

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Acronyms and Abbreviations

AI	Ash Island
CET	Coal export terminal
CHEMP	Compensatory Habitat Environmental Monitoring Program
GGBF	Green and Golden Bell Frog
KI	Kooragang Island
KIWEF	Kooragang Island Waste Emplacement Facility
Mtpa	Megatonne per annum
NCIG	Newcastle Coal Infrastructure Group
Stage 2AA	
Stage 2F	

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 fifth AEMR prepared for the NCIG Project and it covers the period April 2012 to March 2013 (i.e. a 12 month period), which includes the third year of terminal operation and Stage 2AA and Stage 2F construction of the Project.

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.

Dredging activities were undertaken during the reporting period until November 2012, after which dredging activities by NCIG were completed. These activities and related environmental management are not the subject of this AEMR. Only the environmental management requirements of both the CEMP and the OEMP, which are associated with the terrestrially based coal export terminal construction activities, are detailed by this AEMR. Details of the compliance of dredging activities are outlined in separate reports.

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

Table 1 Project Approval, Leases, Licences and Permits

Instrument	Relevant Authority	Date Granted	Duration of Approval
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 and Infrastructure	02 May 2007 & 25 October 2007	Perpetuity

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

- Construction Environmental Management Plan
- Construction Noise Management Plan
- Construction Surface Water Management Plan, including Erosion and Sediment Control Plan
- Construction Traffic Management Protocol
- Acid Sulphate Soil 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

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

Monitoring Programmes

- Environmental Monitoring Programme
- Surface Water Monitoring Programme
- Green and Golden Bell Frog Monitoring Programme
- Avifauna Monitoring Programme

1.3 Project Contacts

Contact Details for the Project are provided below:

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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.

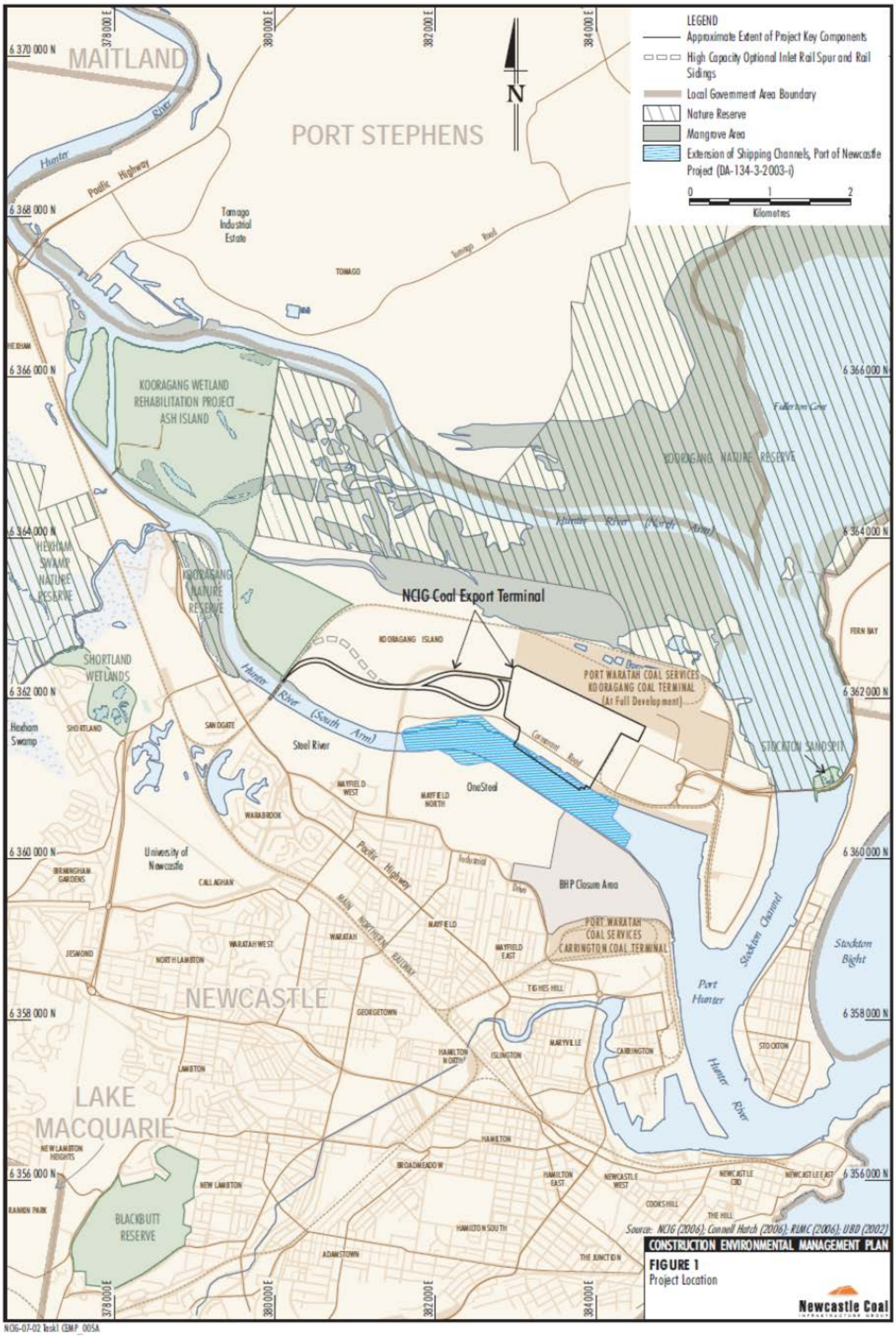


Figure 1: Project location

NCIG is the proponent of the Project and is a consortium of the following six 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 continuing at the end of this reporting period (March 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 dredging during the reporting period (Stage 2F) did not include re-use of dredge material for construction. This material was dumped offshore*);
- 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.

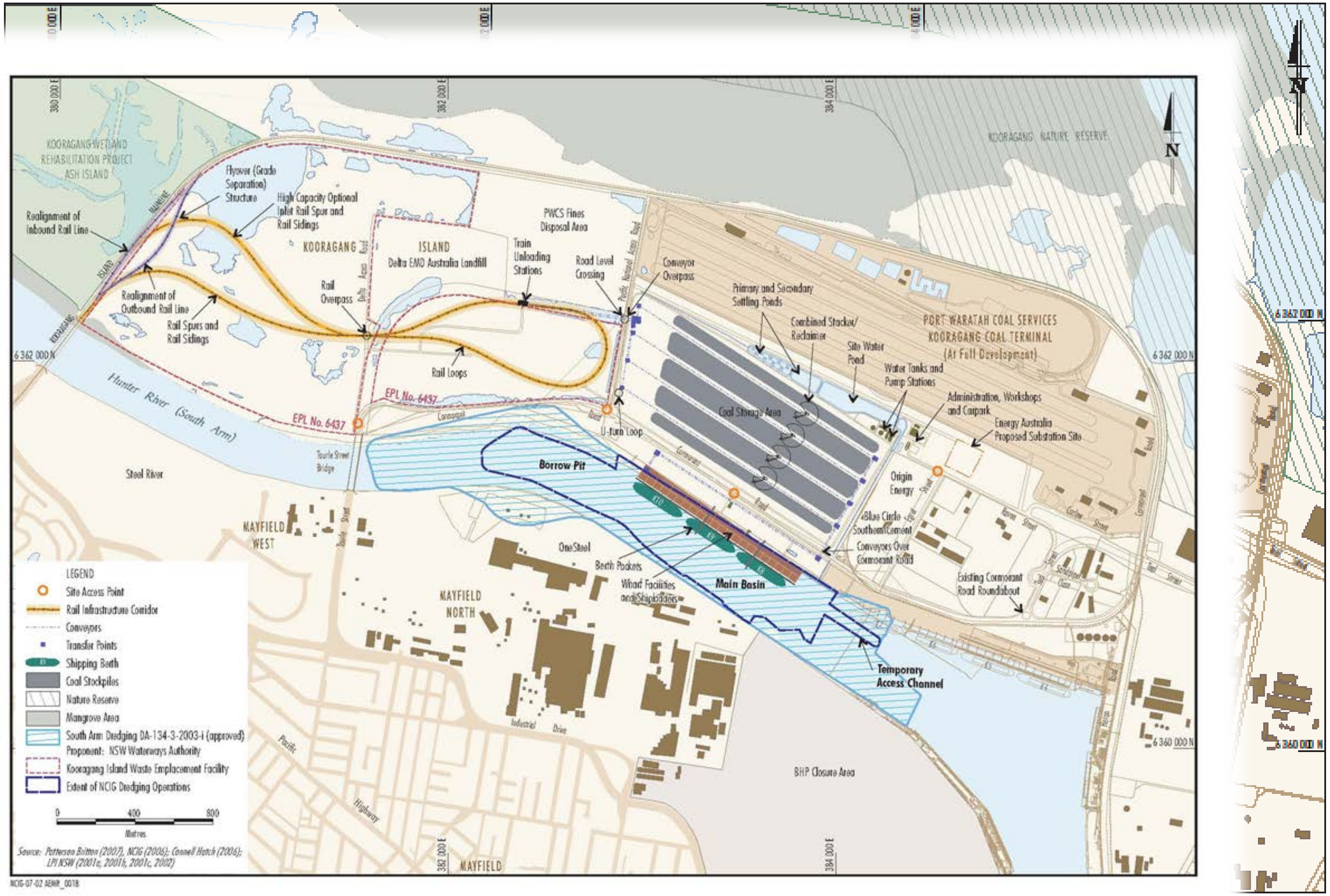


Figure 2: Project Layout

2 Overview of Activities

2.1 Operation

April 2012 to March 2013 reporting period included a continuation of Stage 1 operations, commissioning of Stage 2AA and commencement of Stage 2AA operations. This specifically included operation of Dump Stations 1 and 2, Stacker/Reclaimers 1, 2 and 3 and Ship loader 1, along with associated inbound and outbound conveyor systems. Commissioning was completed on Milestones achieved in this reporting period include:

- April 2012 – 30MT of coal loaded since commencement of operations
- December 2012 – 50MT of coal loaded since commencement of operations

Figure 3: Operation of Stacker Reclaimer 3.

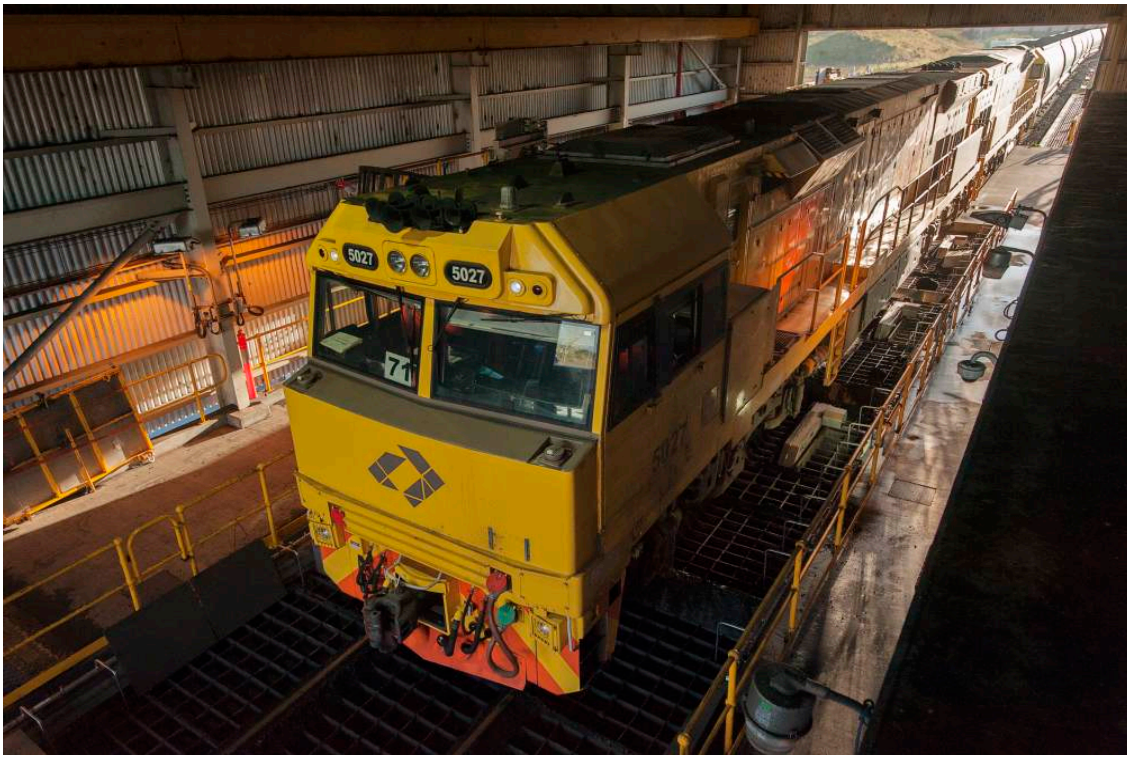


Figure 4: Locomotive in Dump Station 1.

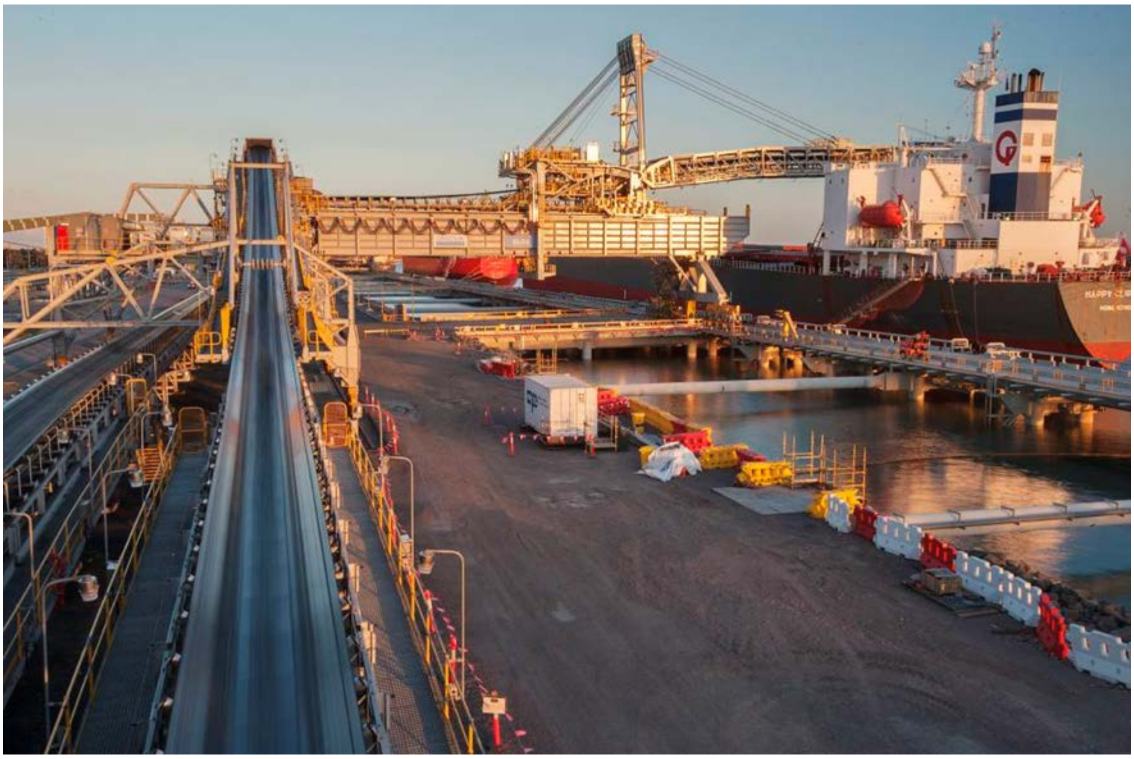


Figure 5: Operation of Ship Loader 2.

Figure 6: Operation of Stockyard Dust Suppression.

Figure 7: Operation of Ship Loader – adjacent cabin view.

Figure 8: Reclaiming of Coal Stockpile.

Figure 9: Dump Station Control Room.

2.2 Construction

Construction activities during this reporting period were associated with the completion of Stage 2AA and commencement of Stage 2F. Construction activities and activities are shown in Figure 10 to Figure 18. The milestones and specific activities associated with construction included:

- May 2012 – Hand-over of Stacker Reclaimer 3 (Stage 2AA) to Operations Team
- June 2012 – Stage 2AA Mechanical Completion
- June 2012 – Commencement of Stage 2F Construction
- July 2012 – Delivery of first Stacker Reclaimer 4 (Stage 2F) components
- August 2012 – Hand-over of Ship Loader 2 (Stage 2AA) to Operations Team
- September 2012 – Hand-over of Dump Station 2 (Stage 2AA) to Operations Team
- December 2012 – Effective Completion of K10 Wharf (Stage 2F) which culminated in the berthing of a panamax vessel
- March 2012 – Practical Completion of Stacker Reclaimer 4 (Stage 2F)

Figure 10: Construction of Ship Loader 2.

Figure 11: Construction of K10 Wharf.

Figure 12: Construction of Dump Station 2.

Figure 13: Construction of Coal Stock pad 5

Figure 14: Construction of Stage 2F Water Infrastructure.

Figure 15: Construction of Stock pad 4 and SR04 Berm.

Figure 16: Construction of Stacker Reclaimer 4.

Figure 17: Construction of Conveyors 17 and 18.

Figure 18: Construction of Stacker Reclaimer 4 Bucket Wheel.

Figure 19: March 2012 Aerial Photograph of Project

Figure 20: March 2013 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 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 22) in accordance with the requirements of the CEMP.

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 Programme

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 22.

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 2012	71.2	2.4	0.0	19.2
May 2012	12.8	0.4	0.0	4.8
June 2012	84.4	2.8	0.0	29.6
July 2012	52.6	1.7	0.0	26.0
August 2012	30.2	1.0	0.0	10.6
September 2012	12.6	0.4	0.0	6.6
October 2012	7.4	0.2	0.0	2.2

Table 3 Rainfall statistics by month

Month	Total rainfall (mm)	Daily average (mm)	Daily minimum (mm)	Daily maximum (mm)
November 2012	22.0	0.7	0.0	5.0
December 2012	42.8	1.4	0.0	15.2
January 2013	100.6	3.2	0.0	52.4
February 2013	119.2	4.3	0.0	27.6
March 2013	82.0	2.6	0.0	61.8
Annual	637.8			

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

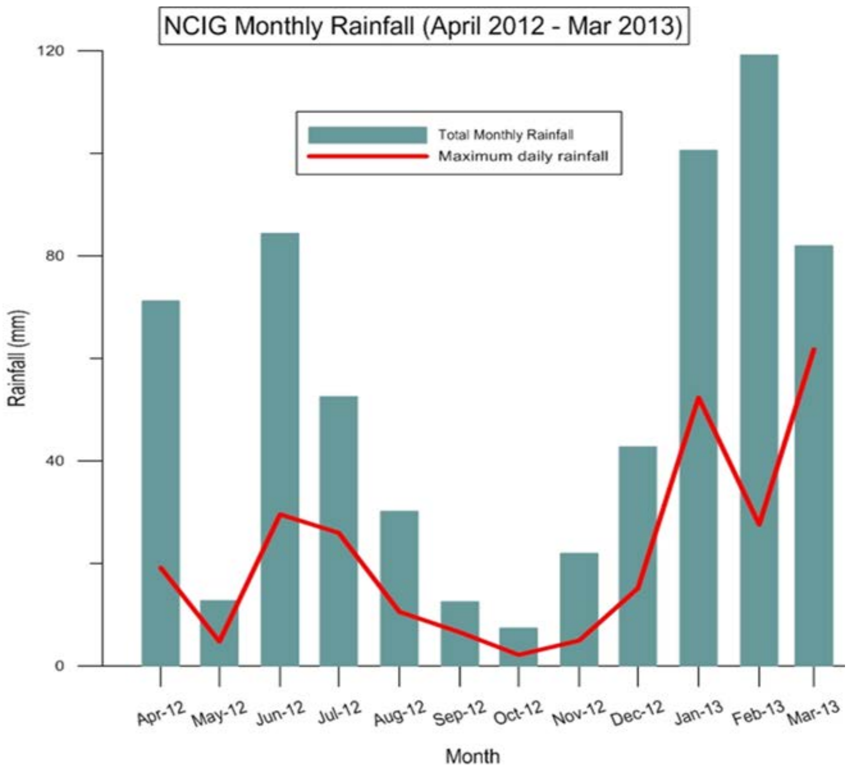


Figure 21: Total and maximum daily rainfall by month

The monthly and daily rainfall recorded at the project site is shown in Figure 21. A total of 637.8 mm of rain was received on the site during the reporting period with the highest rainfall recorded in February 2013. Low rainfall was recorded during the September 2012 to October 2012 period.

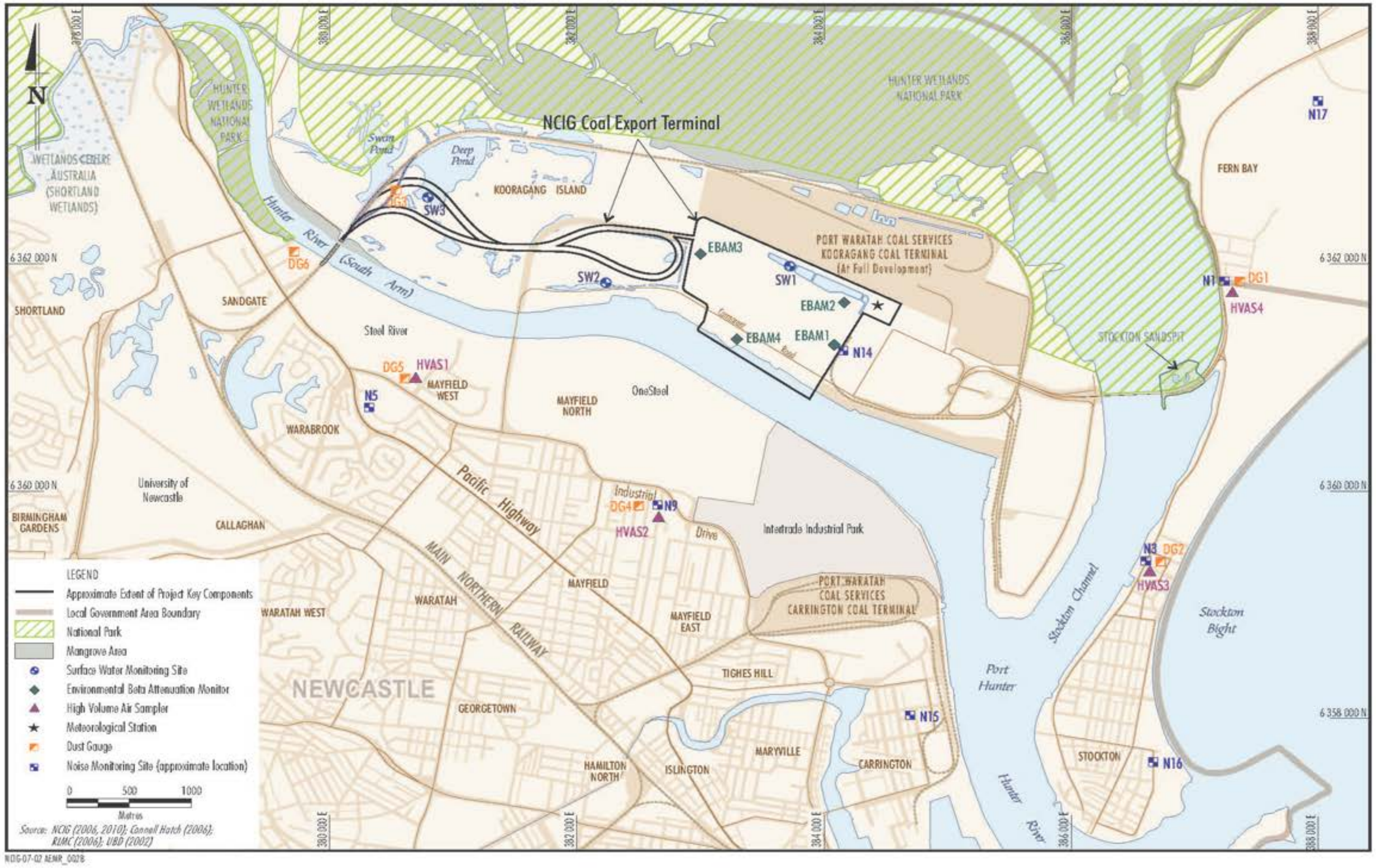


Figure 22: Environmental Monitoring Sites

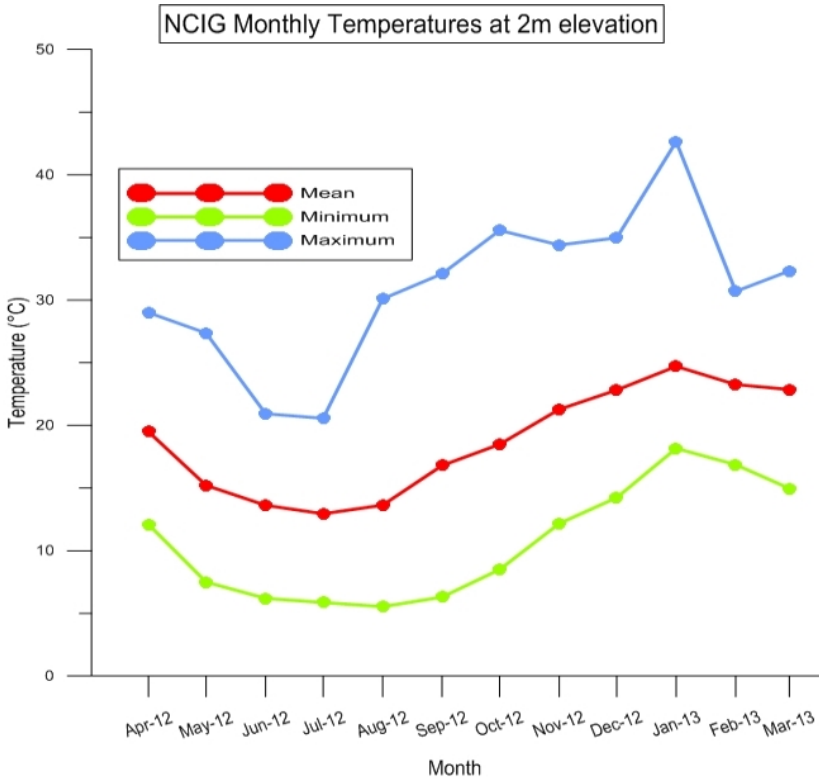


Figure 23: Temperature by month

Figure 23 illustrates the variation in average temperature during the reporting period. These variations from the winter to summer seasons are the expected seasonal normal variations.

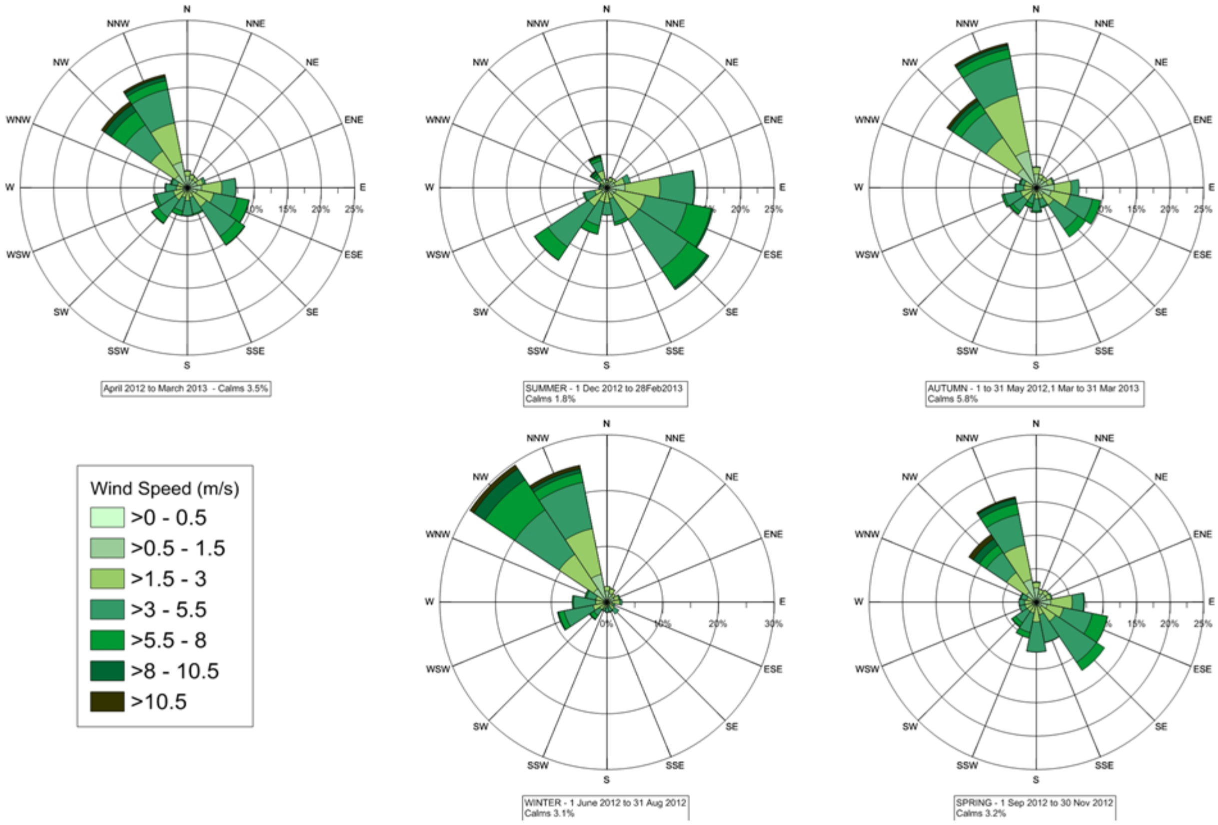


Figure 24: Seasonal Wind Conditions

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

The automated meteorological monitoring station was incorporated into the site management system of NCIG operational activities in 2011/12 and continued to operate in this manner during the 2012/13 reporting period. Parameters such as wind direction are 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. Further improvements will be made involving the classification of dust risk based on forecast and current weather conditions and subsequent alert system.

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/m^3(OEH annual average).

1 The location of monitoring sites is shown on Figure 22.

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 25 and Figure 26 below.

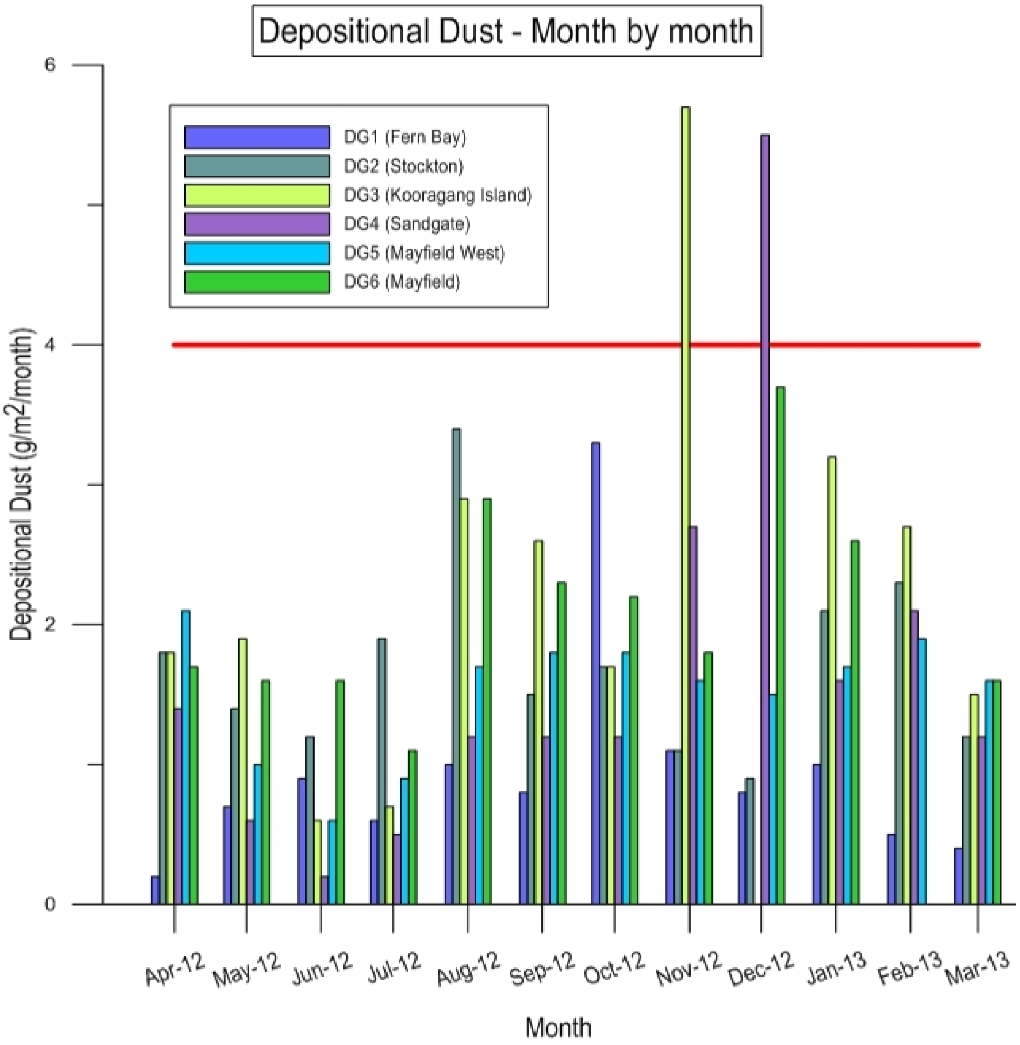


Figure 25: Monthly Depositional Dust

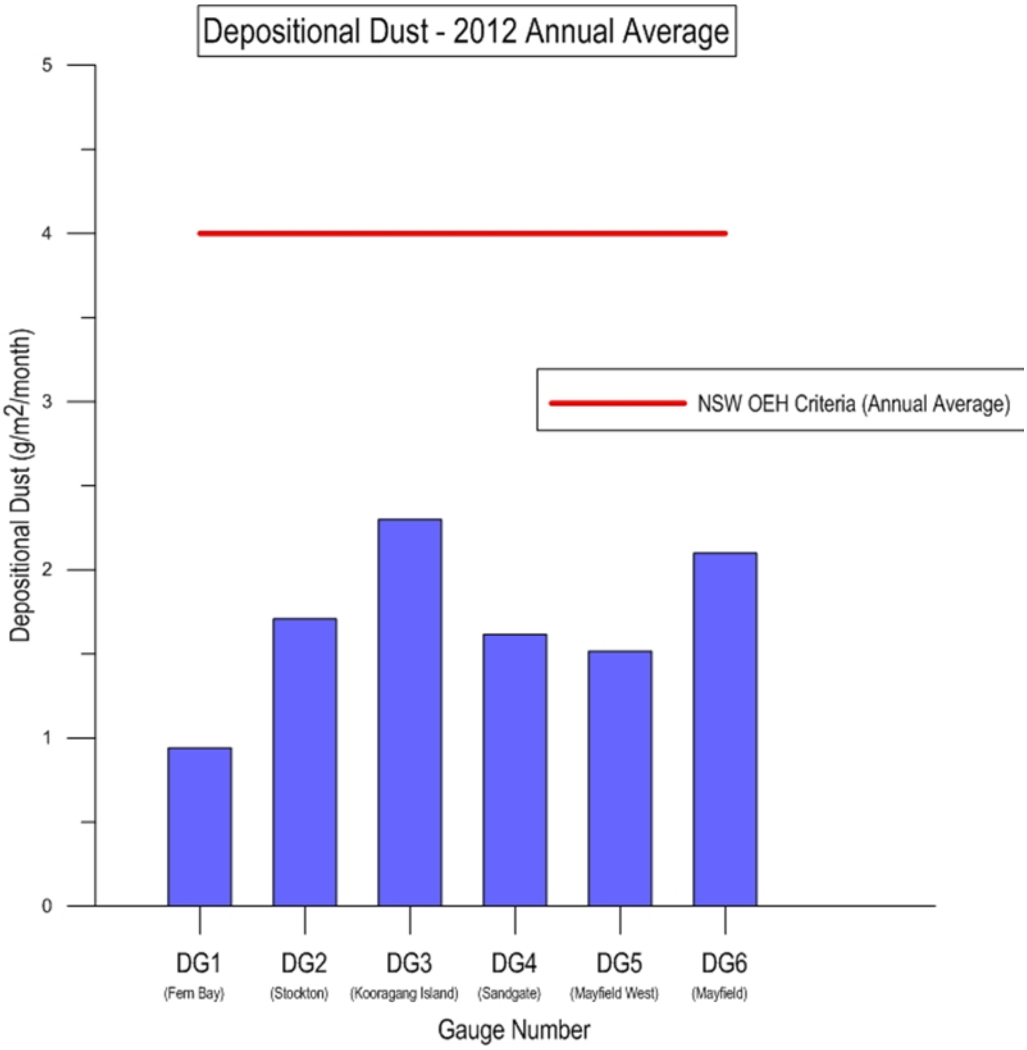


Figure 26: Annual Average Depositional Dust

Average depositional dust results were below the monthly criteria of 4 grams per square metre per month at all depositional dust gauge locations (Figure 26). Figure 25 shows that some individual monthly samples exceeded the 4g/m^2/month criteria.

DG3 was greater than the criteria in November 2012 (5.7), with a high percentage combustible content of 84%. Combustible matter is that portion of the insoluble matter lost during combustion and is an indication of the amount of organic matter in the dust. Any coal particles present in the insoluble deposited dust will be part of the combustible matter fraction, along with other organic matter such as plant fragments, insect material, plastic fragments, wood dust, soot and rubber dust. The ash content is an indication of the mineral content of the dust. The ash is often primarily soil or rock particles, but can include particles such as fly ash and cement dust. (DSITIA, 2012) The high combustible content of the November result for DG3 together with the dominant wind directions of south-easterly and south-westerly for the two months indicate that the source of the dust may be from the adjacent ponds and wetlands and/or from the rail corridor.

DG4 exceeded the criteria in December 2012 (5.5), with a combustible content of 58%. Given the location of this dust deposition gauge and the dominant wind directions of south-easterly and south-westerly, the deposited material would not be sourced from NCIG.

Two of the monthly samples were contaminated by foreign matter. The December 2012 sample for DG3 was contaminated by bird droppings and the February 2013 sample for DG6 was contaminated by insects and tree litter. The results from these samples were excluded from the annual average calculation and are not included in Figure 25 or in Figure 26. All other dust gauges were consistently below the criteria. It should be noted that the criteria is specific only to an annual average for each location. Figure 26 illustrates that the annual average at each location was below $4 g/m^2$/month during the reporting period. Full dust deposition data for the reporting period is provided in Attachment A.

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 27 and Figure 28.

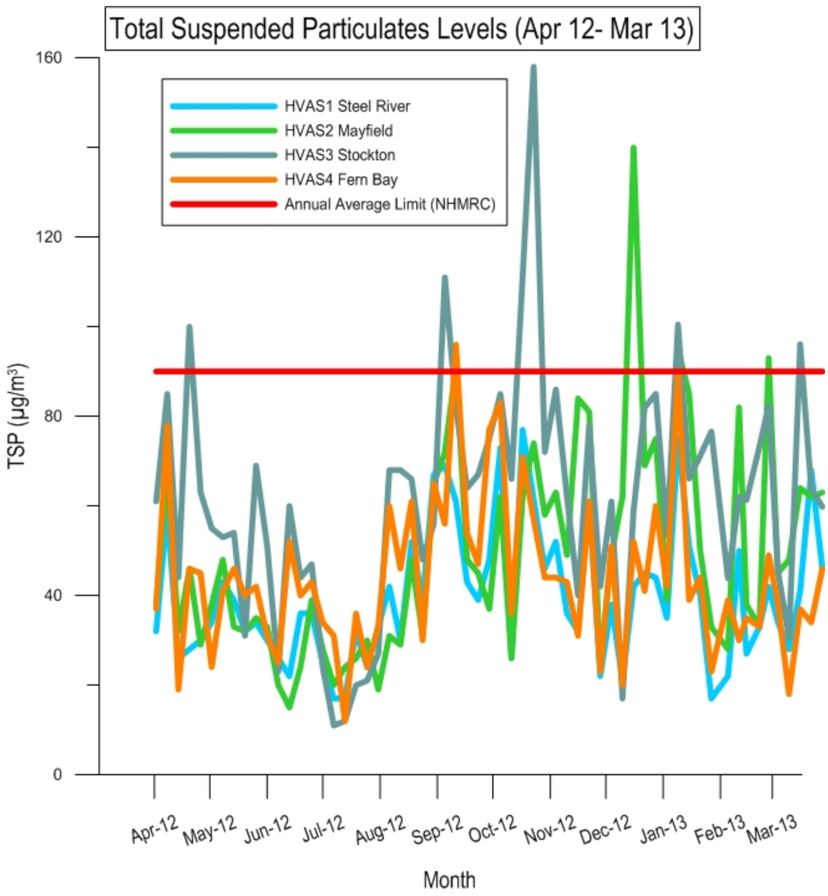


Figure 27: Total Suspended Particulates (TSP)

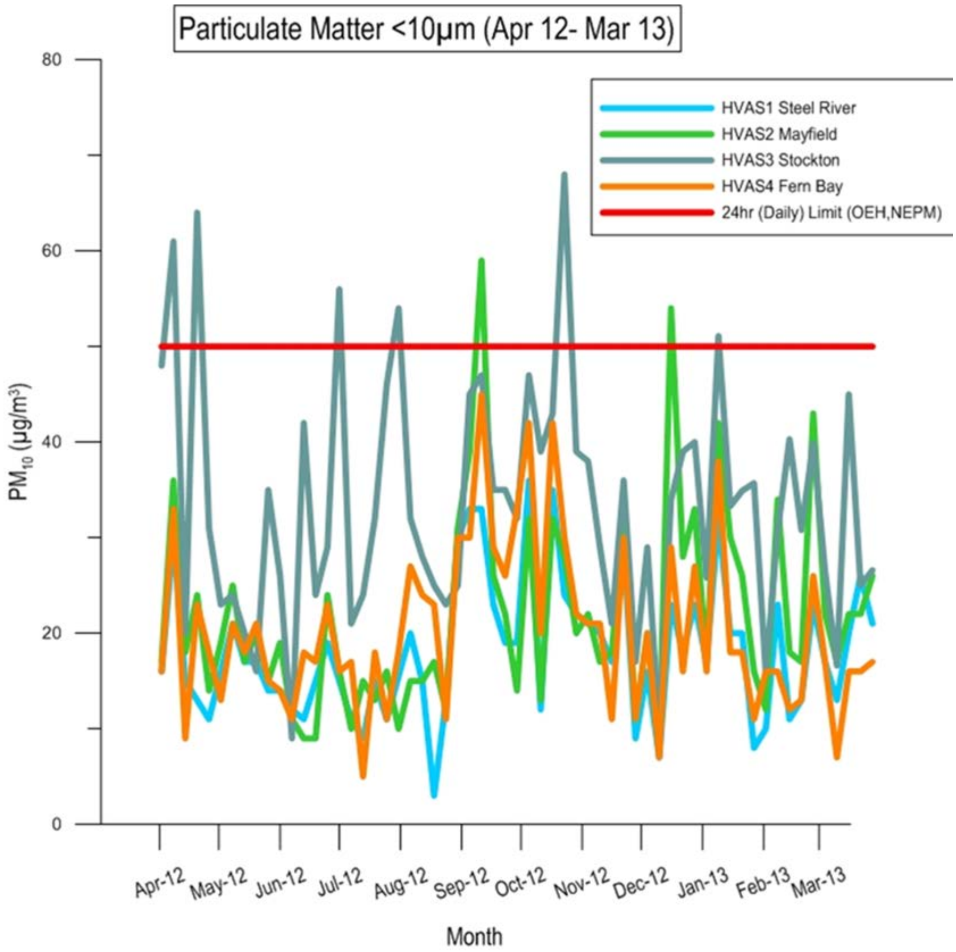


Figure 28: Particulate matter <10µm (PM10)

The annual average TSP concentrations for all four monitoring locations were below the NHMRC Annual Average Limit of 90µg/m^3, as shown in Table 6.

Daily concentrations of PM_{10} were also below their respective guideline of 50µg/m^3 (OEH and NEPM), with the exception of eight individual dates; 11 September 2012, 16 December 2012 (all Mayfield) and 8 April 2012, 20 April 2012, 1 July 2012, 31 July 2012, 23 October 2012 and 9 January 29013 (all Stockton). 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.

Daily average PM_{10} concentrations above the 50µg/m^3 guideline were recorded at the Mayfield (HVAS2) and the Stockton (HVAS3) monitoring stations during the reporting year. 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.

A nor westerly to nor easterly wind direction at elevated wind speeds results in a high risk of particulate emissions sourced from the Kooragang Island vicinity and sampled at the Mayfield monitoring station. These wind conditions can transport particulates from a number of industrial and transport sources to the Mayfield monitoring station.

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

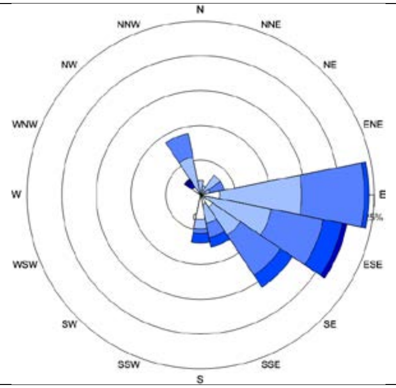
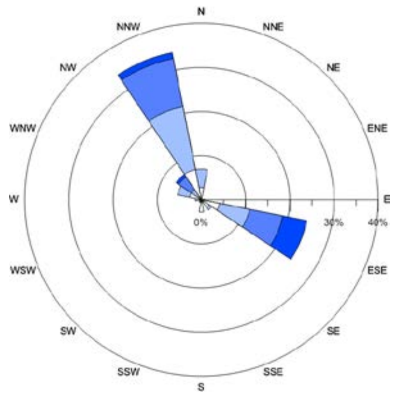
Event	Wind patterns	Comments
8-Apr-12 61 µg/m^3 at Stockton		NCIG is to the northwest of the Stockton monitor. Prevailing winds on this day were from the east, therefore: - Activities at NCIG were unlikely to have contributed to the measured result at Stockton on this day. Outcome: Compliance
20-Apr-12 64 µg/m^3 at Stockton		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, the preceding day recorded 2.6mm of rainfall at NCIG. Wind speeds ranged from 0.2 to 5.7 m/s. Measured PM_{10} concentrations at Beresfield (upwind of Kooragang Island on the day were 20 µg/m^3 (EPA, 2013). The 24-hour average PM10 concentration measured by the BAM on NCIG's eastern boundary was 34 µg/m3. Therefore: - Activities on Kooragang Island may have caused the exceedances of the 50 µg/m3 criterion on this day. The specific source(s) could not be identified. - Activities at NCIG were unlikely to have caused the exceedances, since NCIG's on-site BAM monitoring result showed a 24-hour average PM10 concentration of only 34 µg/m3. - Modelling in the Environmental Assessment suggested that the

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

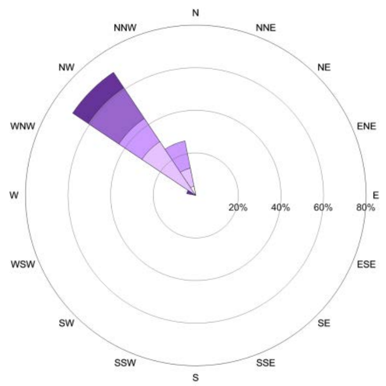
Event	Wind patterns	Comments
		maximum 24-hour average PM10 concentration at Stockton, due to NCIG activities, would be up to around 5 µg/m3 Outcome: Compliance
1 – Jul -12 56 µg/m3 at Stockton (SKM,2013)		NCIG is to the northwest of the Stockton air quality monitor. Prevailing winds on this day were from the northwest. There was no rainfall on this day, or on the preceding day. Wind speeds ranged from 1.2 to 7.5 m/s. Measured PM10 concentrations at Beresfield (upwind of Kooragang Island on this day) were 18 µg/m3 (EPA, 2013). The 24-hour average PM10 concentration measured by the BAM on NCIG's eastern boundary was 14 µg/m3. Therefore: - Activities on Kooragang Island may have caused the exceedances of the 50 µg/m3 criterion on this day. The specific source(s) could not be identified. - Activities at NCIG were unlikely to have caused the exceedances, since NCIG's on-site BAM monitoring result showed a 24-hour average PM10 concentration of only 14 µg/m3. - Modelling in the Environmental Assessment suggested that the maximum 24-hour average PM10 concentration at Stockton, due to NCIG activities, would be up to around 5 µg/m3 Outcome: Compliance

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

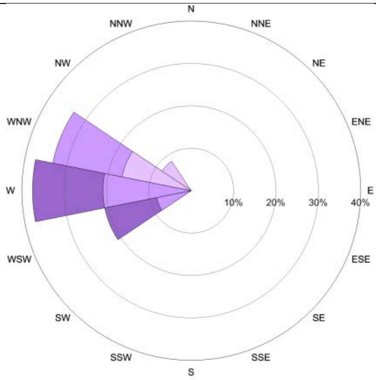
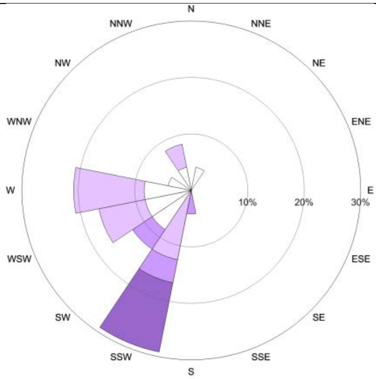
Event	Wind patterns	Comments
31-Jul-12 54 µg/m3 at Stockton (SKM, 2013)		NCIG is to the northwest of the Stockton monitor. Prevailing winds on this day were from the west, therefore: - Activities at NCIG were unlikely to have contributed to the measured result at Stockton on this day. Outcome: Compliance
11-Sep-12 59 µg/m3 at Mayfield (SKM, 2013)		NCIG is to the north-northeast of the Mayfield monitor. Prevailing winds on this day were from the south-southwest, therefore: - Activities at NCIG were unlikely to have contributed to the measured result at Mayfield on this day. Outcome: Compliance

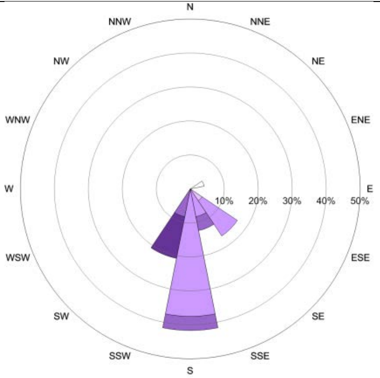
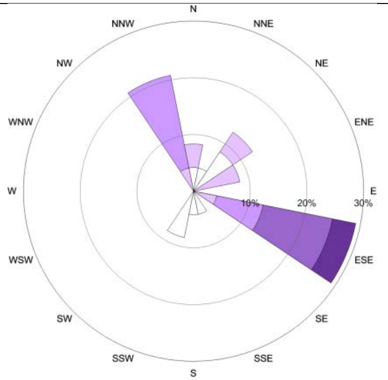
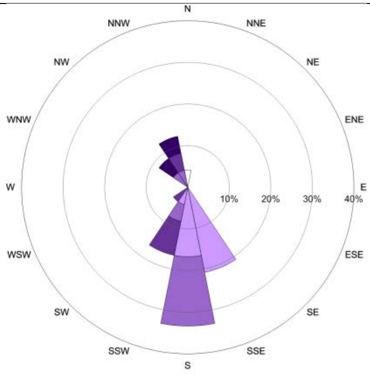
Table 5 Daily PM_{10} events greater than 50µg/m^3 guideline value.		
Event	**Wind patterns**	**Comments**
23-Oct-12 68 µg/m3 at Stockton (SKM,2013)		NCIG is to the northwest of the Stockton monitor. Prevailing winds on this day were from the south, therefore: - Activities at NCIG were unlikely to have contributed to the measured result at Stockton on this day. Outcome: Compliance
16-Dec-12 54 µg/m^3 at Mayfield (SKM,2013)		NCIG is to the north-northeast of the Mayfield monitor. Prevailing winds on this day were from the east-southeast and north-northwest, therefore: - Activities at NCIG were unlikely to have contributed to the measured result at Mayfield on this day. Outcome: Compliance

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

Event	Wind patterns	Comments
9-Jan-2013 51 µg/m^3 at Stockton (SKM,2013)		NCIG is to the northwest of the Stockton monitor. Prevailing winds on this day were from the south, 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 station 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	37.7	44.6	58.7	44.0
PM_{10} annual average criteria (NSW DEC, 2005)	30			
PM_{10}	17.6	20.7	32.4	20.0

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).

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.

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 and high traffic areas using water trucks to minimise the generation of dust;
- 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 Dust Management System were made in the 2012/13 reporting period. These improvements included further implementation of a dust risk classification system and 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.

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 area.	Sediments, soluble salts, heavy metals, organic contaminants, fuels, 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.

Table 7 Potential surface water quality impacts

Project Site	Potential Impact Scenario	Potential Contaminant
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 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 19).

A separate Soil and Water Management Plan was developed for dredging activities in accordance with Condition B4.5(b), Sub-Schedule B, Schedule 2, of the Port Consent. The Soil and Water Management Plan outlines the measures employed to manage surface water and to minimise soil erosion and the discharge of sediments and other pollutants to lands and/or waters for the duration of dredging and excavation works conducted as part of the extension of shipping channels in the Port of Newcastle. While the results for monitoring requirements under the Soil and Water Management Plan are not included in this report, the general aim of protecting water quality in the south arm of the Hunter River was maintained.

It should be noted that dredged material was dumped at sea and was not brought to land for reclamation works during the reporting period.

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 and OEMP. These monitoring elements form the Surface Water Monitoring Programme 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.

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 29). 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. Further additions to the surface water management system were made during the reporting period, including Stage 2F construction. This included subsurface drainage from beneath Coal Stockpile Pads 4 and 5, and associated collection sumps. 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 29 with the water quality results recorded detailed in Appendix B.

Values for pH on site were more variable than the previous reporting period with a range of 7.4 to 8.8, although this is considered to be a healthy range and within historical range. The offsite water resources (6.9 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 higher onsite than offsite, and saw a downward trend across all sites for the monitoring period. Elevated onsite EC is likely due to runoff from reclaimed river sediments used for construction of the stockpads. 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.

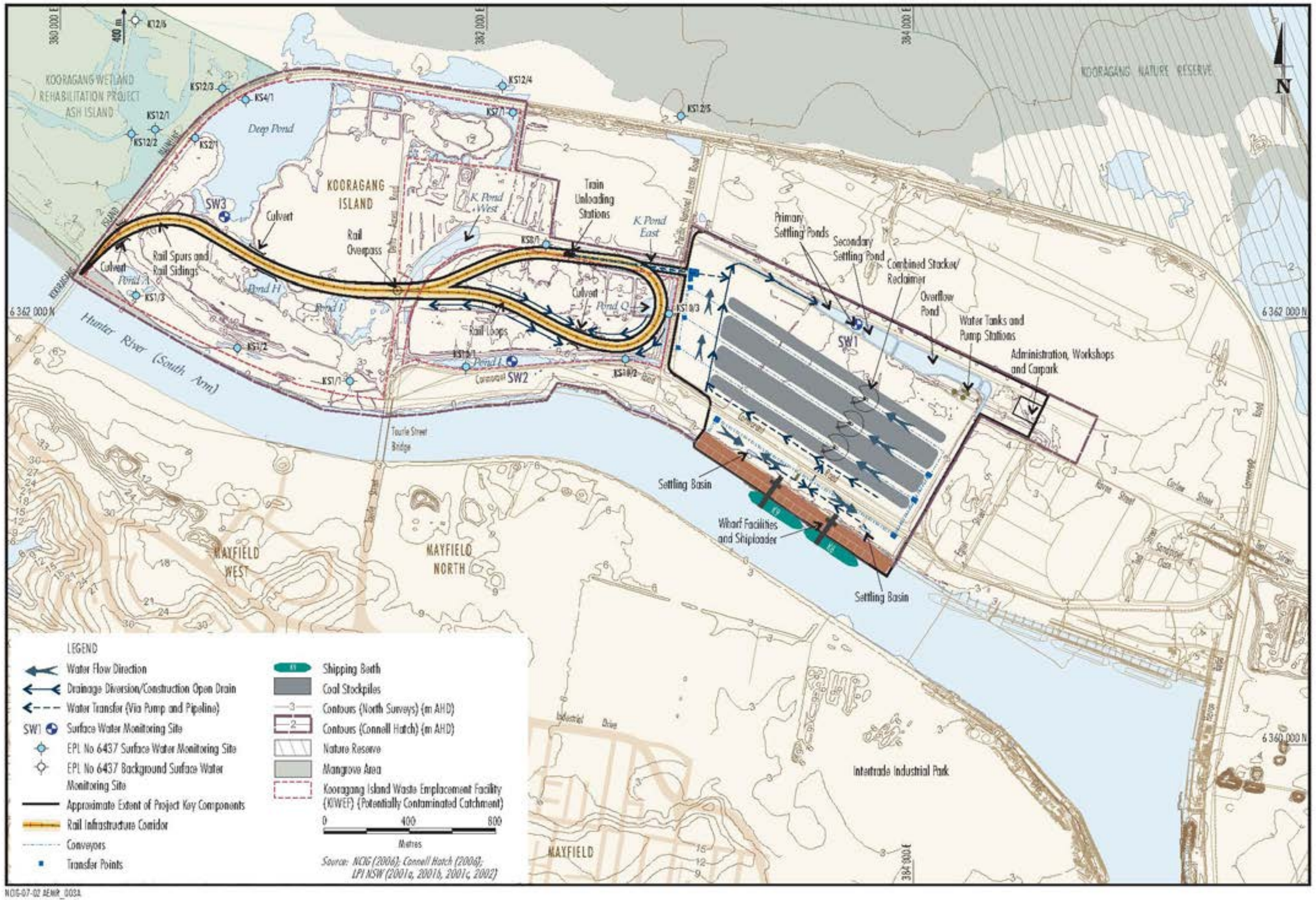


Figure 29: Permanent site drainage layout

3.3.4 Further Improvements

Additional surface water controls will be completed as part of Stage 2F construction, namely the new wharf settling basin and associated sumps and drainage infrastructure. Additional sumps will also be constructed for the Stage 2F stockyard. Both the wharf and stockyard sumps and settling basins will be directed to the settling pond system at the northern side of the stockyard.

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 to 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 air quality 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.

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 was completed during this reporting period. Ongoing amendments to construction erosion and sediment control 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 monitoring period prior to the current reporting 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 29), 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.

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 EPL 12693.

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.

[1] The location of monitoring sites is shown on Figure 29

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 illustrated in Appendix D.

An assessment of the monitoring records found that the Trigger Values were not exceeded at any of the required monitoring locations and is summarised in Table 11. Concentrations at GW1 were also within ranges previously recorded at this location with the exception of one analyte in December 2012. Ammonia was high for the current reporting year at a concentration of 780 µg/L when compared to the limited dataset available.

Table 11 Summary of the Groundwater Monitoring Results April 2012- March 2013

Monitoring Sites	Dates of Sampling	Any exceedances of site specific trigger values?	Comments
GW1 (Monitoring Point 1).	8/6/12 & 11/12/12	N/A	
K9/3N (Monitoring Point 20)	11/12/12	No	December 12 sample not collected due to standpipe damage.
K9/3S (Monitoring Point 21)	11/12/12	No	December 12 sample not collected due to standpipe damage.
K11/1 (Monitoring Point 22)	8/6/12 & 11/12/12.	No	
K11/1S (Monitoring Point 23)	8/6/12&11/12/12.	No	
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.	Not required to be sampled as no exceedances of trigger criteria.

Minor excavation works for the wharf settling basin and sumps were completed during the reporting period. Groundwater encountered during this work was tested prior to dewatering, and was found to be within acceptable levels, with similar concentrations to previous excavations in similar areas.

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

Groundwater quality monitoring will be expanded in the next reporting period to include the Rail Flyover.

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

There were no capping works undertaken during the period, as Stage 2AA rail construction was completed.

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 commence during the next reporting period. Rail earthworks will be capped with low permeability material in accordance with the NCIG Environmental Assessment.

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.

During the reporting period there was an excavation undertaken that required initiation of the representative surface and sub-surface soil sampling and analysis programme. The excavation into natural estuarine material at the wharf occurred in November 2012 and was part of the Stage 2F construction activities. Sampling was undertaken in accordance with the NSW Acid Sulfate Soil Management Advisory Committee (ASSMAC), *Acid Sulfate Soil Manual* (1998). Laboratory analysis resulted in one soil sample being classified as ASS. The excavated soil was treated on-site in accordance with the ASSMP. Validation sampling of the treated soil was conducted and found that the neutralisation process had been successful.

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 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. No piling activities were undertaken within 180m of an industrial receiver and, as such, no vibration monitoring was conducted during the period.

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 throughout the reporting period noise surveys identified that current construction, as well as operation of the NCIG Terminal was conducted below the relevant noise criteria.

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 30). 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 30: 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 31). 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 31). 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.

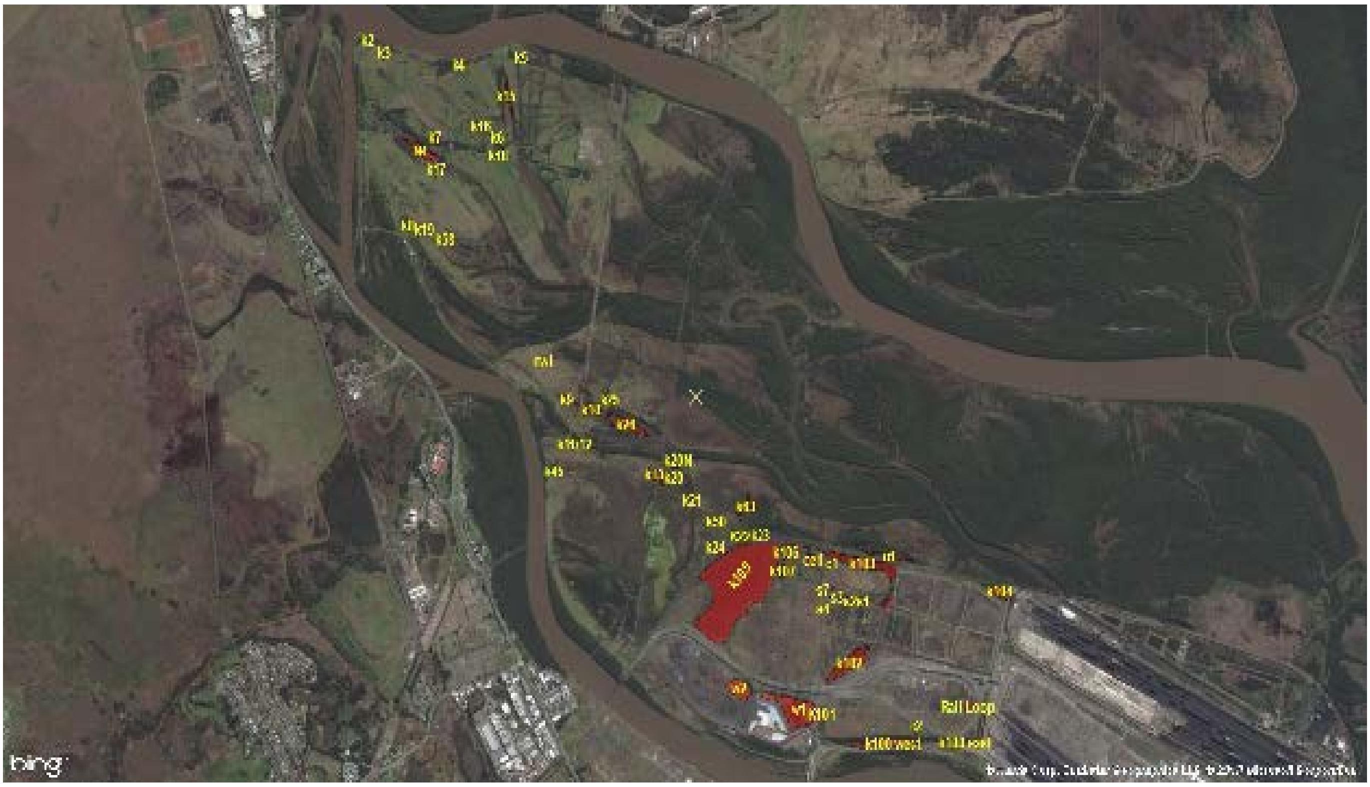


Figure 31: Green and Golden Bell Frog Surveyed Areas

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
4/4/2012	1	Good	7cm.	DS02 cable pit	Pond I
20/4/2012	1	Good	6cm	CV01 tunnel	Pond I
29/01/2013	1	Good	8cm	CV01 tunnel	Pond I
12/03/2013	1	Good	8cm	DS01 CV01 conveyor	Pond I

During the reporting period a total of four (4) 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. All specimens were alive and in good condition, ranging from 6–8cm in length. The majority of frogs were considered to be adults, 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 2012/13 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 2012, December 2012, January 2013 and March 2013.

Table 17 Green and Golden Bell Frogs Population Estimate

Pond surveyed	October 2012		December 2012		January 2013		March 2013	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
C1	NS	NS	NS	NS	0	0	26	13
C2	NS	NS	NS	NS	NS	NS	26	13
K1	NS	NS	NS	NS	NS	NS	0	0
K10	0	0	0	0	0	0	0	0
K100 centre	0	0	0	0	0	0	0	0
K100 east	0	0	0	0	0	0	0	0
K100 extension	39	26	0	0	0	0	0	0
K100 west	0	0	0	0	26	13	0	0
K101	NS	NS	NS	NS	24	11	19	5
K102	NS	NS	NS	NS	46	34	0	0
K103	NS	NS	NS	NS	374	383	39	26
K104	0	0	NS	NS	48	37	25	12
K105	NS	NS	NS	NS	40	28	45	33
K106	NS	NS	NS	NS	0	0	0	0
K107	NS	NS	NS	NS	24	10	0	0
K11/12	0	0	0	0	0	0	0	0
K13	0	0	0	0	0	0	0	0
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	0	0	0	0
K2	0	0	0	0	0	0	0	0
K20	0	0	0	0	0	0	0	0
K21	0	0	0	0	0	0	0	0
K22/23	24	53	67	151	68	97	162	162
K24	0	0	0	0	0	0	0	0
K25	0	0	0	0	0	0	0	0
K26	0	0	0	0	0	0	21	8
K27	0	0	0	0	NS	NS	0	0
K29	NS	NS	NS	NS	NS	NS	23	10
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	NS	NS
K58	NS	NS	NS	NS	NS	NS	0	0

Table 17 Green and Golden Bell Frogs Population Estimate

Pond surveyed	October 2012		December 2012		January 2013		March 2013	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
K6	0	0	0	0	0	0	0	0
K63	0	0	0	0	0	0	17	3
K7	0	0	0	0	0	0	0	0
K8	0	0	0	0	0	0	0	0
K9	0	0	0	0	NS	NS	0	0
N1	NS	NS	0	0	81	71	NS	NS
N4	NS	NS	NS	NS	NS	NS	0	0
Rail loop	8	8	12	12	6	6	62	52
S1	NS	NS	NS	NS	0	0	0	0
S2	NS	NS	NS	NS	0	0	0	0
S3	NS	NS	NS	NS	0	0	0	0
S4	NS	NS	NS	NS	0	0	0	0
S5	NS	NS	NS	NS	0	0	0	0
S6	NS	NS	NS	NS	0	0	0	0
S7	NS	NS	NS	NS	0	0	0	0
W1	NS	NS	NS	NS	26	13	NS	NS
W2	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 during October and December. Therefore, to produce a more realistic estimate of the population in these two months the ponds that were not able to be surveyed were factored into the calculation by assuming a stable population at ponds that had contained GGBF during surveys in previous years. Adjusted for these calculations, the estimate of total GGBF on KI/AI was between 831 and 836 in January 2013, and 522 and 523 in March.

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 2012 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 2011 results, there has been an increase (14%) in the total number of birds using the pond from 8178 to 9321 in 2012. This is due mainly to an increase in overall pond usage during June and July. This was likely due to:

- an increase in average rainfall for the period and resulting high pond levels, encouraging several water fowl to populate the pond over an extended period

- Conversely, there was a low number of shorebirds utilising the ponds, also because of the above average pond levels. This discouraged shorebirds from using the pond as a refuge site. In addition, rainfall in central Australia resulted in migration of shorebird species away from the coast to inland water systems.

Table 18 Avifauna 2012 Monitoring Results

Species	20/1/12	11/2/12	11/3/12	21/4/12	18/5/12	23/6/12	21/7/12	15/9/12	12/10/12	16/11/12	17/12/12	Total
Musk Duck *Biziura lobata*	1	3	1		3	1	2	2	2	2	1	18
Black Swan *Cygnus atratus*	21	11	15		10	5	11	9	5	17	19	123
Australian Shelduck *Tadorna tadornoides*					2							2
Pacific Black Duck *Anas superciliosa*	14	3	6	8	11	9	13	2	2	69	7	144
Australasian Shoveler *Anas rhynchotis*	3	7			4							14
Grey Teal *Anas gracilis*	68	124			166	5	4	60	124	212	456	1219
Chestnut Teal *Anas castanea*	409	7	36		581	730	400	220	460	276	738	3857
Pink-eared Duck *Malacorhynchus membranaceus*					1				4		15	20
Hardhead *Aythya australis*	91	55	27		54	90	110	35	14	33	92	601
Australasian Grebe Tachybaptus novaehollandiae	*21*		24	6	95	13	12	7	27	41	43	289
Hoary-headed Grebe *Poliocephalus poliocephalus*			4	5	35	4	9	9	7	12		85
Australasian Darter *Anhinga novaehollandiae*									1	2	1	4
Little Pied Cormorant *Microcarbo melanoleucos*	1								1	1	1	4
Little Black Cormorant *Phalacrocorax sulcirostris*	10	6	8	4	6	1	1	1	5		15	57
Great Cormorant *Phalacrocorax carbo*	1		1					2	7	3	2	16

Table 18 Avifauna 2012 Monitoring Results

Species	20/1/12	11/2/12	11/3/12	21/4/12	18/5/12	23/6/12	21/7/12	15/9/12	12/10/12	16/11/12	17/12/12	Total
Australian Pelican *Pelecanus conspicillatus*		1			2				21	28	17	69
White-faced Heron *Egretta novaehollandiae*			2		4			1	7		1	15
Little Egret *Egretta garzetta*					7		5	2	1	4	5	24
White-necked Heron *Ardea pacifica*										1		1
Eastern Great Egret *Ardea modesta*	3				6	1		3		3	4	20
Intermediate Egret *Ardea intermedia*						1		2		2	2	7
Australian White Ibis *Threskiornis molucca*	3								1	27	31	62
Royal Spoonbill *Platalea regia*	1									4	41	46
Whistling Kite *Haliastur sphenurus*					1	2						3
White-bellied Sea-Eagle *Haliaeetus leucogaster*									2			2
Spotted Harrier *Circus assimilis*					1							1
Swamp Harrier *Circus approximans*					3		1		2		1	7
Australian Hobby *Falco longipennis*					1							1
Peregrine Falcon *Falco peregrinus*					1							1
Purple Swamphen *Porphyrio porphyrio*	44	11	32	15	14	3	14	5			43	181
Dusky Moorhen *Gallinula tenebrosa*	2					1					1	4
Eurasian Coot *Fulica atra*	151	108	89		209	138	148	200	145	304	574	2066

Table 18 Avifauna 2012 Monitoring Results

Species	20/1/12	11/2/12	11/3/12	21/4/12	18/5/12	23/6/12	21/7/12	15/9/12	12/10/12	16/11/12	17/12/12	Total
Red-necked Stint *Calidris ruficollis*											5	5
Sharp-tailed Sandpiper *Calidris acuminata*									38			38
Black-winged Stilt *Himantopus himantopus*							1	7		1	89	98
Red-necked *Avocet Recurvirostra novaehollandiae*											1	1
Black-fronted Dotterel *Elseyornis melanops*	2									1	4	7
Red-kneed Dotterel *Erythrogonys cinctus*											3	3
Masked Lapwing *Vanellus miles*	2		5					1	2	11	4	25
Silver Gull *Chroicocephalus novaehollandiae*										6	30	36
Caspian Tern *Hydroprogne caspia*											1	1
Superb Fairy-wren *Malurus cyaneus*			6									6
White-fronted Chat *Epthianura albifrons*					9							9
Grey Fantail *Rhipidura albiscapa*					1							1
Willie Wagtail *Rhipidura leucophrys*					10							10
Australian Raven *Corvus coronoides*			4		3							7
Australasian Pipit *Anthus novaeseelandiae*					1							1
Red-browed Finch *Neochmia temporalis*					6							6

Table 18 Avifauna 2012 Monitoring Results

Species	20/1/12	11/2/12	11/3/12	21/4/12	18/5/12	23/6/12	21/7/12	15/9/12	12/10/12	16/11/12	17/12/12	Total
Welcome Swallow *Hirundo neoxena*					100							100
Golden-headed Cisticola *Cisticola exilis*			4									4
Total 2012	**848**	**336**	**264**	**38**	**1347**	**1004**	**731**	**568**	**878**	**1060**	**2247**	**9321**
Total 2011	**447**	**965**	**2271**	**763**	**396**	**27**	**92**	**685**	**990**	**477**	**477**	**8178**
% change on 2011	**90**	**-65**	**-88**	**-95**	**240**	**3619**	**695**	**-17**	**-11**	**122**	**371**	**14**

Note 1: No survey was performed in August 2012 due to lack of access; nil observations.
Note 2: There was no access to the site in April, June, July and September. Observations were made from the western boundary of the site. Counts are therefore not comprehensive.

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 2012 and March 2013.The following points highlight the major works undertaken and milestones achieved during this reporting period.

Consultative Board –Consultative Board meetings were held on 23 May and 5 December 2012. 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. The Terms of Reference for the Board were reviewed and updated during the first meeting. At each meeting, papers have been presented on a range of topics for the consideration and discussion of Board members. The topics discussed include:

- Land allocation process;
- Research initiatives;
- Population modelling;
- Population of constructed habitat; and
- Ameliorative works.

Compensatory Land Package – In the May 2012 meeting of the Consultative Board, a renewed approach to quantification of compensatory land area was proposed. The approach includes population modelling of a Green and Golden Bell Frog (GGBF) population introduced to the NCIG Research Area trial ponds, establishing occupancy rates for various habitat types, comparing these habitat types with those impacted by the NCIG Project, and then calculating the likely impacted population from this process. The size and types of habitat to be constructed to sustainably support this population will then be calculated, with twice this land area constructed, in accordance with PA 06_0009, Condition 2.20.

NCIG received draft conditions in the first quarter of 2013 for a Modification under the existing terminal approval (Project Approval 06_0009), to construct and operate a rail flyover; an additional piece of rail infrastructure to increase inbound capacity and to bring the capacity of the terminal to 66 Million tonnes per annum. The draft conditions include a requirement to provide for the establishment of 75ha of compensatory habitat for the GGBF in a location agreed by the Director-General. The amount of habitat may be reduced if NCIG can show that the original impacted population was less than 37.5ha, using a scientific methodology agreed to by the Department of Planning and infrastructure. The population modelling is to be completed by 30 June 2015 and the establishment of habitat to be completed by 31 December 2016. The National Park status of the Ash Island land area requires that a process is followed to facilitate access. This requires completion of Review of Environmental Factors (REF) for construction and operation of the GGBF habitat to enable a determination and approval provided by NPWS.

NCIG has commenced correspondence with NPWS regarding access to additional land on Ash Island, to investigate the suitability of habitat construction. A topographical survey and flora investigations of potential habitat locations were performed in the first quarter 2013 with fauna, soil, surface water and groundwater investigations planned. Results of all investigations including those completed in 2011 and 2012, will form a landscape plan for GGBF habitat in locations deemed to be suitable for habitat construction. The landscape plan will be included in the REF required by the draft conditions of approval for the modification.

Figure 32: CHEMP Consultative Board Inspection of GGBF Research Ponds

Research Area Ponds and Monitoring– A licence was provided by the National Parks and Wildlife Services to NCIG to occupy land in the Hunter Wetlands National Park on Ash Island, for the purpose of the GGBF compensatory habitat development in the form of Research Area ponds. The licence was signed by NCIG and then subsequently by NPWS on 29 June 2012.

A Construction Environmental Management Plan (CEMP) for the Research area was developed and approved by NPWS. Construction and planting of the research ponds was completed on 20 November 2012 after a three month construction period. Water carts were used to fill and maintain the water level in the ponds with potable water until the first significant rainfall occurred in January 2013. This rainfall allowed the ponds to continue to establish under natural conditions. Discussions between Hunter Water and NPWS took place to connect the research ponds to existing potable water infrastructure on Ash Island. A small water distribution system was installed for maintenance of pond water level should the experimental design be potentially impacted upon by excessively low pond water levels. The use of potable water is not considered a sustainable practice for full-scale compensatory habitat and associated ponds.

A Translocation Proposal to release captive-bred Bell Frogs into the research Area was approved by NPWS Licencing Division at the beginning of February 2013. This allowed for the release, pending negative Chytrid screening tests of captive bred animals. Screening tests were successful and the first animals were released into ponds on 17 February 2013. Animals were released into half (8) of the sixteen ponds, to monitor future pond occupancy relative to release ponds and non-release ponds. At the commencement of the release period, tadpoles were kept in a 1 m^3 mesh basket within the release ponds to monitor the health of animals in a controlled manner. As no mortalities were observed in the baskets, the animals were gradually released from the baskets into the ponds. The final release date was 21 February 2013, and approximately 6500 animals were released.

Since the introduction of the captive-bred animals into the ponds, the University of Newcastle has been intensively monitoring released animals for health. In preparation for ongoing monitoring, captured animals larger than 15mm with are tagged with a unique microchip indicator and re-released. This will provide an understanding of population size over time and movement within the Research Area.

Figure 33: Green and Golden Bell Frogs Research Ponds

Behavioural Research - Further research work relating to the behavioural aspects of the Green and Golden Bell Frog continued throughout the reporting year. The overall research package is composed of a number of questions, the first of which asks if the Green and Golden Bell Frog is attracted to areas occupied by conspecifics (individuals of the same species).Following on from pilot studies completed during the previous reporting period, field studies were conducted in ponds at Kooragang island and also at Sydney Olympic Park to investigate if *L. aurea* is attracted to areas that are not currently inhabited through the use of artificial conspecific calls.

Remaining research questions relating to habitat suitability and discrimination between diseased/infected conspecifics, will be answered subsequently based on the findings of the work currently being undertaken.

Green and Golden Bell Frog (GGBF) Annual Monitoring - As a condition of Project Approval 06_0009, NCIG are required to undertake monitoring of GGBF in locations around the NCIG Terminal on Kooragang Island. This area has recently been inaccessible for NCIG personnel due to Pre-Feasibility Investigation work undertaken by Port Waratah Coal Services for the T4 Project.

As part of T4 Pre-feasibility works, PWCS has been undertaking GGBF monitoring in locations previously monitored by NCIG. The University of Newcastle conducted this monitoring on behalf of PWCS, which started with the first substantial rain at the end of 2012. Discussions have been held between NCIG and PWCS regarding monitoring information sharing. Coordination with the University of Newcastle and details regarding rationalisation of other monitoring activities on Kooragang Island are planned.

Ameliorative Works – Since the repair works on Wader Creek (Creek 4) culvert and application of scour protection by NPWS, Kooragang Wetlands Centre has installed drop boards into the Fish Fry Creek (Creek 5) culvert for the purpose of hydrological management of Area E. The purpose of this is to manage the 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.

Figure 34: 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 2012 to March 2013

Works/Milestone/Stage	Intended Completion Date
Consultative Board Meetings	May and December 2012
Submission of REF for construction of GGBF trial compensatory habitat on Ash Island, to NPWS	April 2012
Approval of trial GGBF compensatory habitat on Ash Island	June 2012
Construction of GGBF trial compensatory habitat on Ash Island	4th Quarter 2012
Planting of vegetation growing in Hunter Wetlands Centre Nursery for planting in constructed habitat	4th Quarter 2012
Populating of trial habitat with captive-bred Green and Golden Bell Frogs	4th Quarter 2012/1st Quarter 2013
Commencement of Mark/Recapture GGBF Monitoring in trial site	1st Quarter 2013
Continuation of Behavioural Research on the Green and Golden Bell Frog by the University of Newcastle	Throughout the coming reporting period
Implementation of hydrological management controls in Creek 5 (Fish Fry Creek) to limit propagation and reduce existing area of mangroves	4th Quarter 2012
Completion of Green and Golden Bell Frog compensatory habitat	December 2016

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.

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.

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 35. . 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.

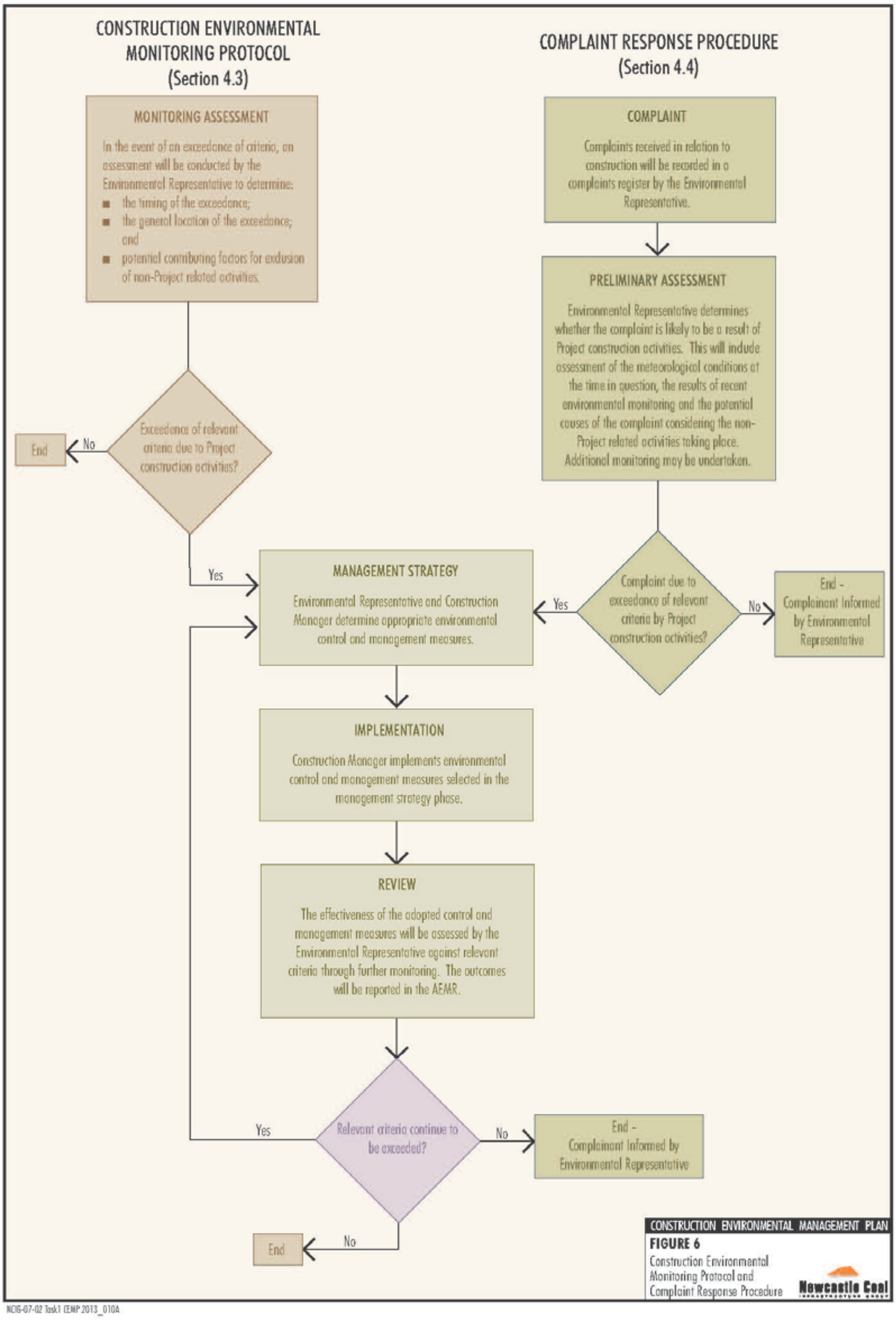


Figure 35: Complaint Response Procedure

Table 20 Community Complaints register summary

Date of complaint	Environmental concern raised	Issue	Action taken
15-Jul-12	Dust	EPA received a complaint from member of the public in relation to dust potentially impacting Stockton. Complainant stated that coal dust was coming from stockpiles on Kooragang Island but was unable to provide specific detail in relation to exact location of dust sources (ie either NCIG or PWCS).	Investigated circumstances of complaint and provided details to EPA.
15-Jul-12	Dust	A resident of Stockton rang and stated that he had driven along Cormorant Road and did not see the stockpile sprays operating. The stated that we were therefore not managing dust and that Stockton people were being affected. He did not observe any dust coming from the site when he drove by	Investigated circumstances and found that stockpiles sprays were operating. Likely not to be visible at the time of complaint as they were operating at rear of site.
22-Aug-12 The information received stated that whist driving in a westerly direction water from yard sprays landed on his car.	Dust	Water from stockyard dust suppression sprays contacted vehicle when member of the public drove in a westerly direction past NCIG site.	Investigated circumstances on site. The sprays were in operation along the south side of Pad 1 at approx. 1945hrs. There was a slight breeze from the nth/east. NCIG initiated a test cycle. An NCIG technician travelled along Cormorant Rd, confirmed that water also landed on windscreen of LV.
22-Aug-12	Dust	Boral cement made a complaint in relation to dust at their facility. The site manager believes that the dust deposited on their site was from NCIG as a result of the high winds over the 17th-20th August	Conducted follow up with Boral representatives and stated a commitment to work maintain open dialogue with Boral

Table 20 Community Complaints register summary

Date of complaint	Environmental concern raised	Issue	Action taken
		period. Boral Cement site personnel are concerned about health and amenity issues.	ongoing regarding dust. Also committed to looking for improvements in managing dust.
30-Aug-12 .	Dust	Resident from Fern Bay complained about dust they are experiencing at their house that they believe originates from NCIG. The dust has been an issue for some time and not relating to an event. Issue of amenity and cleaning. They also believe that NCIGs dust management/watering system is inadequate	Offered to take dust sample from residence of complainant. Offer was declined.
7-Sep-12	Dust	Origin Energy made a complaint about the amount of dust, particularly coal dust, which is being deposited on their site. Attended a site meeting and inspections and observed considerable dust within administration building and exterior work areas. Dust had a primarily black appearance and likely to be coal origin.	Conducted follow up with Origin representatives and stated a commitment to work maintain open dialogue with Origin ongoing regarding dust. Recorded as a registered complaint. Also committed to looking for improvements in managing dust.
14-Sep-12	Dust	Complaint received through 1800 number service relating to dust at Mayfield East residence. Details provided that resident has cleaning and amenity issues.	Attempted to follow up this complaint with no success.
20-Sep-12	Noise	An EPA Officer contacted NCIG regarding a noise complaint made by a Stockton resident. The noise complaint was made the preceding evening. EPA believed this may have been coming from NCIG, possibly the wharf.	NCIG contacted the complainant over phone. Meeting arranged between NCIG, PWCS and complainant to discuss Noise Management Program and reduction of alarm

Table 20 Community Complaints register summary

Date of complaint	Environmental concern raised	Issue	Action taken
			noise. Complainant will contact NCIG directly in the future if required.
10-Jan-13	Dust	A contractor on NCIG site mentioned to Env Advisor that a family member, resident of Mayfield has observed significant dust build-up around house and in pool over last 1-2 months.	NCIG contacted complainant directly and visited the residence on the same day. There was insufficient dust present to collect a sample; complainant will contact NCIG when more dust has accumulated.

NCIG regularly undertakes community consultation, in particular in conjunction with PWCS through their community consultation program. This happens between 2-4 times per year, and continued through 2012/13.

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 36: 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
August 2012	Community Newsletter
September 2012	Community Support Program – submissions called, grants provided (include no.)
March 2013	Community Support Program – submissions called, as above.
April 2013	Community Newsletter

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 Management Plan

Table 22 Construction Environmental Monitoring Program

Monitoring Focus	Monitoring Sites	Frequency	Criteria
	within 180 m of piling activities.		
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 IS19011:2002, Guidelines for Quality and/or Environmental Management Systems Auditing;

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

4.1 April 2012

A review of the compliance status of the NCIG Coal Export Terminal operational activities was undertaken by an NCIG Environmental Representative in April 2012. A review of the Compliance Tracking Program document was undertaken in April 2012 to confirm the ongoing compliance of the NCIG project against the requirements of the development consent (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 2012. With completion of the review, the Compliance Tracking Program document was revised and submitted to the Department of Planning.

4.2 November 2012

An independent review of the Compliance Tracking Program document was undertaken in November 2012 by MJM Environmental consultants to *ISO19011:2002 Guidelines for auditing management systems* to confirm the ongoing compliance of the NCIG project against the requirements of the development consent (06_0009). This review specifically focussed on the compliance of the Stage 1 NCIG Coal Export Terminal operations, Stage 2AA construction completion and Stage 2F construction works against the Development Consent (06_0009) and meets the requirements of Condition 5.1a).

The outcome of the MJM assessment of the NCIG compliance status is as follows:

… NCIG was generally in compliance with the relevant conditions of Project Approval 06-009.

On this basis NCIG continued operations of the Stage 1 NCIG Coal Export Terminal in accordance with the approved management plans, licences and permits, completed the Stage 2AA construction activities and commenced the Stage 2F construction activities.

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 November 2012. 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 53 Mtpa capacity Stage 1 and Stage 2AA of the NCIG Coal Export Terminal.
- Completion, commissioning and operation of Stage 2F of the NCIG Coal Export Terminal is scheduled to occur.

6 References

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 June 2013 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 2012	2.6	0.1	12.6	20.5	2.7	77.5	115	3	657
May 2012	3.0	0.1	13.1	16.0	2.7	73.7	105	4	524
June 2012	3.3	0.1	11.5	17.2	2.3	67.0	77	6	475
July 2012	3.4	0.1	10.1	16.4	1.0	77.8	89	6	498
August 2012	3.8	0.2	15.7	16.3	2.5	85.2	132	5	637
September 2012	3.3	0.0	14.2	19.8	3.3	96.8	181	2	770
October 2012	3.5	0.2	11.8	19.4	2.6	73.7	205	3	872
November 2012	3.1	0.2	10.2	20.8	3.2	79.2	189	1	911
December 2012	3.6	0.3	10.8	17.7	4.5	70.3	208	3	959
January 2013	3.7	0.2	13.2	17.9	3.5	89.4	211	0	984
February 2013	3.4	0.3	9.3	17.8	1.0	69.4	200	4	904
March 2013	3.2	0.1	9.9	18.8	4.7	85.2	175	2	819

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 2012	19.5	12.1	29.0	18.9	11.1	28.1	4	1
May 2012	15.2	7.5	27.4	14.7	6.9	26.8	24	3
June 2012	13.6	6.2	20.9	13.2	5.5	20.6	27	4
July 2012	12.9	5.9	20.6	12.4	4.9	20.3	16	2
August 2012	13.6	5.5	30.1	13.2	4.9	29.9	51	7
September 2012	16.8	6.3	32.1	16.3	5.4	31.6	21	3
October 2012	18.5	8.5	35.6	17.9	7.8	34.7	16	2
November 2012	21.3	12.2	34.4	20.7	11.6	34.0	1	0
December 2012	22.8	14.2	35.0	22.2	13.6	34.2	0	0
January 2013	24.7	18.2	42.6	24.1	17.5	42.2	4	1
February 2013	23.3	16.9	30.7	22.7	16.3	30.2	0	0
March 2013	22.9	15.0	32.3	22.2	14.1	31.5	2	0

Appendix B

Surface Water Monitoring Results

pH	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13
Pond 1	8.27	8.5	8.68	8.41	8.11	8.52	8.34	8.48	8.33	8.31	8.43	8.15	7.79	8.25	8.36
Pond 2 (SW1)	8.11	8.55	8.61	8.23	8.2	8.11	8.22	8.23	7.97	8.27	8.25	7.71	7.69	8.59	8.33
Pond 3	8.16	8.44	8.78	8.58	8.34	8.03	8.13	8.06	8.5	8.54	8.71	7.54	8.25	8.63	8.27
DS02 Works Outlet/WTPO1	8.62	9.06	9.78	9.04		8.85									
Deep Pond (SW3)	8.12	8.19	7.24	6.93	7.14	7.21	7.38	7.43	7.36	7.96	8.28	8.49	8.35	7.5	7.47
Black Swan Pond (SW2)	7.78	8.15	9.23	8.03	8.5	7.96	8.1	7.84	7.93	8.4	9.04	7.1			8.86
Western Rail Channel Clearwater	8.11	8.33	8.66	8.75	8.28	8.39	8.3	8.18	8.06	8.12	8.27	7.42	8.06	8.48	8.29
Clearwater (weir overflow)															
NW Sump									8.22						

EC (mS/cm)	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13
Pond 1	2.71	2.6	2.99	2.74	1.47	3.51	2.61	2.56	2.93	2.97	1.66	0.813	1.52	1.08	2.71
Pond 2 (SW1)	3.97	2.16	2.57	1.94	2.11	2.8	2.26	2.55	2.61	3.26	1.22	0.736	1.13	0.87	2.3
Pond 3	4.67	2.57	1.97	1.43	2.8	2.6	1.98	2.03	2.53	3.3	1.95	1.36	1.4	0.67	1.962
DS02 Works Outlet/WTPO1	4.66	2.79	3.39	3.06		3.44									
Deep Pond (SW3)	0.533	0.777	0.67	0.717	0.773	0.809	0.85	1.13	1.09	1.52	1.92	2.088	3.55	0.82	1.127
Black Swan Pond (SW2)	3.81	2.77	1.72	1.54	1.65	2.03	1.75	1.97	2.35	2.55	3.06	3.2		1.44	1.785
Western Rail Channel Clearwater	6.3	1.67	1.7	1.49	2.52	2.28	1.73	2.1	2.77	5.84	7.78	3.2	1.58	1.08	1.456

	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13
Clearwater (weir overflow)									4.52						
NW Sump															

Turbidity (NTU)	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13
Pond 1	*-	*-	46	72	675	120	149.8	113	588	40.2	152	189.1	51.8	315	133.1
Pond 2 (SW1)	*-	*-	35	24	50	28	35.6	38.6	62.8	14	78.2	229	55.3	90.6	32.1
Pond 3	*-	*-	10	7	5.2	30	13	11.2	14.6	9.4	9.8	116.1	23.5	83.2	20
DS02 Works Outlet/WTPO1	*-	*-	42	48		59									
Deep Pond (SW3)	*-	*-	38	88	83.2	16	24.6	32.7	71.5	82.3	33.3	96.6	123.7	13.2	8.3
Black Swan Pond (SW2)	*-	*-	2	4	12.3	16	13.3	9.2	6.6	78.4	379	598		12.1	5.7
Western Rail Channel															
Clearwater	*-	*-	7	4	5	9	9.3	22.8	11.5	37.3	56.1	62.4	72.1	14.4	513
NW Sump									43.5						

Water Temp (°C)	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13
Pond 1	23.3	30.7	27.3	20.9	30.2	16.5	NA	21.8	25.4	25.8	28.5	34.4	n/a	34.4	35.7
Pond 2 (SW1)	23.2	28.5	24.9	18.9	28.5	14.6	NA	20.3	25.9	26	27.9	32.2	n/a	32	33.6
Pond 3	23.2	28.1	23.9	19.1	28.2	13.8	NA	21.6	24.4	20.1	28	28.7	37.8	33.3	32.8
DS02 Works Outlet/WTPO1	23.8	29.7	25.3	20.9	*-	16.4									
Deep Pond (SW3)	23.7	25.6	25.9	22.2	27.7	16.3	NA	14.8	25.7	17.4	26.5	28.8	32	27.2	34
Black Swan Pond (SW2)	12.7	30	26.1	20.6	25.8	17.1	NA	23.9	26.1	30.6	32.3	28.1		26.9	37.1
Western Rail Channel															
Clearwater	23.1	27.6	24.1	18.9	25.6	14.6	16.2	19.3	22.9	18.5	30.4	22.3	n/a	26.5	35.1

Clearwater (weir overflow)	
NW Sump	26.1

Appendix C

Dust Deposition Monitoring Results

Month	Limit	DG1 (Fern Bay)	DG2 (Stockton)	DG3 (Kooragang Island)	DG4 (Sandgate)	DG5 (Mayfield West)	DG6 (Mayfield)
Apr-12	4	0.2	1.8	1.8	1.4	2.1	1.7
May-12	4	0.7	1.4	1.9	0.6	1.0	1.6
Jun-12	4	0.9	1.2	0.6	0.2	0.6	1.6
Jul-12	4	0.6	1.9	0.7	0.5	0.9	1.1
Aug-12	4	1.0	3.4	2.9	1.2	1.7	2.9
Sep-12	4	0.8	1.5	2.6	1.2	1.8	2.3
Oct-12	4	3.3	1.7	1.7	1.2	1.8	2.2
Nov-12	4	1.1	1.1	5.7	2.7	1.6	1.8
Dec-12	4	0.8	0.9	*	5.5	1.5	3.7
Jan-13	4	1	2.1	3.2	1.6	1.7	2.6
Feb-13	4	0.5	2.3	2.7	2.1	1.9	*
Mar-13	4	0.4	1.2	1.5	1.2	1.6	1.6

* contaminated sample.

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

	Reporting Units	95% Marine Waters ANZECC Trigger Level		EP Licence Trigger Level (Site specific)	Bore GW1			
		Sourced from CEMP	Sourced from OWMP		1/07/2011	2/12/2011	8/06/2012	11/12/2012
EPA Point Number					1	1	1	1
Sample Number					07116902001	12116902001	06126902001	12126902001
Date of Sampling					1/07/2011	2/12/2011	8/06/2012	11/12/2012
Time of Sampling					11:20	11:15	11:50	13:10
Sampler					C. South	K. Hawes	K. Hawes	K.Hawes
Groundwater Level	metres				2.15	1.43	1.38	1.54
Temperature	°C				19.0	20.0	19.0	20.0
Analyte								
pH	pH units	7.0-8.5	7.0-8.5		7.4	7.7	7.3	7.56
EC	µS/cm				9240	9810	9960	9930
TDS	mg/L				6348	6559	6514	7100
TSS	mg/L				21	26	25	28
Metals - Dissolved								
Al	mg/L		ID		<0.01	<0.01	<0.01	<0.01
Cd	mg/L	0.0055			0.0086	0.0022	<0.0001	0.0002
Co	mg/L		0.001		<0.001	<0.001	<0.001	<0.001
Cu	mg/L		0.0013		0.004	0.003	<0.001	0.001
Pb	mg/L	0.0044			0.004	<0.001	<0.001	<0.001
Mn	mg/L	0.08	0.08		0.032	0.176	0.093	0.204

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

Phenol	µg/L		<1	<1	<1	<1
Sulfate	mg/L		500	698	640	642

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
EPA Point Number					20	20	20	20
Sample Number					07116902002	12116902002	06126902002	12126902002
Date of Sampling					1/07/2011	2/12/2011	8/06/2012	11/12/2012
Time of Sampling					10:35	10:45	9:25	11:45
Sampler					C. South	K. Hawes	K. Hawes	K.Hawes
Groundwater Level	metres				2.91	2.75	Stand pipe damaged	2.84
Temperature	°C				18.5	20.0		20.0
Analyte								
pH	pH units	7.0-8.5	7.0-8.5		7.1	7.2		7.5
EC	µS/cm				19000	19620		9120
TDS	mg/L				15417	14974		6580
TSS	mg/L				20	12		167
Metals - Dissolved								
Al	mg/L		ID		<0.01	<0.01		0.03
Cd	mg/L	0.0055			0.0014	0.0015		<0.0001
Co	mg/L		0.001		<0.001	<0.001		<0.001
Cu	mg/L		0.0013		0.008	0.004		<0.001
Pb	mg/L	0.0044			<0.001	<0.001		<0.001
Mn	mg/L	0.08	0.08		0.014	1.47		4.73
Ni	mg/L	0.07	0.07		0.003	0.002		0.002
Zn	mg/L	0.015	0.015		0.029	0.023		0.018
Fe	mg/L		ID		<0.05	<0.05		2.35
As III	µg/L	ID			<1	<2		<2

Hg	mg/L	0.0004			<0.0001	<0.0001	<0.0001
Hexavalent Cr	mg/L	0.0044			<0.010	<0.010	<0.010
Cations - Dissolved							
Mg	mg/L		ID		476	417	146
Na	mg/L		ID		5400	3910	2070
K	mg/L		ID		202	203	107
PAH							
Polynuclear Aromatic Hydrocarbons - 16 analytes	µg/L		ID	1	<0.5	<0.5	<0.5
TPH							
C6-9 Fraction	µg/L			20	<20	<20	<20
C10-14 Fraction	µg/L			50	<50	<50	<50
C15-28 Fraction	µg/L			100	<100	<100	<100
C29-36 Fraction	µg/L			50	<50	<50	<50
BTEX							
Benzene	µg/L			700	<1	<1	<1
Toluene	µg/L			180	<5	<5	<5
Ethyl Benzene	µg/L			5	<2	<2	<2
m+p Xylene	µg/L			75	<2	<2	<2
o Xylene	µg/L			350	<2	<2	<2
Cyanide							
Free	µg/L			4	<4	<4	<4
Total	µg/L			81.1	<4	<4	4
Ammonia	µg/L				100	1090	2900
Phenol	µg/L			400	<1	<1	<1
Sulfate	mg/L				1690	2310	643

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
EPA Point Number					21	21	21	21
Sample Number					07116902003	12116902003	06126902003	12126902003
Date of Sampling					1/07/2011	2/12/2011	8/06/2012	11/12/2012
Time of Sampling					10:40	10:30	9:30	12:10
Sampler					C. South	K. Hawes	K. Hawes	K.Hawes
Groundwater Level	metres				2.02	1.99	1.91	2.13
Temperature	°C				18.0	21.0	Stand pipe damaged	21.0
Analyte								
pH	pH units	7.0-8.5	7.0-8.5		7.4	7.6		7.6
EC	µS/cm				9940	10010		11890
TDS	mg/L				6791	6790		10400
TSS	mg/L				698	1240		18985
Metals - Dissolved								
Al	mg/L		ID		<0.01	0.08		<0.01
Cd	mg/L	0.0055			0.0004	0.0043		<0.0001
Co	mg/L		0.001		0.001	<0.001		<0.001
Cu	mg/L		0.0013		0.003	0.003		<0.001
Pb	mg/L	0.0044			<0.001	<0.001		<0.001
Mn	mg/L	0.08	0.08		0.358	0.348		0.842
Ni	mg/L	0.07	0.07		0.002	0.002		<0.001
Zn	mg/L	0.015	0.015		<0.005	0.063		<0.005
Fe	mg/L		ID		<0.05	<0.05		0.13
As III	µg/L	ID			<1	<1		<5
Hg	mg/L	0.0004			<0.0001	<0.0001		<0.0001

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

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
EPA Point Number					22	22	22	22
Sample Number					07116902004	12116902004	06126902004	12126902004
Date of Sampling					1/07/2011	2/12/2011	8/06/2012	11/12/2012
Time of Sampling					11:58	10:15	13:00	11:05
Sampler					C. South	K. Hawes	K. Hawes	K.Hawes
Groundwater Level	metres				1.50	1.66	1.58	2.11
Temperature	°C				19	18	19	19.0
Analyte								
pH	pH units	7.0-8.5	7.0-8.5		7.2	7.2	7.4	7.5
EC	µS/cm				3310	914	709	995
TDS	mg/L				2239	528	437	618
TSS	mg/L				121	180	271	74
Metals - Dissolved								
Al	mg/L		ID		<0.01	<0.01	0.01	0.01
Cd	mg/L	0.0055			<0.0001	0.0002	<0.0001	<0.0001
Co	mg/L		0.001		<0.001	0.002	<0.001	<0.001
Cu	mg/L		0.0013		<0.001	<0.001	<0.001	<0.001
Pb	mg/L	0.0044			<0.001	<0.001	<0.001	<0.001
Mn	mg/L	0.08	0.08		0.746	1.04	0.296	0.744
Ni	mg/L	0.07	0.07		<0.001	0.001	<0.001	<0.002
Zn	mg/L	0.015	0.015		0.018	0.007	<0.005	0.016
Fe	mg/L		ID		<0.05	1.38	<0.05	0.22
As III	µg/L	ID			<1	1	<1	<1
Hg	mg/L	0.0004			<0.0001	<0.0001	<0.0001	<0.0001

Hexavalent Cr	mg/L	0.0044			<0.010	<0.010	<0.010	<0.010
Cations - Dissolved								
Mg	mg/L		ID		23	10	11	12
Na	mg/L		ID		516	86	49	81
K	mg/L		ID		13	7	10	11
PAH								
Polynuclear Aromatic Hydrocarbons - 16 analytes	µg/L		ID	2.2	<0.5	<0.5	<0.5	<0.5
TPH								
C6-9 Fraction	µg/L			20	<20	<20	<20	<20
C10-14 Fraction	µg/L			50	<50	<50	<50	<50
C15-28 Fraction	µg/L			100	<100	<100	<100	<100
C29-36 Fraction	µg/L			50	<50	<50	<50	<50
BTEX								
Benzene	µg/L			700	<1	<1	<1	<1
Toluene	µg/L			180	<5	<5	<2	<2
Ethyl Benzene	µg/L			5	<2	<2	<2	<2
m+p Xylene	µg/L			75	<2	<2	<2	<2
o Xylene	µg/L			350	<2	<2	<2	<2
Cyanide								
Free	µg/L			4	<4	<4	<4	<4
Total	µg/L			16.6	<4	<4	<4	<4
Ammonia	µg/L				680	310	130	0.39
Phenol	µg/L			400	<1	<1	<1	<2
Sulfate	mg/L				112	49	23	30

Bore K11/1 S

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

Hexavalent Cr	mg/L	0.0044			<0.010	<0.010	<0.010	<0.010
Cations - Dissolved								
Mg	mg/L		ID		376	311	306	177
Na	mg/L		ID		3910	4400	4720	3830
K	mg/L		ID		184	186	212	199
PAH								
Polynuclear Aromatic Hydrocarbons - 16 analytes	µg/L		ID	1.5	<0.5	<0.5	<0.5	<0.5
TPH								
C6-9 Fraction	µg/L			20	<20	<20	<20	<20
C10-14 Fraction	µg/L			50	<50	<50	<50	<50
C15-28 Fraction	µg/L			100	<100	<100	<100	<100
C29-36 Fraction	µg/L			50	<50	<50	<50	<50
BTEX								
Benzene	µg/L			700	<1	<1	<1	<1
Toluene	µg/L			180	<5	<5	<2	<2
Ethyl Benzene	µg/L			5	<2	<2	<2	<2
m+p Xylene	µg/L			75	<2	<2	<2	<2
o Xylene	µg/L			350	<2	<2	<2	<2
Cyanide								
Free	µg/L			4	<4	<4	<4	<4
Total	µg/L			75.6	<4	<4	<4	5
Ammonia	µg/L				4950	<100	4920	6110
Phenol	µg/L			400	<1	<1	<1	<1
Sulfate	mg/L				809	786	740	682

Appendix E

CHEMP Quarterly Reports and Minutes

Compensatory Habitat Consultative Board Meeting – Minutes
Meeting No: 3
23rd May, 2011 1000 – 1400
Venue: NCIG Administration Building

Attendees:	Apologies:
Mr Ado Zanella (AZ) – NSW Department of Planning and Infrastructure Dr Jose Rodriguez (JR) – 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 Dr Rob Yeates (RY) – Newcastle Coal Infrastructure Group Mr Doug Beckers (DB) – NSW Office of Environment and Heritage, NPWS	Mr Tom Bagnat (TB) – NSW Office of Environment and Heritage, NPWS Mr Dean Chapman (DC) – Hunter/Central Rivers Catchment Management Authority

Item	Description	Action Owner
1.0	**Welcome / Introductions**	
1.1	Meeting Open 1010hrs	
1.2	Apologies recorded – D.Chapman, T.Bagnat (D.Beckers as alternate).	
1.3	Minutes from Previous Meeting	
1.3a	Provide copy of presentations to attendees with minutes (PR) – completed – closed.	
1.3b	Progress captive breeding of bell frogs for introduction into compensatory habitat (PR) – completed – closed.	
1.3c	Schedule be provided with the meeting minutes (PR) – completed – closed.	
1.3d	Provision and distribution of university paper on hydrological model limitations (PR) – completed – closed.	
2.0	**Update on Trial Green and Golden Bell Frog Habitat progress**	
2.1	PR provided an update on the site selection and REF approval process for Trial GGBF Habitat, including: - Soil, Surface Water and Groundwater Investigations - Pond Site Selection/Design Forum - Fauna Impact Statement - Topographical Survey - Stakeholder Liaison - Site Confirmation - Detailed Pond Design	
2.2	PB asked that updated dates for Determination and Licence issue and Site Mobilisation be updated (as compared with those shown in the presentation), due to provision of a Request for Additional Information from NPWS on Tuesday 22 May. The expected timing of events - NCIG response with additional information – Friday 26 May.	

	- NPWS anticipated provision of Determination and Licence – Friday 1 June. - Site Mobilisation – Monday 4 June.	
3.0	Proposed Trial Habitat Monitoring and Modelling	
3.1	NJ provided a presentation and discussion paper on proposed methodology for population monitoring and modelling to address two objectives: - To inform the composition of future compensatory works - To define the GGBF population and subsequently the GGBF habitat area disturbed by the NCIG Project.	
3.2	DB stated that NPWS, as representative of OEH/EPA on the Board, are uncomfortable in being involved in discussions regarding the definition of the original area of impact from the NCIG Project.	
3.3	AZ confirmed that DoPI are concerned about the original area of impact not yet being resolved, i.e. resolution in differing quantification of land areas (8 and 34Ha).	
3.4	NJ stated that the intent of the paper is to outline and discuss proposed monitoring and modelling methodology. This will allow Consultative Board members to provide guidance/advice and raise any issues with the proposed methodology. NCIG is not intending on seeking endorsement or comment on the impact area as this will be decided in consultation with regulatory authorities.	
3.5	DB recognised that resolution on the original impact area would have repercussions on the amount of land that NPWS would have to make available for Compensatory Work.	
3.6	RY asked who would be responsible for defining research methodology and completing the PhD. PR commented that the University of Newcastle have the capability to define the research question, experience in population modelling and resources to complete the work.	
3.7	AW highlighted the uniqueness of Population Modelling in the Australian Environment (utilising highly opportunistic species) in comparison with the Northern Hemisphere (seasonal dependent species).	
3.8	AW identified the opportunity that NCIG Trial Habitat provides in being able to control variable to understand population dynamics. Provided previous example of Sydney Olympic Park where approximately 100 ponds have been constructed over a period of time with occupancy in only a handful of ponds. Little control over variables providing unreliable results for monitoring and modelling.	
3.9	DB mentioned that NCIG should consider measures of success for Compensatory Habitat, eg. Two successive breeding seasons, management of ponds. Also mentioned that a Site Management Plan would need to be developed for ongoing management of habitat, including Weed and Gambusia management.	
3.10	DB asked if the results of BHPB modelling will be used in proposed NCIG modelling work. PR identified there will be opportunity to validate occupancy rates from NCIG modelling work with previous GGBF modelling (eg. SOP, BHPB if this becomes available).	
3.11	RY reaffirmed NCIG's commitment to following through on the obligations defined in the CHEMP. It is NCIG's opinion that the process so far is logical and that the proposed methodology for quantification of habitat disturbed is open-ended but based on expert advice and sensible. NCIG recognises its commitments under the Conditions of Approval.	
4.0	Annual Monitoring	
4.1	AW presented the results of the NCIG GGBF Annual Monitoring Season 2011/2012. Noted that there was high activity in Spring, however this dropped through Summer –	

	reasons are not clear, however thought that lower temperatures may have had an effect.	
4.2	DB highlighted that with the advent of PWCS T4, there will certainly be significant fragmentation in the KI/AI population.	
5.0	Wetland Vegetation Progress	
5.1	PR provided an update on the progress of Wetland Plants collected, germinated and grown at Hunter Wetlands Centre, to be replanted in NCIG Trial Comp Habitat.	
5.2	AW highlighted the importance of ongoing habitat maintenance for success of the introduced GGBF population and university monitoring and subsequently modelling	
5.3	DB mentioned that during the same process in the BHPB Trial Habitat a number of species established themselves that were not planted.	
5.4	AW noted that Persicaria species are not suitable for GGBF Habitat. DB confirmed there were significant numbers of L.Peronii in Persicaria on Ash Island when allocating plants for NCIG project. *Discuss with D.Beckers and A.White fate of these plants and general vegetation in Trial Site.*	PR
5.5	AW identified that main concern is to provide sufficient breeding and shelter habitat for GGBF. Foraging Habitat will be sufficient.	
5.6	DB mentioned that water supply shortly after replanting will be critical to wetland plant success. Should be contingency for water supply should there be no rain.	
6.0	Breeding Program	
6.1	PR provided a presentation and discussion paper on Newcastle University's Breeding Program. Highlighted that NCIG and potentially PWCS have essentially assumed funding of the former BHPB-established facility. University is also responsible for the Translocation Application for "supplementation" of the existing AI population with captive-bred frogs.	
6.2	DB mentioned that the Animal Ethics Committee will ask that evidence of Ethics Approval be kept at the NCIG Trial Site as well as the breeding facility – considered that trial habitat constitutes part of the approved facility.	
7.0	Conspecifics Research Update	
7.1	PR presented a discussion paper on the progress of University's research on Attraction to Conspecifics and Perception of Suitable Habitat. Work to date included both field and lab-based experimentation.	
7.2	AW mentioned that previous research suggests that the volume of GGBF calling is critical to the success of populations.	
8.0	Ameliorative Works collaboration	
8.1	NJ provided an update on progress of KWRP approval and implementation of Area E Shorebird Habitat improvement (Mangrove control and removal). Mentioned that approval is provided and that trial installation of drop boards has occurred. Outlined that NCIG had participated in trial drop board placement with KWRP. NCIG is working with KWRP to assist in completing necessary monitoring works and therefore guiding the adaptive management strategy.	
8.2	DB asked that the height (AHD) of the existing invert be confirmed (0.2m AHD or less than).	
9.0	General Business	
9.1	DB committed to formalising a contact within NPWS for the NCIG Trial Habitat Project. To discuss with Deon Von Rensburg and reply to NCIG.	DB

10.0	Next Meeting	
10.1	Proposed for late November/Early December 2012.	PR
10.2	Minutes to be distributed to attendees and those not present.	PR
10.3	Meeting close 1400hrs.	

Newcastle Coal
INFRASTRUCTURE GROUP

Compensatory Habitat Consultative Board Meeting – Minutes
Meeting No: 4
5th December, 2012 1100 – 1430
Venue: NCIG Administration Building and Research Area Ponds, Ash Island

Attendees:	Apologies:
Mr Ado Zanella (AZ) – NSW Department of Planning and Infrastructure Mr Callaghan 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 Dr Ligia Pizzatto (LP) – 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 Dr Rob Yeates (RY) – Newcastle Coal Infrastructure Group Mr Richard Colbourne (RC) – NSW Office of Environment and Heritage, NPWS (present during Pond Site Visit) Mr Doug Beckers (DB) – NSW Office of Environment and Heritage, NPWS (present during Pond Site Visit)	Mr Tom Bagnat (TB) – NSW Office of Environment and Heritage, NPWS Mr Dean Chapman (DC) – Hunter/Central Rivers Catchment Management Authority Dr Jose Rodriguez (JR) – Newcastle University Mr Glenn Snow – NSW Department of Planning and Infrastructure Miss Ingrid Ilias – NSW Department of Planning

Item	Description	Action Owner
1.0	Welcome / Introductions	
1.1	Meeting Open 1110hrs	
1.2	Apologies recorded – D.Chapman (CC as alternate), T.Bagnat (DVR as alternate), J.Rodriguez, G.Snow, I.Ilias	
1.3	Minutes from Previous Meeting	
1.3a	Discuss with D.Beckers and A.White fate of unwanted plants and general vegetation in Trial Site (PR) – completed – closed.	
1.3b	D.Beckers committed to formalising a contact within NPWS for the NCIG Trial Habitat Project. To discuss with Deon Von Rensburg and reply to NCIG (DB) – completed – closed.	
1.3c	Minutes to be distributed to attendees and those not present (PR) – completed – closed.	
2.0	Update on Green and Golden Bell Frog Research Habitat progress	
2.1	PR provided an update on the approval of REF, Determination and Licence. Details of construction and planting of GGBF Research Area were provided, including: - Site mobilisation - Upgrade of access track - Clearing of vegetation - Construction of frog-proof fence	

	- Fauna Clearance of internal enclosure - Management of vegetation - Commencement of pond excavation and treatment for Acid Sulphate Soils - Validation testing of treated soils - Shaping of ground surface - Removal of wastage - Demobilisation - Wetland Planting - Addition of Potable Water	
2.2	- CC raised concerns regarding flood management of constructed ponds. Commented that 1.1mAHD was below expected high tide marks and that this may reach pond enclosure. PR to provide details of topographical survey to CC and include flood management in Environmental Management Plan for the ponds. MM mentioned that recent high tides did not inundate Research Area. PR to check level of recent high tide mark with Newcastle University.	PR
3.0	University Proposed Approach for Population Modelling of Pre-impact Population	
3.1	JC provided a presentation on the proposed approach to calculate the Pre-impact Population of GGBF prior to the NCIG Development. This included: - The use of recent datasets and models used to generate estimates of the population size in the existing landscape in combination with an aerial photography/GIS - The assumption that the population size is a function of the habitat area and structure - Qualified estimate of the original population size from measures of the change (in this case, loss) in habitat area and structural alteration - Generation of population size estimates based on discrete landscape information, data sets and models (eg. PRESENCE, MARK)	
3.2	NJ advised that PWCS and BHPB were being consulted with regarding access and use of recent GGBF population datasets to assist in implementation of modelling approach	
3.3	PR mentioned that model would allow an estimate to be made of the pre-impact population in a timeframe sooner than using only NCIG monitoring data (from Research Area Ponds). NCIG monitoring data could be used to refine the population model in the future.	
4.0	Conspecific Attraction Research Update	
4.1	LP provided a presentation on Conspecific Attraction research to date. This included experiments looking at: - Aggregation of tadpoles based on familiarity and environmental conditions - Chemical, auditory and visual cues used for conspecific attraction in the adult and juvenile stages - Selection of bad habitat occupied by conspecifics vs good habitat unoccupied by conspecifics - Recognition and preference of natal/home ponds - Mating system in relation to aggregation of calling males and aggregations around dominant males This work is being done to provide a more complete picture of GGBF lifecycle in relation to behavioural ecology. Findings may be applied to constructed habitat to improve population success and chance of breeding	
4.2	MM commented that application of findings may include playing recordings of calling GGBF males to artificially develop aggregations of other conspecifics to improve range	

	of local population, or design for shallow ponds (warmer temperatures) if found that this is more conducive for breeding sites.	
5.0	Breeding Program and Translocation	
5.1	MM provided an overview of the breeding program, Translocation Proposal and introduction into constructed habitat. This included: - Completion and submission of the Translocation Proposal. NPWS Licensing contacted and approval would be provided soon. - Minimum requirements of Translocation Proposal, including Chytrid and Genetic Testing - Recent breeding observed in captive population (four events to date) - Staged introduction including, sub-sample of tadpoles kept in pond water in laboratory for observation, introduction of 50 individuals per pond in mesh baskets for observation, complete introduction pending success. Success is defined by set survivorship thresholds and pre-established Trigger Action Response Plans (TARPs). - Introduction expected to be in the next 1-2 months	
6.0	Research Area Site Visit	
6.1	Bus trip to Research Area Ponds for inspection by Consultative Board. Brief introduction and decontamination of footwear by PR and informal walk around conducted by attendees. RC and DB (NPWS) joined at this point to inspect ponds. Subsequently bus returned to NCIG site.	
7.0	Next Meeting	
7.1	Proposed for May/June 2013.	PR
7.2	Minutes to be distributed to attendees and those not present.	PR
7.3	Meeting close 1430hrs.	

Appendix F

Green and Golden Bell Frog

Annual Report on the 2012/13 Field Season

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

Annual Report on the 2012/13 Field Season
For
PORT WARATAH COAL SERVICES

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 the second year continued it. Moving into the third year of the research program, in addition to continuing to understand the bell frog population as it currently exists on KI/AI, there was a recognition of the need to expand the scope of the program to address questions surrounding GGBF persistence in some habitats but not others, and whether these factors could be drawn out and incorporated into successful habitat creation programs in the future. As such, several aims were developed for the 2012/2013 GGBF season, including:

1. Identify the specific abiotic features of the wetlands where the bell frogs currently occur on Kooragang /Ash Island that make them suitable for the frogs. Identify, through experiments, whether these abiotic factors are contributing to inhibition of the amphibian chytrid fungus and possibly increase GGBF survival.
2. Continue to obtain details on the size of the bell frog population, its demography and movement in the area to further benchmark the population for future mitigation. Importantly for the 2012/2013 season, include the BHPB wetlands in these surveys (considered extremely important for the GGBF habitat corridor), as well as the recently constructed clusters of ponds near the cell and in the south eastern corner of T4.
3. Utilise molecular genetic tools for better understanding of population demographics (particularly parental contribution to breeding and survivorship of offspring).
4. Identify if temperature and salinity can be used in conjunction with one another to increase the probability of survival in constructed wetlands.

This report outlines the findings of aim 2 above.

It was found that, despite significant site-access issues to T4 early in the spring and summer season of 2012-13, population estimates for KI/AI were able to be made in January and March 2013, with a maximum population estimate of ca. 834 frogs. This is comparable to the two previous seasons and suggests that the population might be currently stable, albeit small in size.

Frogs were found at 20 ponds giving naïve pond occupancy of 36.4%. This might be artificially low due to the site-access issues on T4, but is comparable to the 2011/2012 season nonetheless. Tadpoles (indicating breeding) were 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 2011/2012 season, although most of the movement activity was concentrated around K22/K23. One very large movement was observed between the Rail Loop and K22 on Ash Island (>2km) and suggests that the frogs are still moving across T4. It also suggests that the current rail infrastructure is not an absolute block to dispersal.

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 season (see Clulow et al, 2012). This program aimed to investigate three specific questions relating to GGBF population ecology on the island, including:

1. What is the 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 and 2011/2012 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 third year of the research program, in addition to continuing to understand the bell frog population as it currently exists on KI/AI, there was a distinct recognition of the need to expand the scope of the program to address questions surrounding GGBF persistence in some habitats but not others, and whether these factors could be drawn out and incorporated into successful habitat creation programs in the future. As such, several aims were developed for the 2012/2013 GGBF season, including:

1. Identify the specific abiotic features of the wetlands where the bell frogs currently occur on Kooragang /Ash Island that make them suitable for the frogs. Identify, through experiments, whether these abiotic factors are contributing to inhibition of chytrid and possibly increase GGBF survival.
2. Continue to obtain details on the size of the bell frog population, its demography and movement in the area to further benchmark the population for future mitigation. Importantly for the 2012/2013 season, include the BHPB wetlands in these surveys (considered extremely important for the GGBF habitat corridor), as well as the recently constructed clusters of ponds near the cell and in the south eastern corner of T4.
3. Utilise molecular genetic tools for better understanding population demographics (particularly parental contribution to breeding and survivorship of offspring).

4. Identify if temperature and salinity be used in conjunction with one another to increase the probability of survival in constructed wetlands.

This report outlines the findings of aim 2 above.

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, In Press; 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, In Press; 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, In Press). 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 far 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). Therefore, the bell frog’s distribution may also be limited to sites with ephemeral water bodies that are free of mosquito fish, but that also dry at a rate that allows tadpoles to develop and metamorphose.

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 2012/2013 that this report addresses is to build upon the population demographic data gathered through field surveys in the 2010/2011 & 2011/2012 GGBF seasons by conducting further surveys in the 2012/2013 season. This will allow us to begin to build a picture of the GGBF population on KI/AI both spatially and temporally, which in turn will help us to understand the dynamics that might be driving the population, and will 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 requires 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 past two seasons, the BHP wetlands and the two recently created clusters of ponds were included this 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 every six weeks from October 2012 to March 2013 (surveys conducted in October & December 2012, and January and March 2013). 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 November & December 2012 and February & April 2013 in K22/23, February & April 2013 in K29 (The Cell), and September & November 2012 and January 2013 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 be injected subcutaneously into the dorsal lymph space and the tag manipulated so 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.

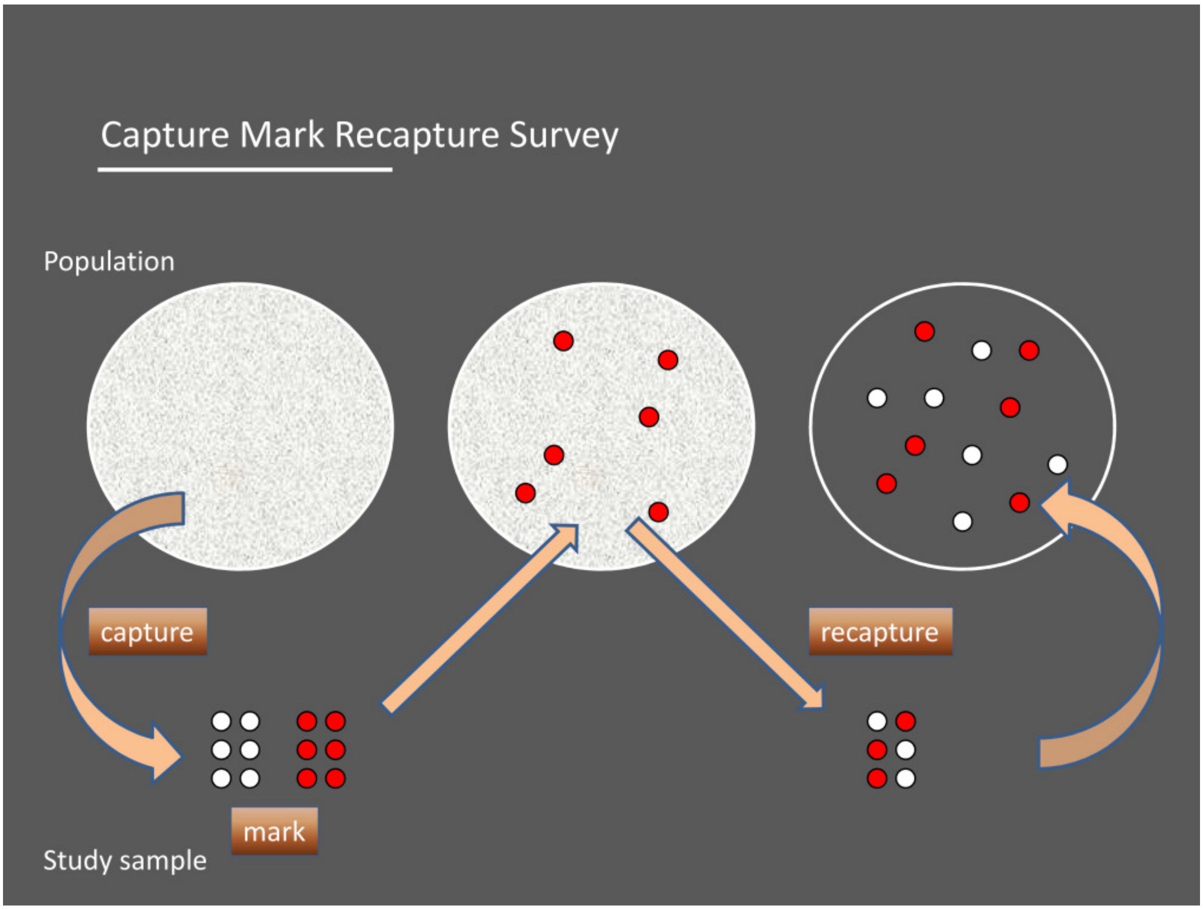

Figure 1. A simple illustration of capture-mark-recapture survey (based on two capture events only). Left circle: nothing is known about the population size, then during the first capture event animals are caught, marked and released. Middle circle: the number of marked animals within the population 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 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, 4 to 9 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 survey 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).

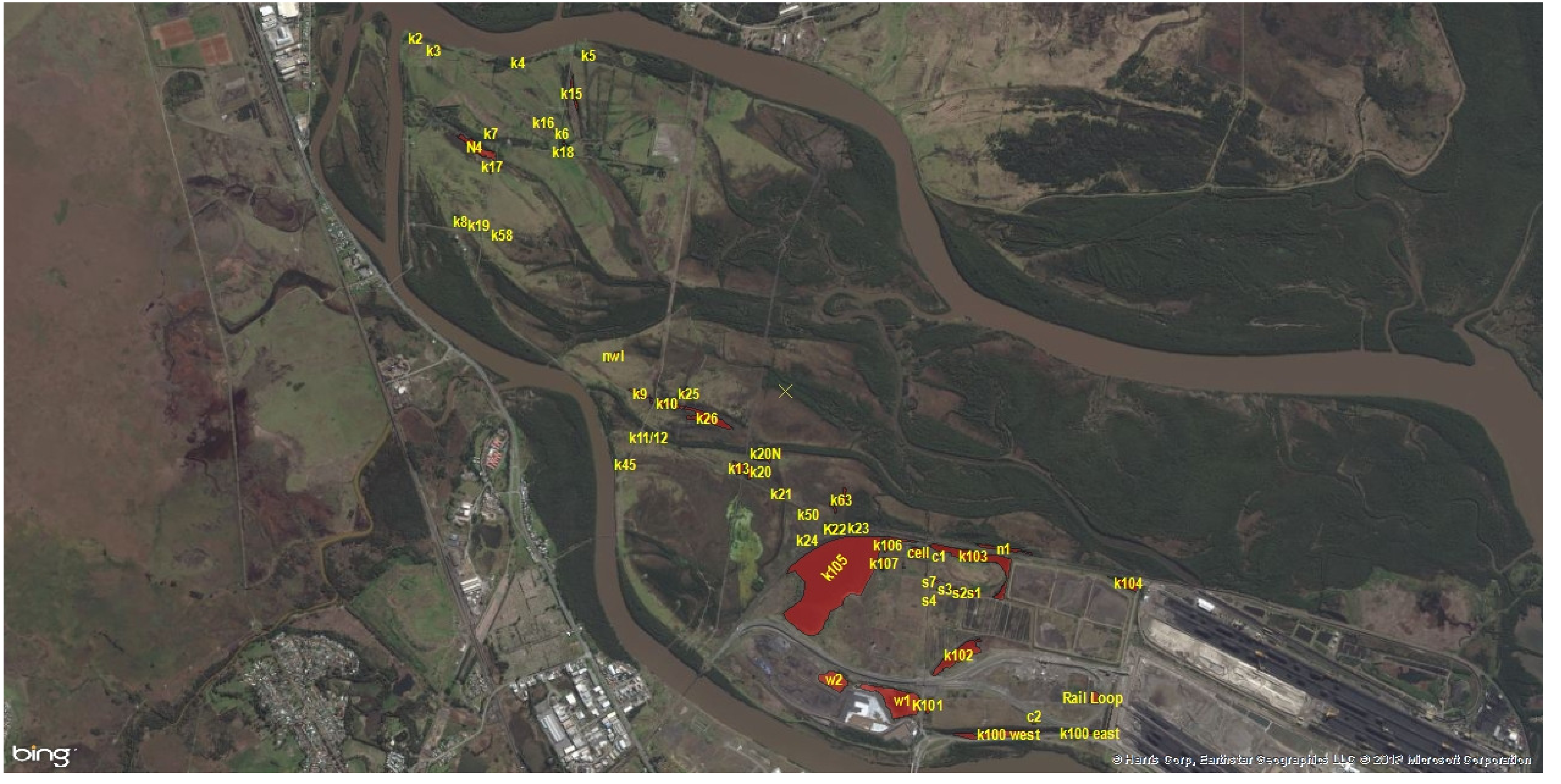

Figure 2. Part of Kooragang Island showing regularly surveyed waterbodies and their identification number.

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 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 and 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 and population sizes. 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).

Monthly survival estimates were obtained from the best model for each pond and used to calculate annual survival probability using: $\varphi_{annual} = \varphi^{12}$.

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 every six weeks from December 2011 to March 2012.

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 and 2012/2013 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 was combined. Forty-two secondary surveys were conducted at these ponds within seven primary occasions in November 2011, January/February 2012, March 2012, November 2012, December 2012, February 2013 and April 2013. A total of 836 captures of 451 individuals were made at ponds K22/23, with individuals recaptured between 1 and 13 times. Twenty-one secondary surveys were conducted at pond K29 within five primary occasions in November 2011, January 2012, March 2012, February 2013 and April 2013. A total of 195 captures of 92 individuals were made at pond K29, with individuals recaptured between 1 and 11 times. Twenty secondary surveys were conducted at the Rail Loop within five primary occasions in February 2012, March 2012, September 2012, November 2012 and January 2012. A total of 91 captures of 50 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 different base models for each pond (**Error! Not a valid bookmark self-reference.**). For all ponds, the best models described population size (N) as a function of time but this variation was not consistent between ponds. Monthly apparent survival estimates for ponds K22/23 were varied with time in the best model (**Error! Not a valid bookmark self-reference.**). Survival probability [95% CI] was found to range from relatively high (0.64 [0.40 – 0.82]) to quite low (0.31 [0.16-0.42]) for this pond. The best models of the candidate set for pond K29 estimated apparent survival probability as constant (**Error! Not a valid bookmark self-reference.**1). The monthly survival probability for bell frogs at K29 was estimated to be 0.92 [0.66 – 0.99]. The monthly survival probability at the Rail Loop was estimated as 0.80 [0.71 – 0.86] throughout the study period indicating fairly high apparent survival. Deaths and emigration were not separable at any of the ponds and the apparent survival estimates above reflect an unknown combination of the two.

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 K23, K22, K29 and the Rail Loop on Kooragang Island between October 2012 and March 2013. 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(t)p=c(t)N(t)	318.67	0.00	0.99	55
ϕ(.)p=c(t)N(t)	328.20	9.53	0.01	51
ϕ(t)p=c(.)N(t)	341.71	23.03	0.00	24
ϕ(.)p=c(.)N(t)	342.40	23.72	0.00	21
ϕ(t)p=c(t)N(.)	392.69	74.02	0.00	50
ϕ(.)p=c(t)N(.)	398.90	80.23	0.00	46
Pond K29				
ϕ(.)p=c(t)N(t)	211.27	0.00	0.84	28
ϕ(t)p=c(t)N(t)	215.91	4.64	0.08	31
ϕ(.)p=c(t)N(.)	216.00	4.73	0.06	25
ϕ(t)p=c(t)N(.)	219.71	8.45	0.01	28
ϕ(.)p=c(.)N(t)	222.38	11.11	0.01	15
ϕ(t)p=c(.)N(t)	224.27	13.00	0.00	19
Rail Loop				
ϕ (t) G"=G'(.) p(.) c(γ) N(t)	166.4759	0	0.28977	16
ϕ (t) G"=G'(.) p=c(.) N(t)	166.881	0.4051	0.23664	11
ϕ (.) G"=G'(.) p(.) c(γ) N(t)	168.1996	1.7237	0.12239	13
ϕ (t) G"=G'(.) p(.) c(.) N(t)	169.0448	2.5689	0.08021	12
ϕ (t) G"=G'=0 p=c(.) N(t)	169.4101	2.9342	0.06682	11
ϕ (t) G"=G'=0 p(.) c(γ) N(t)	169.4797	3.0038	0.06453	16
ϕ (.) G"=G'(.) p=c(.) N(t)	169.6432	3.1673	0.05947	8
ϕ (.) G"=G'(.) p(.) c(.) N(t)	171.6148	5.1389	0.02219	9
ϕ (t) G"=G'(t) p=c(.) N(t)	171.8781	5.4022	0.01945	14
ϕ (t) G"=G'=0 p(.) c(.) N(t)	172.0485	5.5726	0.01786	12
ϕ (t) G"=G'(t) p(.) c(γ) N(t)	172.5424	6.0665	0.01395	19
ϕ (t) G"=G'(t) p(.) c(.) N(t)	174.1585	7.6826	0.00622	15
ϕ (t) G"(t) G'(t) p=c(.) N(t)	180.7241	14.2482	0.00023	17
ϕ (t) G"(t) G'(t) p(.) c(γ) N(t)	182.7084	16.2325	0.00009	22
ϕ (t) G"(t) G'(t) p(.) c(.) N(t)	183.2463	16.7704	0.00007	18
ϕ (t) G"(t) G'(t) p=c(γ) N(t)	183.3197	16.8438	0.00006	21
ϕ (t) G"(t) G'(t) p(t) c(t) N(t)	184.3275	17.8516	0.00004	23

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 the 2012/2013 surveys (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.

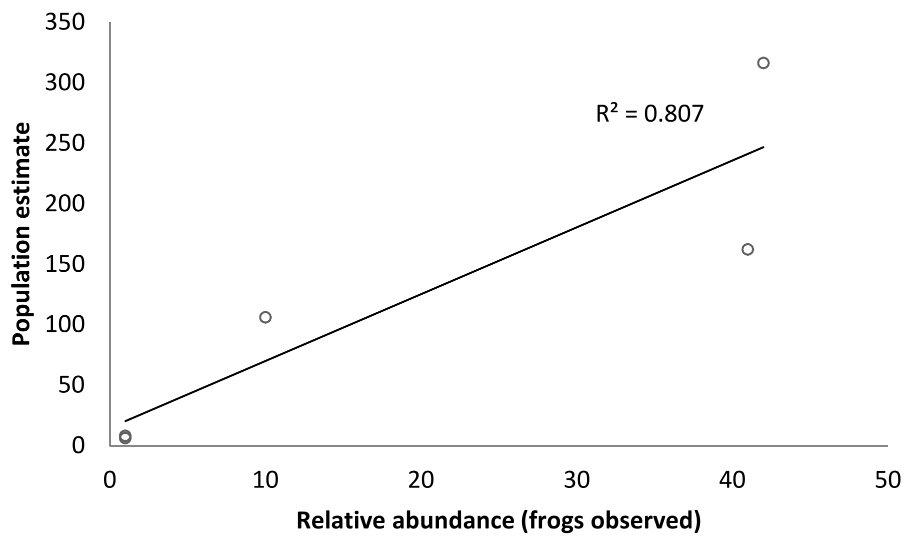

Figure 3. Linear regression between relative abundance (number of frogs observed during VES survey) and estimated abundance (population estimate using mark-recapture data) (n=5; P = 0.038; R2 = 0.807).

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.

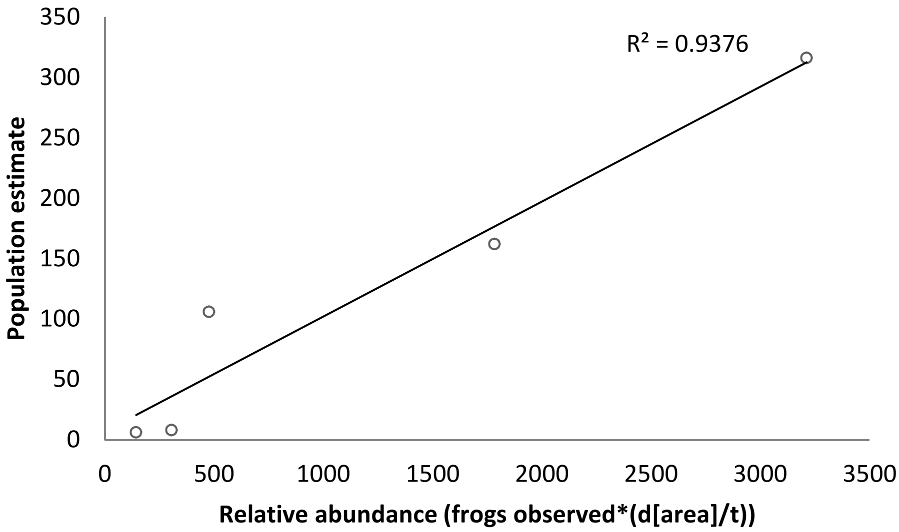

Figure 4. Linear regression between relative abundance (number of frogs observed during VES survey multiplied by pond surface area (m2) divided by person survey minutes) and estimated abundance (population estimate using mark-recapture data) (n=5; $P < 0.007$; $R2 = 0.938$).

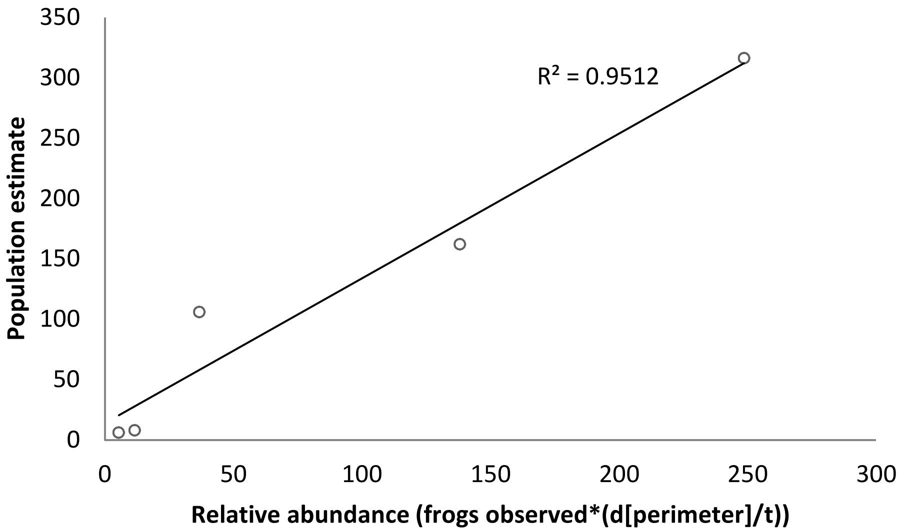

Figure 5. Linear regression between relative abundance (number of frogs observed during VES survey multiplied by pond perimeter (m) divided by person survey minutes) and estimated abundance (population estimate using mark-recapture data) (n=5; $P < 0.005$; $R2 = 0.951$).

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 link 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	Jan	Mar	Oct	Dec	Jan	Mar	Oct	Oct	Dec	Dec	Jan	Jan	Mar	Mar
Pond									1	2	1	2	1	2	1	2
c1	NS	NS	0.00	20.00	NS	NS	0.00	15.67	NS	NS	NS	NS	0	0	26	13
c2	NS	NS	NS	20.00	NS	NS	NS	15.67	NS	NS	NS	NS	NS	NS	26	13
K1	NS	NS	NS	0.00	NS	NS	NS	0.00	NS	NS	NS	NS	NS	NS	0	0
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 CENTER	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	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 Extension	2.00	0.00	0.00	0.00	20.80	0.00	0.00	0.00	39	26	0	0	0	0	0	0
K100 West	0.00	0.00	0.48	0.00	0.00	0.00	10.48	0.00	0	0	0	0	26	13	0	0
K101	NS	NS	2.86	1.43	NS	NS	8.48	4.24	NS	NS	NS	NS	24	11	19	5
K102	NS	NS	1.36	0.00	NS	NS	26.36	0.00	NS	NS	NS	NS	46	34	0	0
K103	NS	NS	10.91	0.75	NS	NS	300.55	20.66	NS	NS	NS	NS	374	383	39	26
K104	0.00	NS	4.44	1.40	0.00	NS	28.81	9.05	0	0	NS	NS	48	37	25	12
K105	NS	NS	0.49	0.58	NS	NS	21.95	25.96	NS	NS	NS	NS	40	28	45	33
K106	NS	NS	0.00	0.00	NS	NS	0.00	0.00	NS	NS	NS	NS	0	0	0	0
K107	NS	NS	1.67	0.00	NS	NS	8.06	0.00	NS	NS	NS	NS	24	10	0	0
K11/12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0
K13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0
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	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0
K21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0
K22/23	4.29	12.14	7.76	1.03	41.86	118.60	75.80	10.10	24	53	67	151	68	97	162	162
K24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	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	0.00	0.00	0.36	0.00	0.00	0.00	5.94	0	0	0	0	0	0	21	8
K27	0.00	0.00	NS	0.00	0.00	0.00	NS	0.00	0	0	0	0	NS	NS	0	0
K29	NS	NS	NS	1.20	NS	NS	NS	7.84	NS	NS	NS	NS	NS	NS	23	10
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	NS	0.00	0.00	0.00	NS	0	0	0	0	0	0	NS	NS
K58	NS	NS	NS	0.00	NS	NS	NS	0.00	NS	NS	NS	NS	NS	NS	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	1.60	0.00	0.00	0.00	2.67	0	0	0	0	0	0	17	3
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	NS	0.00	0.00	0.00	NS	0.00	0	0	0	0	NS	NS	0	0
N1	NS	0.00	4.55	NS	NS	0.00	55.61	NS	NS	NS	0	0	81	71	NS	NS
N4	NS	NS	NS	0.00	NS	NS	NS	0.00	NS	NS	NS	NS	NS	NS	0	0
Rail Loop	0.91	NS	0.43	3.16	11.65	NS	5.45	40.47	8	8	12	12	6	6	62	52
s1	NS	NS	0.00	0.00	NS	NS	0.00	0.00	NS	NS	NS	NS	0	0	0	0
s2	NS	NS	0.00	0.00	NS	NS	0.00	0.00	NS	NS	NS	NS	0	0	0	0
s3	NS	NS	0.00	0.00	NS	NS	0.00	0.00	NS	NS	NS	NS	0	0	0	0
s4	NS	NS	0.00	0.00	NS	NS	0.00	0.00	NS	NS	NS	NS	0	0	0	0
s5	NS	NS	0.00	0.00	NS	NS	0.00	0.00	NS	NS	NS	NS	0	0	0	0

s6	NS	NS	0.00	0.00	NS	NS	0.00	0.00	NS	NS	NS	NS	0	0	0	0
s7	NS	NS	0.00	0.00	NS	NS	0.00	0.00	NS	NS	NS	NS	0	0	0	0
W1	NS	NS	0.55	NS	NS	NS	10.20	NS	NS	NS	NS	NS	26	13	NS	NS
W2	NS	NS	0.00	0.00	NS	NS	0.00	0.00	NS	NS	NS	NS	0	0	0	0
c1	NS	NS	0.00	20.00	NS	NS	0.00	15.67	NS	NS	NS	NS	0	0	33	20
c2	NS	NS	NS	20.00	NS	NS	NS	15.67	NS	NS	NS	NS	NS	NS	33	20
TOTAL	**7**	**12**	**35**	**52**	**74**	**119**	**552**	**158**	**71**	**88**	**79**	**163**	**764**	**702**	**465**	**337**
AVERAGE ESTIMATE									**79**		**121**		**733**		**401**	

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 hence 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 waterbodies 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**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).

Due to site access issue on the proportion of KI known as T4 (a site that contains close to 50% of the ponds on KI/AI and many known GGBF ponds), many ponds were not able to be surveyed in October and December of 2012. Therefore, population estimates in these months (an average of 79 and 121 respectively; Table 2) are considered vast under-estimates of population size across KI/AI and should not be taken in any other context. Site-access was restored to the majority of T4 after December 2012, and many more ponds were therefore surveyed in January and March 2013. These resulted in 'raw' average estimates of 733 and 401 frogs respectively (Table 2). There were, however, still a number of ponds that were not able to be surveyed, some of which had GGBF in them the last time they were able to be surveyed. Therefore, to produce a more realistic estimate of the population in these two months the ponds that were not able to be surveyed were factored into the calculation by assuming a stable population at ponds that had previously contained GGBF, based upon the last time each of these ponds were surveyed (an assumption that may or may not hold true at each pond). Adjusted for these calculations, the estimate of total GGBF on KI/AI was between 831 and 836 in January 2013, and 522 and 523 in March.

3.2 Distribution and pond occupancy across Kooragang and Ash Islands

From October 2012 to March 2013, 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 20 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 36.4% across the season (although this should be taken into the context of restricted access issues as outlined above). Calling was detected at 11 ponds, tadpoles at four ponds, metamorphs at one pond and juveniles at five ponds (**Error! Reference source not found.**). Pond K23 was found to have the highest number of adults detected, K105 had the highest number of calling males, K22 had the highest number of tadpoles and metamorphs and K104 had the highest number of juveniles detected (**Error! Reference source not found.**).

Visual encounter and mark-recapture surveys together captured a total of 438 bell frogs of which 213 were male and 148 were female, giving a male : female sex ratio of 1.4 : 1.0. An additional 77 bell frogs were juveniles.

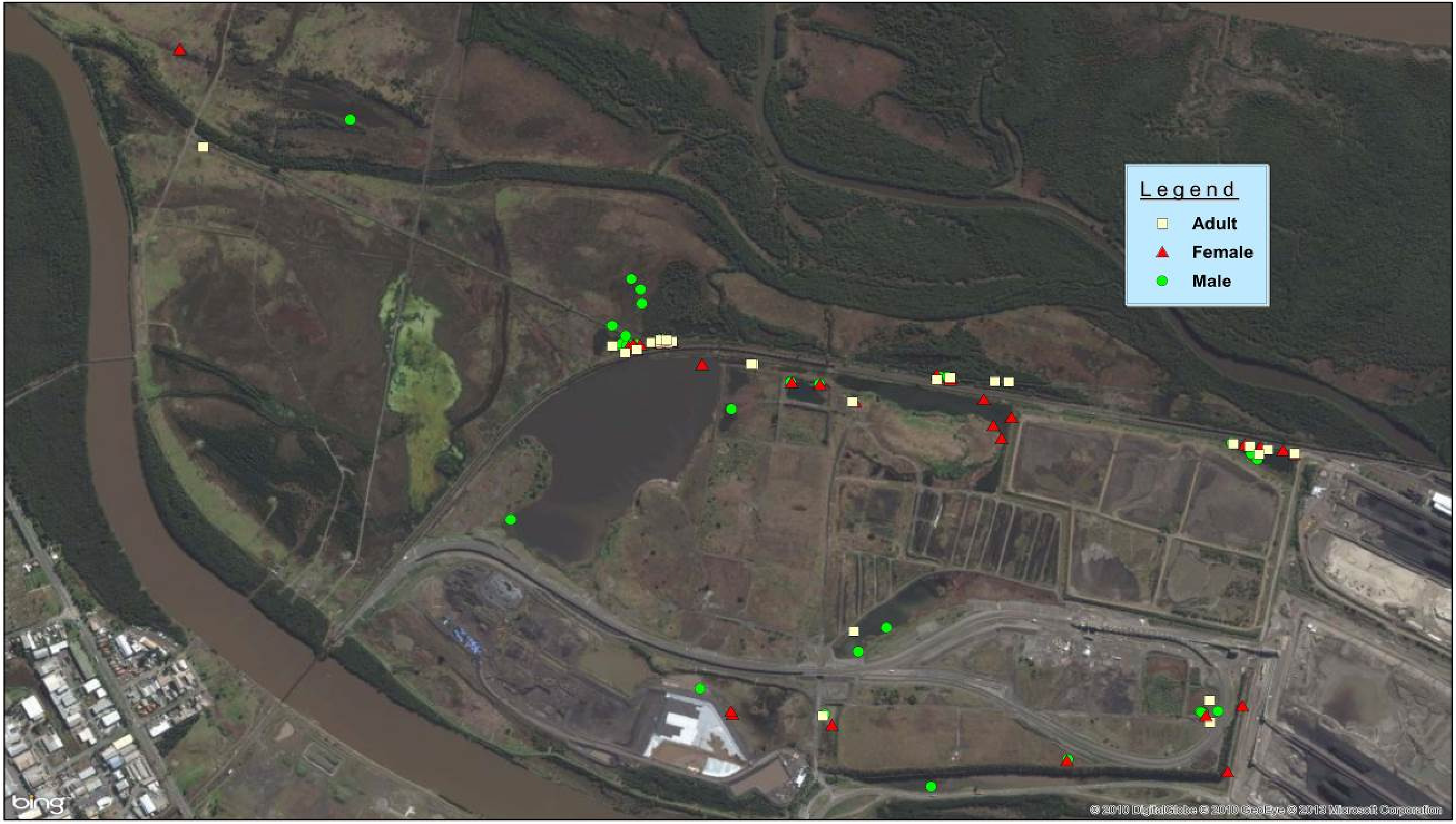

Figure 6. Aerial photograph of Ash and Kooragang Islands showing the locations of GGBF records from the 2012/2013 season. Source: Microsoft Bing, March 2013.

Figure 7. Aerial photograph of Ash and Kooragang Islands the location of calling green and golden bell frogs, metamorphs and juveniles and the ponds where tadpoles were found (shown in blue), from October 2012 to March 2013. Source: Microsoft Bing, March 2013.

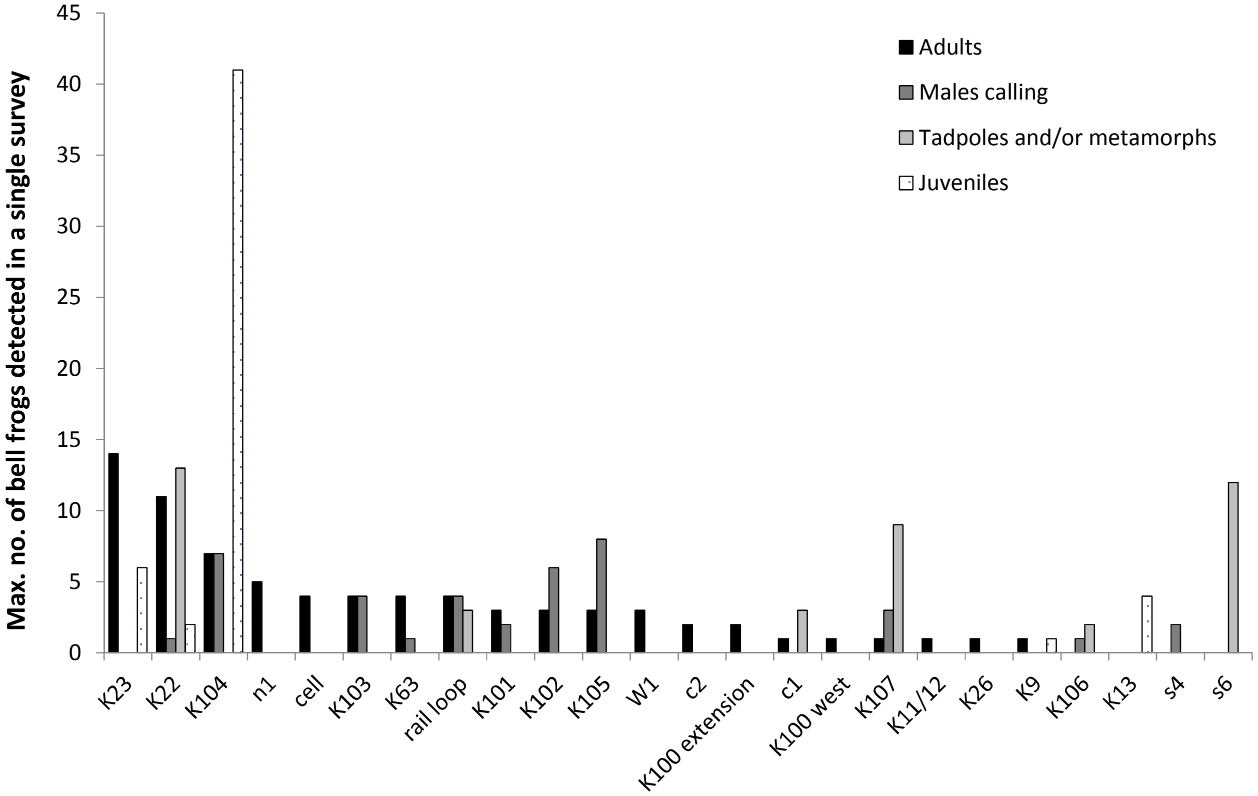

Figure 8. The maximum number of green and golden bell frog adults, metamorphs and juveniles seen during visual encounter surveys, males heard calling during auditory surveys and tadpoles captured on any single survey occasion across Ash and Kooragang Islands between October 2012 and March 2013.

3.3 Movement and landscape connectivity

Assessing movement and landscape connectivity

A total of 22 new GGBF movements between ponds occurred in the 2012/2013 season (including those that occurred between seasons), with 19 of those movements occurring between K22 and K23 (a distance of approximately 80m). Two other moderate movements also occurred; one each on Ash Island between K22 and K63 to the north (approximately 250m), and one on T4 on Kooragang Island between K101 and the newly created cluster of ponds known as C2 (approximately 700m). Finally, one movement that is considered to be very long was recorded between the Rail Loop pond and K22. This movement occurred between November 2012 and February 2013. Figure 9 shows the capture locations of that particular individual frog in November 2012 and February 2013, and the most direct movement path possible. The distance between the two water bodies via the most direct path (straight line) is > 2.1km (although the actual path travelled was likely much longer), and would involve either crossing the rail line or travelling around and through the entrance of the rail loop on two occasions (with the former considered the most likely). The frog was a large male of 63.38 mm in snout-vent length.

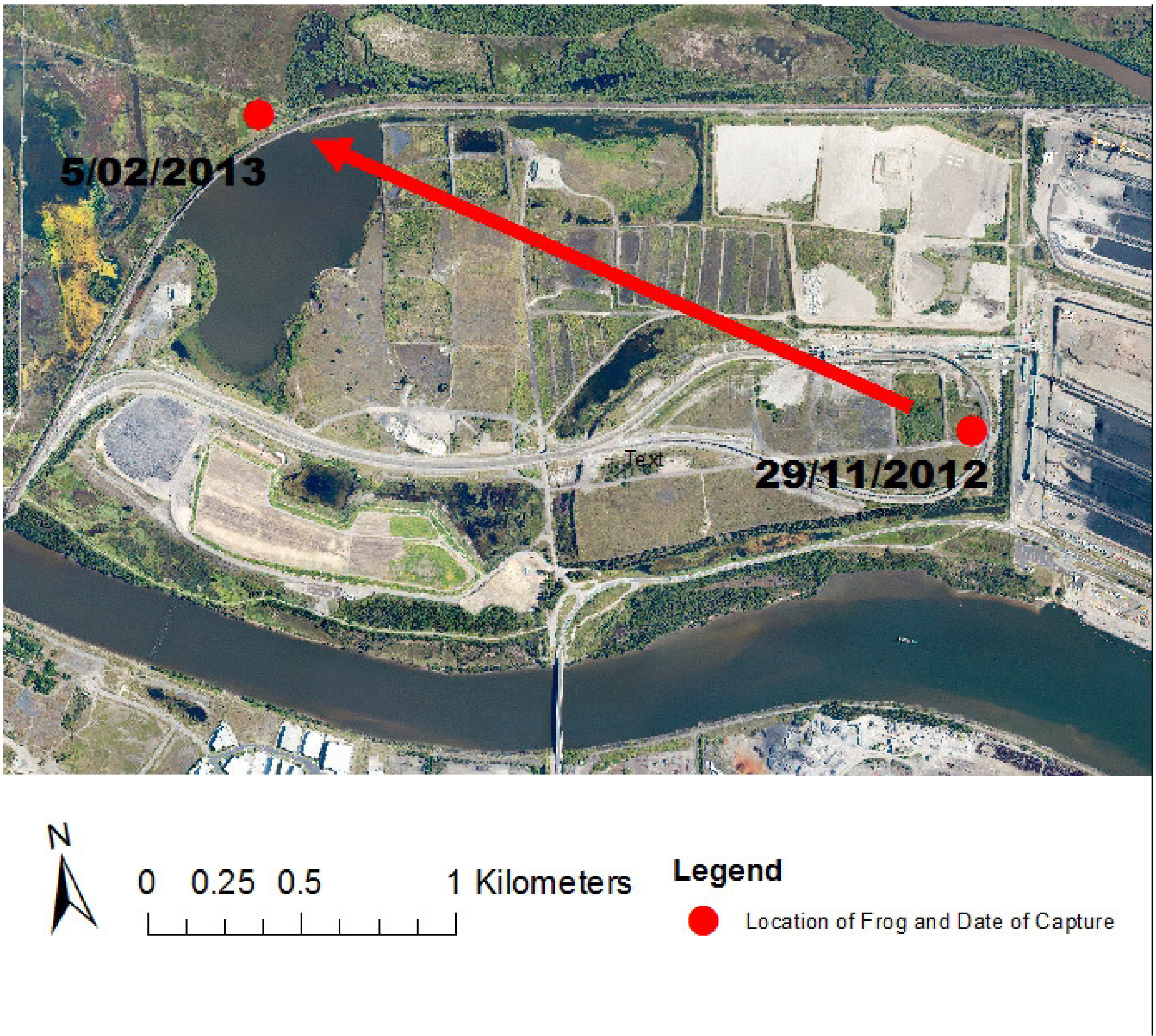

Figure 9: Aerial photograph showing the capture locations, dates and most direct line of travel of the individual male GGBF found inside the study area in November 2012, and found in K22 on Ash Island in February 2013 during PWCS investigations.

4 Discussion

4.1 Population size and apparent survival estimates

One of the biggest issues in the 2012/2013 season was site-access, with no access to the T4 site for the majority of the season. T4 contains a large proportion of the known GGBF ponds on Kooragang Island and, as such, the results on the GGBF population demography should be considered in that context. As T4 was not able to be surveyed during the October and December 2012 periods, the population estimates during this time do not reflect the population of the island as a whole, but rather only those ponds that were able to be surveyed. By the January 2013 survey, most of the ponds were able to be surveyed and the population estimate for the island is considered to be reasonably robust, particularly when the missing ponds are factored back in as described above in the results. With that in mind, the largest population estimate for KI/AI as a whole in the 2012/2013 season was ca. 834 animals recorded in January 2013. This is comparable to the previous two years of up to 930 animals in 2011/2012 (Clulow et al, 2012) and up to 967 animals in 2011 (Leu et al, 2011) suggesting that the population may be currently stable, albeit small in size. It is also comparable to previous estimates from Ash and Kooragang Island, which found a population size (±SE) of 1995 (±315) males in the year 2000, 905 (±145) in 2001 (Hamer, Lane et al. 2007). However, it is difficult to identify population stability in the short-term, with fluctuations known to occur on a decadal scale (Penman and Lemckert 2008). Continuing to monitor the population over several more years will paint a much clearer picture on the direction that the population is heading .

Monthly apparent survival was fairly consistent to previous years (Clulow et al, 2012; Leu et al, 2011), although was low at times in K22/K23 (as low as 0.31). It is vitally important when considering apparent survival to recognise how apparent survival differs from true survival. Apparent survival is a combination of mortalities and permanent emigration away from a site. These two factors combined are inseparable without determining one of the factors alone, which often remains incredibly difficult in a field setting. Therefore, an annual apparent survival estimate does not necessarily translate to true survival, but rather a portion of this estimate is likely due to emigration away from the site/s being sampled. Furthermore, the possibility that a high proportion of the apparent survival estimate is due to emigration rather than mortalities is very real. This could account for a reasonable amount of the variation observed in apparent survival estimates across different sites and at different points in time. Significant breeding occurred in K22 in the 2012/2013 season, and this lower rate in apparent survival might reflect large dispersal events away from the pond, rather than large mortalities, although it could also represent higher juvenile mortality. The remaining ponds where mark-recapture was conducted had fairly consistent monthly survival across the season.

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).

That being said, violations of the Robust design models were controlled as much as possible and the model output seemed reasonably sensible in most instances. It is, however, worth noting that there was an apparent population decline observed in March, 2013. This may be due to the animals' behaviour changing (a broken assumption in the modelling process) rather than an absolute decline in numbers. For example, March is at the very end of the breeding season and it is likely that many animals are starting to 'go to ground' in preparation of aestivating for the winter season (and so become invisible to the survey technique). This would result in an underestimate of true population size, resulting in an artificially small population estimate. This might explain why there was a general decrease in the population size in March at several ponds. Alternatively, there could have been a die-off in the newly emerging juvenile population which contributed to the decrease in numbers.

4.2 Distribution and pond occupancy use across Kooragang and Ash Islands

Frogs were found to occur in 20 ponds in the 2012/2013 season, with naïve pond occupancy of 36.4%. It is important to note that this figure could be artificially low due to site-access issues restricting access to many ponds on KI for more than half of the season. Regardless, this naïve pond occupancy on Kooragang and Ash Islands was comparable to the 2011/2012 season where frogs were found in 23 ponds, or naïve occupancy of 41.8% (Clulow et al, 2012).

Importantly, GGBF were found to utilise the newly created clusters of ponds placed on T4, with both clusters observed to have at least one frog. GGBF were also found in one of the BHPB wetlands which has important implications for the management of T4 and for the island as a whole. 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.

Tadpoles were found in just 5 ponds across KI/AI in the 2012/2013 season. 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 on T4, with the remaining two occurring inside the NCIG rail loop, and on Ash Island in the National Park (K22). Calling by males was found to be widespread across the island with calling males observed in 11 ponds. Eight of the ponds containing calling males were located on T4.

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 2012/2013 season, although movements were also observed across T4. One very long range movement (>2km) was observed to occur right across the island (from the Rail Loop on Kooragang Island to K22 on Ash Island) and is assumed to have crossed through T4.

The movement in and out of the rail loop clearly demonstrates that GGBFs are able to cross the existing rail infrastructure in its current form, in at least some capacity. This was also observed in the 2011/2012 season (Clulow et al, 2012). 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.

The movement of >2km observed in the 2012/2013 season is greater than movements observed in the 2010/2011 or 2011/2012 seasons (although a movement of > 1km was observed in 2011/2012; Clulow et al, 2012), and greater than many studies on GGBF movement. Previous mark-recapture studies show that the average distances moved by individual *L. aurea* range between 40.7 m (Murphy, 1995), 148.5 m (Kurnell Peninsula; (Christy, 2000) and 52 m (Homebush Bay; (Christy, 2000), but in general there have been few instances where large distances have been observed. When large movements have occurred, these were observed to be up to 632 m since the previous capture location, (Christy, 2000) however the time period between captures is not mentioned. This is similar to the mark-recapture study conducted by Hamer et al. (2008) on Kooragang Island, where the majority of *L. aurea* individuals were recaptured at the same water body as the initial capture (53% males, 65% females) while only some individuals were observed to move distances of greater than 200 m between capture periods. The most extreme movement documented for *L. aurea* on any one occasion was when one individual was observed to have travelled up to 1.5 km in a single night, although it is noteworthy that it was followed by the observer with the aid of a light (Pyke and White, 2001). It is unknown why such a large movement has been observed during this study, but suggests that such movements might occur more commonly than previously thought.

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References

Amstrup SC, McDonald TL, Manly BFJ, 2005. Handbook of capture-recapture analysis. Princeton: Princeton University Press.

Burnham, K. P. and D. R. Anderson (2002). Model Selection and Multi-model Inference: A Practical Information-Theoretic Approach. New York, Springer.

Christy, M. T. (1996). "The efficacy of using Passive Integrated Transponder (PIT) tags without anaesthetic in free-living frogs." Australian Zoologist 30(2): 139-142.

Christy, M. T. (2000). The ecology and conservation biology of the green and golden bell frog Litoria aurea (Lesson) (Anura:Hylidae), PhD Thesis, School of Biological Sciences, University of Sydney.

Clulow, S., Leu, S., Stockwell, S., Clulow, J. & Mahony M. (2012). Research program on the green and golden bell rog (*Litoria aurea*) on Kooragang Island. Annual report prepared for PWCS.

Crump, M. L. and N. J. J. Scott (1994). Visual encounter surveys. Measuring and Monitoring Biological Diversity - Standard Methods for Amphibians. W. R. Heyer, M. A. Donnelly, R. W.

Cumming, G., F. Fidler, et al. (2007). "Error bars in experimental biology." The Journal of Cell Biology 177(1): 7-11.

Dodd JCK. ed, 2010. Amphibian ecology and conservation. A handbook of techniques. Oxford: Oxford University Press.

Hamer A, Mahony M, 2010. Rapid turnover in site occupancy of a pond-breeding frog demonstrates the need for landscape-level management. Wetlands 30:287-299.

Hamer AJ, Lane SJ, Mahony MJ, 2002. Management of freshwater wetlands for the endangered green and golden bell frog (*Litoria aurea*): roles of habitat determinants and space. Biol Conserv 106:413-424.

Hamer AJ, Lane SJ, Mahony MJ, 2008. Movement patterns of adult green and golden bell frogs *Litoria aurea* and the implications for conservation management. J Herpetol 42:397-407.

Hamer AJ, Mahony MJ, 2007. Life history of an endangered amphibian challenges the declining species paradigm. Aust J Zool 55:79-88.

Hamer, A. J., S. J. Lane, et al. (2007). "Life-history of an endangered amphibian challenges the declining species paradigm." Australian Journal of Zoology 55(2): 79-88.

Krebs CJ, 2001. Ecology. The experimental analysis of distribution and abundance, 5 ed. Menlo Park, California: Benjamin Cummings.

Mackenzie, D. I. and W. L. Kendall (2002). "How should detection probability be incorporated into estimates of relative abundance?" Ecology 83(9): 2387-2393.

Mackenzie, D. I., D. K. Nichols, et al. (2002). "Estimating site occupancy rates when detection probabilities are less than one." Ecology and Society 83(8): 2248-2255.

MacKenzie, D. I., J. D. Nichols, et al. (2006). Occupancy Estimation and Modeling. London, Academic Press.

Mahony, M., Hamer, A. J., Pickett, E., McKenzie, D., Stockwell, M., Garnham, J., Keely, C., Deboo, M., O'Meara, J., Pollard, C., Clulow, S., Lemckert, F., Bower, D. S., & Clulow, J. (In Press). Setting conservation and research priorities for endangered species in the face of uncertainty: a case study using bell frogs in eastern Australia. *Herpetological Conservation and Biology*.

Murphy, M. J. (1995) A capture/recapture study of the endangered hylid frog Litoria aurea. Herpetofauna, 25, 19-21.

Nichols, J. D. (2005). Modern open-population capture-recapture models. Handbook of Capture-Recapture Analysis. S. C. Amstrup, T. L. McDonald and B. F. J. Manly. New Jersey, Princeton University Press: 88-123.

Penman, T. D. and F. L. Lemckert (2008). "Monitoring the green and golden bell frog: Current problems and an alternative approach." Australian zoologist 34(3): 373-378.

Pollock, K. H. (1982). "A capture-recapture design robust to unequal probability of capture." Journal of Wildlife Management 46: 757-760.

Primack RB, 1998. Essentials of conservation biology. Sunderland: Sinauer Associates.

Pyke, G. H. (2005). "The use of PIT tags in capture-recapture studies of frogs: a field evaluation." Herpetological Review 27: 195-196.

Pyke GH, White AW, 2000. Factors influencing predation on eggs and tadpoles of the endangered green and golden bell frog *Litoria aurea* by the introduced plague minnow *Gambusia holbrooki*. Aust Zool 31:496-505.

Pyke GH, White AW, 2001. A review of the biology of the green and golden bell frog *Litoria aurea*. Aust Zool 31:563-598.

Stockwell, M. P. (2012). "Impact and mitigation of he emerging infectious disease chytridiomycosis on the endangered green and golden bell frog." PhD Thesis, The University of Newcastle.

Stockwell M, Clulow J, Mahony M, 2010. Monitoring and research outcomes for the green and golden bell frog (*Litoria aurea*) at Sydney Olympic Park 2009/10. In: Annual Report: The University of Newcastle.

Traill LW, Brook BW, Frankham RR, Bradshaw CJA, 2010. Pragmatic population viability targets in a rapidly changing world. Biol Conserv 143:28-34.

White, G. C. and K. P. Burnham (1999). "Program MARK: survival estimation from populations of marked animals." Bird Study 46 (Suppl): S120-S139.

White AW, Pyke GH, 1996. Distribution and conservation status of the green and golden bell frog *Litoria aurea* in New South Wales. Aust Zool 30:177-189.