



CROYDON GOLD MINE
REHABILITATION MONITORING PROGRAM

NOVEMBER 2014

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1 INTRODUCTION

The Croydon Gold Mine (the Project) is located to the immediate west of the Croydon township, 560 kilometres (km) west of Cairns, Queensland (QLD) (Figure 1). The Project was formerly a large low-grade gold mine and has since been closed and decommissioned. Activities at the Project include maintenance, monitoring and reclamation works (as required).

Mining Lease (ML) 5248 was granted on 4 August 1988 to Goldfields Kalgoorlie Limited. ML 5248 was later transferred to Aurion Gold Limited, before the company was acquired by Placer Dome Australia in November 2003, which was then acquired by Barrick Gold of Australia (Barrick) in 2005. Barrick holds Environmental Authority No. EPML00950913 (EA) for the Project.

This Rehabilitation Monitoring Program (RMP) has been prepared in accordance with EA Condition C2-2:

C2-2 The Post Mine Land Use Plan must be included in the Plan of Operations and updated with each subsequent Plan of Operations, describing how the rehabilitation objectives in Schedule C – Table 1 will be achieved. The Post Mine Land Use Plan must include:

...

(n) rehabilitation monitoring program, including the monitoring of:

(i) surface water quality;

(ii) groundwater quality;

(iii) erosion rates;

(iv) integrity and effectiveness of final cover systems; and

(v) health and resilience of vegetative cover.

Other EA conditions of relevance to this RMP are provided below:

C3-1 The holder of the environmental authority must conduct a Rehabilitation Monitoring Program on at least a yearly basis, which must include sufficient spatial and temporal replication to enable scientifically justifiable conclusions as established under the rehabilitation program or other methodology to the satisfaction of the Administering Authority.

C3-2 The rehabilitation monitoring program must be developed by 1 October 2008 and be implemented by a person nominated by the environmental authority holder possessing appropriate qualifications and experience in the field of rehabilitation management.

C3-3 Verification of rehabilitation success is to be determined by comparison with the criteria documented in the Post Mine Land Use Plan required under Condition C2-1.

The above conditions are also addressed where relevant in this RMP.

In accordance with EA Condition C2-2 this RMP will be included in the Croydon Gold Mine Plan of Operations.

The remainder of this RMP is structured as follows:

Section 2: Provides a description of the Project.

Section 3: Presents an overview of rehabilitation monitoring at the Project.

Section 4: Details the surface water monitoring program.

Section 5: Illustrates the stream sediment monitoring program.

Section 6: Presents the groundwater monitoring program.

Section 7: Describes the rehabilitation monitoring program.

Section 8: Details monitoring of erosion and the final cover systems at the Project.

Section 9: Describes the review process for this RMP.

Section 10: Lists the references cited in this RMP.

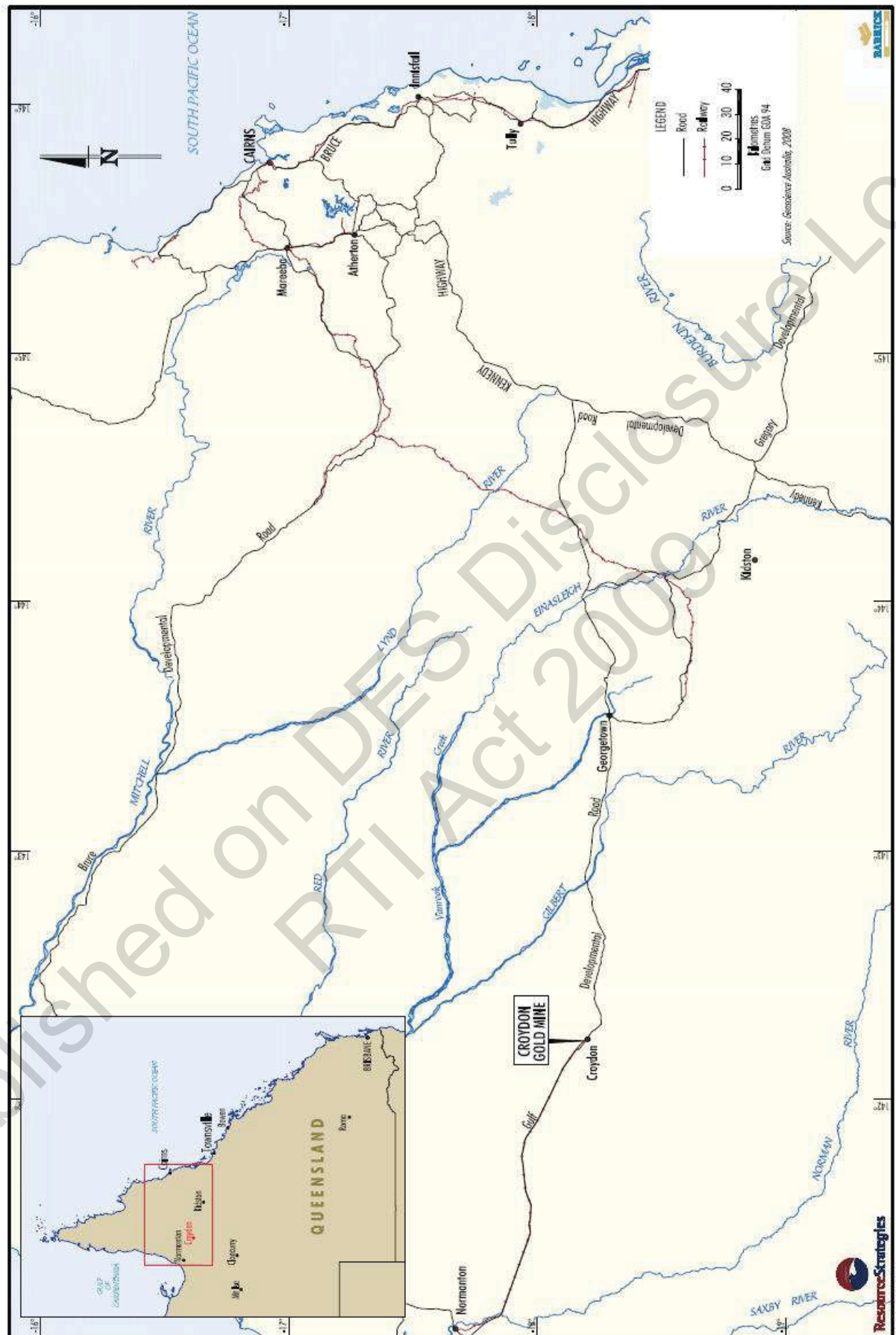


Figure 1: Regional Location

2 BACKGROUND

Extensive gold mining at the Project commenced in the late 1880s for approximately 30 years, before recommencing in 1987. Operational mining ceased in 1990 and the Project was decommissioned by late 1993 (Barrick, 2008). Reclamation performance was audited in 1996/97 and significant additional reclamation works were undertaken in 1996 and 1997 (Barrick, 2008).

The mining-related landforms on ML 5248 comprise of waste rock dumps, open pits and infrastructure areas (i.e. abandonment bunds, hardstand areas, water management structures and roads/tracks) surrounding the open pits and waste rock dumps.

Specifically they include (Figure 2):

- Golden Butterfly Pit;
- Golden Butterfly North Pit;
- Golden Butterfly waste rock dump;
- Content Pit;
- Content waste rock dump;
- Lady Isabella Pit;
- abandonment bunds across the access ramps of the four open pits;
- hardstand areas adjacent to the Content and Golden Butterfly waste rock dumps;
- water diversion bunds and sediment dams adjacent to the Content and Golden Butterfly waste
- rock dumps; and
- roads and tracks.

Schematic diagrams of the final landforms, inclusive of drainage features, are provided in Figure 3 of the Post Mine Landuse Plan (Appendix A of the Plan of Operations [Barrick, 2008a]).

The final landform concept is to achieve a stable post-mining landform that is able to meet the identified post-mining landuse and rehabilitation objectives. The post-mining land descriptions and rehabilitation objectives are specified in Schedule C – Table 1 of the EA, which is reproduced in Table 2.

3 OVERVIEW OF PROJECT REHABILITATION MONITORING

Monitoring of surface water, groundwater, vegetation and soil fertility at the Project has been conducted since 1997. Annual rehabilitation monitoring results are available from 1997 to 2001 and from 2004 to present. Vegetation, soil fertility and erosion monitoring has occurred at vegetation monitoring transects on the Golden Butterfly and Content waste rock dumps and at analogue transects between these two waste rock dumps (Figure 2).

Surface water monitoring has occurred at monitoring sites in the receiving waters of Slaughteryard Creek and Belmore Creek, as well as at the base of the access ramp to the four open pit on-site storages of Golden Butterfly Pit, Golden Butterfly North Pit, Lady Isabella Pit and Content Pit (Figure 2).

Groundwater monitoring has occurred at BH1 and BH2 adjacent to the Golden Butterfly Pit, BH3, BH5 and BH7 on the eastern side of the Golden Butterfly waste rock dump and at bores GBMB1, GBMG3 and GBMB6 parallel to Slaughteryard Creek (Figure 2).

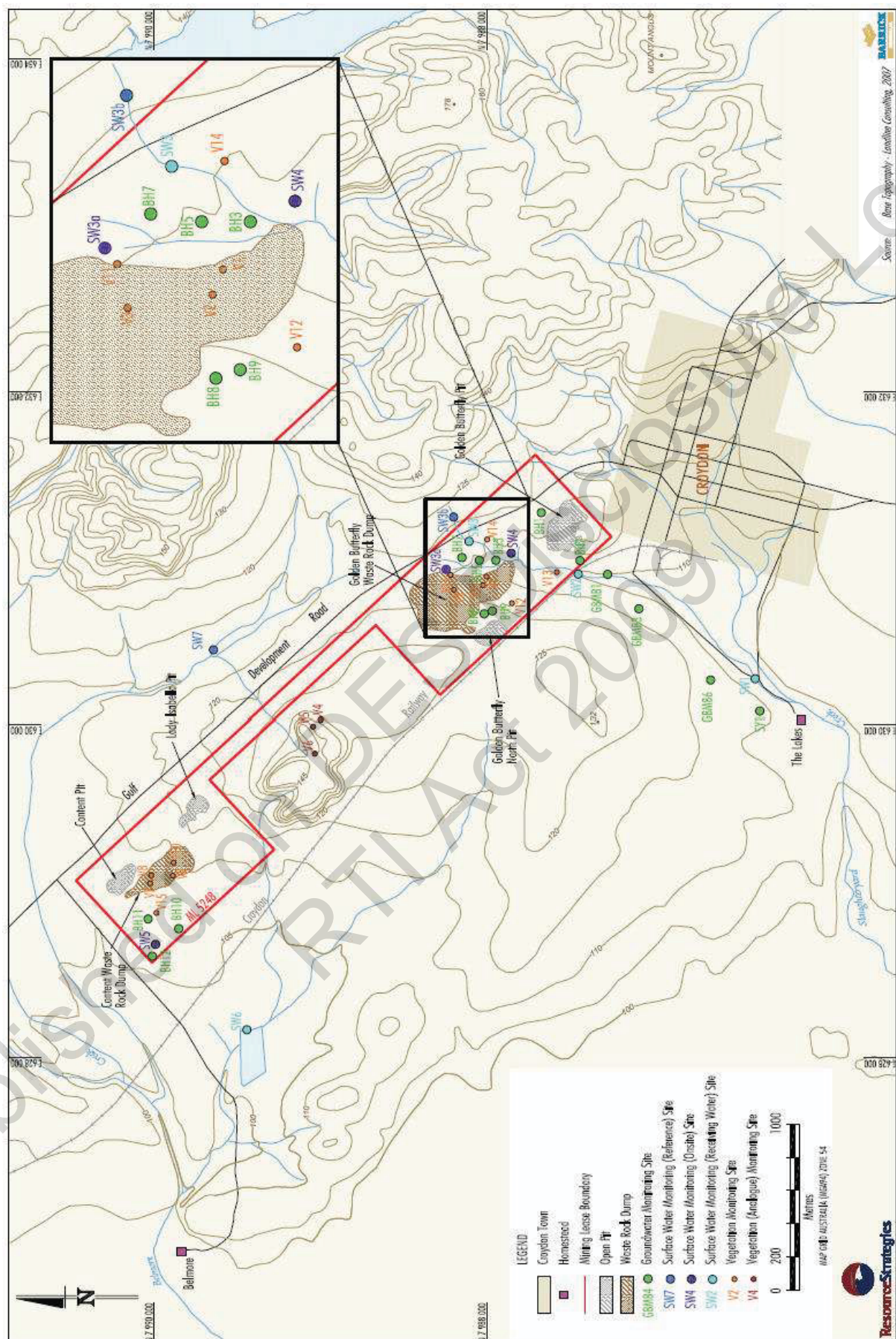


Figure 2: Site Location and Location of Environmental Monitoring Stations

4 SURFACE WATER MONITORING

Surface water monitoring will be conducted at the Project in accordance with EA No. EPML00950913. A description of the surface water monitoring program is provided in Sections 4.1 and 4.2.

The surface water monitoring program described below is based on the existing monitoring program

4.1 RECEIVING WATERS

In accordance with EA Condition F1-3 receiving waters monitoring will be conducted at the locations defined in Schedule F – Table 1 of the EA for the parameters identified in Schedule F – Tables 2 and 3 of the EA. The frequency of monitoring will be conducted in accordance with EA Condition F1-3. A summary of the receiving waters monitoring for the Project is provided in Table 1.

Table 1: Receiving Water Monitoring Programme

Monitoring Location (refer Figure 2)	Frequency	Parameters
SW1 Lower Slaughteryard Creek	<p>For routine monitoring:</p> <ul style="list-style-type: none"> • Twice yearly once during wet season (January – March) & once during dry season (July – September). <p>Event based sampling of discharge event¹ or flow events²:</p> <ul style="list-style-type: none"> • One representative sample must be taken of a discharge event or flow event. • Where a discharge event or a flow event has a duration of 24 hours or 	<p>pH EC Turbidity Sulphate Fluoride Aluminium Arsenic Boron Cadmium Chromium (CrVI) Cobalt Copper Mercury (inorganic) Nickel Selenium (total) Zinc</p>
SW2 Slaughteryard Creek West Tributary at the ML boundary		
SW3 Slaughteryard Creek upstream of the Golden Butterfly WRD		
SW6 Belmore Creek borrow pit / stock dam		
BCDS Belmore Creek Downstream		
Reference Sites		
SW3b Reference point for Slaughteryard Creek		
BCUS Reference point for Belmore Creek		

1 Discharge event is an unauthorised surface water discharge from water storages or contaminated areas on the licensed place.

2 Flow event is a surface water flow in Slaughteryard Creek and/or Belmore Creek that occurs as a result of rainfall.

Note: Where discharge events or flow event occur simultaneously only one set of samples are required to be taken.

No sample is required where there is insufficient flow during the dry season (July – September).

The sampling method for the receiving waters will comply with the latest edition of the Environmental Protection Agency's Water Quality Sampling Manual in accordance with EA Condition F1-2. As required by EA Condition F1-6(a) monitoring will be performed by a person or body possessing appropriate experience and qualifications to perform the required measurements.

4.2 ON-SITE STORAGES

In accordance with EA Condition F3-1 monitoring of the on-site storages will be conducted at the locations defined in Schedule F – Table 7 for the parameters identified in Schedule F – Table 8. The frequency of monitoring will be conducted in accordance with EA Condition F3-1. A summary of the monitoring for the on-site storages for the Project is provided in Table 2.

Table 2: On-site Storages Monitoring Programme

Monitoring Location (refer Figure 2)	Frequency	Parameters
Golden Butterfly Pit (base of ramp)	For routine monitoring: • Twice yearly once during wet season (January – March) & once during dry season (July – September).	pH EC Turbidity Sulphate Fluoride Aluminium Arsenic Boron Cadmium Chromium (CrVI) Cobalt Copper Mercury (inorganic) Nickel Selenium (total) Zinc
Golden Butterfly North Pit (base of ramp)		
Lady Isabella Pit (base of ramp)	Event based sampling of discharge event ¹ or flow events ² : • One representative sample must be taken of a discharge event or flow event. • Where a discharge event or a flow event has a duration of 24 hours or	
Content Pit (base of ramp)		
SW3a		
Golden Butterfly WRD toe drain		
SW4		
Stock water dam		
SW5		
Sediment Dam at lease boundary		

¹ Discharge event is an unauthorised surface water discharge from an on-site water storage.

Note:

- Samples must be analysed for all parameters listed in Schedule F – Table 8.

- Monitoring of the storage is to be conducted at the spillway.

- No sample is required where there is insufficient water present in on-site locations during the dry season (July – September).

The sampling method for the on-site storages will comply with the latest edition of the Environmental Protection Agency's Water Quality Sampling Manual in accordance with EA Condition F1-2. As required by EA Condition F1-6(a) monitoring will be performed by a person or body possessing appropriate experience and qualifications to perform the required measurements.

5 STREAM SEDIMENT MONITORING

In accordance with EA Condition F2-1 stream sediment monitoring will be conducted at the locations and frequencies defined in Schedule F – Table 4 of the EA for the parameters identified in Schedule F – Table 5 and Table 6 of the EA. A summary of the stream sediment monitoring for the Project is provided in Table 3.

Table 3: Stream Sediment Monitoring Programme

Monitoring Location (refer Figure 2)	Frequency	Parameters
SW1 Lower Slaughteryard Creek	Twice yearly in wet season (January – March) & dry season (July – September).	Aluminium Arsenic Boron Cadmium Chromium Cobalt Copper Mercury Nickel Selenium Zinc
SW2 Slaughteryard Creek West Tributary at the ML boundary		
SW3 Slaughteryard Creek upstream of the Golden Butterfly WRD		
SW6 Belmore Creek borrow pit / stock dam		
BCDS Belmore Creek Downstream		
Reference Sites		
SW3b Reference point for Slaughteryard Creek		
BCUS Reference point for Belmore Creek		

The sampling method for stream sediment will comply with the Australian Standard 5667.12 Guidance on Sampling of Bottom Sediments 1998 in accordance with EA Condition F2-4. As required by EA Condition F1-6(a) monitoring will be performed by a person or body possessing appropriate experience and qualifications to perform the required measurements.

6 GROUNDWATER MONITORING

Groundwater monitoring will be conducted at the Project in accordance with EA No. EPML00950913. A description of the groundwater monitoring program is provided below. The groundwater monitoring program described below is based on the existing monitoring program currently being used at the Project.

In accordance with EA Condition F4-1 groundwater monitoring will be conducted at the locations and frequencies defined in Schedule F – Table 9 of the EA for the parameters identified in Schedule F – Tables 10 and 11 of the EA. A summary of the groundwater monitoring for the Project is provided in Table 4.

Table 4: Groundwater Monitoring Programme

Monitoring Location (refer Figure 2)	Frequency	Parameters
BH1 North of Golden Butterfly Pit	Annually during the dry season	pH
BH2 South-west of Golden Butterfly Pit		EC
BH3 South-east of Golden Butterfly Waste Rock Dump		Turbidity
BH5 East of Golden Butterfly Pit Waste Rock Dump		Sulphate
BH7 East of Golden Butterfly Waste Rock Dump		Fluoride
BH8 West of Golden Butterfly Waste Rock Dump		Aluminium
BH9 West of Golden Butterfly Waste Rock Dump		Arsenic
BH10 West of Content Waste Rock Dump		Boron
BH11 West of Content Waste Rock Dump		Cadmium
BH12 West of Content Waste Rock Dump at lease boundary		Chromium (CrVI)
GBMB1 Slaughteryard Creek		Cobalt
GBMB3 Slaughteryard Creek		Copper
GBMB6 Slaughteryard Creek		Mercury (inorganic)
SY1 Slaughteryard Creek		Nickel
		Selenium (total)
		Zinc

The sampling method for groundwaters will comply with the latest edition of the Environmental Protection Agency's Water Quality Sampling Manual in accordance with EA Condition F1-2. As required by EA Condition F1-6(a) monitoring will be performed by a person or body possessing appropriate experience and qualifications to perform the required measurements.

In accordance with EA Condition F4-4 annual groundwater reports analysing the groundwater chemistry and hydrogeological status of all groundwater bores and groundwater conditions will be prepared by November each year.

7 REHABILITATION MONITORING

A monitoring program will be implemented to assess the performance of rehabilitation at the Project. In accordance with EA Conditions C3-1 and C3-2, rehabilitation monitoring will be conducted on at least a yearly basis by a person nominated by Barrick possessing appropriate qualifications and experience in the field of rehabilitation management.

The monitoring program described below is based on the existing monitoring program currently being used at the Project. Section 7.1 describes the monitoring program, Section 7.2 discusses data analysis and assessment, and Section 7.3 outlines rehabilitation objectives and criteria.

7.1 MONITORING PROGRAM

Details of monitoring transect location selection, number and frequency of monitoring are detailed in the attached "Rehabilitation Monitoring Method". This document describes the soil surface and reclamation evaluation procedures to be used by Barrick Gold Corporation (Barrick) held mines for monitoring and analysis of reclamation performance in accordance with Barrick's Environmental Management Systems (EMS).

These procedures have been developed in accordance with Barrick's EMS and Corporate Closure Group in Salt Lake City, Utah, USA. Unless superseded by site-specific permitting requirements, these procedures also support the process leading to eventual financial guarantee or assurance release in accordance with reclamation permit requirements for documentation of successful reclamation. Two important side-benefits of these procedures will be: 1) the timely detection of latent reclamation issues or problems along with recommendations for corrective action, and 2) a standardized means of recording information that will help preclude loss of such information due to staffing changes / turnover.

7.2 DATA ANALYSIS AND ASSESSMENT

The rehabilitation monitoring results obtained from annual monitoring will be reviewed by a person possessing appropriate qualifications and experience in the field of rehabilitation management to track rehabilitation progress against the analogue sites and the rehabilitation objectives and criteria discussed in Section 7.3.

The monitoring programs outlined in this RMP will allow sufficient spatial and temporal replication to enable scientifically justifiable conclusions to be established.

7.3 REHABILITATION OBJECTIVES AND CRITERIA

7.3.1 Rehabilitation Objectives

The rehabilitation objectives for the Project are prescribed in Condition C1-1 of the EA in Schedule C – Table 1 which is reproduced in Table 5. This condition requires ML 5248 (except for the open pits) to be rehabilitated to a post-mine landuse of low intensity grazing/disturbed native habitat. Condition C1- 1 of the EA also requires ML 5248 (except for the open pits) to be rehabilitated to a land classification of Class VI or better (DME, 1995).

The open pits are required to be rehabilitated to a post-mine landuse of "non-beneficial land use" and to a land classification of Class VIII (DME, 1995) by Condition C1-1 of the EA.

Table 5: Schedule C - Table 1 of the EA MIN10401906

Rehabilitation Objectives				
Landform (refer Schedule H – Map 1)	Surface Area (ha)	Post-mine Land Description	Land Classification ¹	Analogue Site Identification
Golden Butterfly North Pit	1.6	Non-beneficial land use	Class VIII	Sites to be rehabilitated to a standard nominated in the rehabilitation program developed in accordance with Condition C2-1 based on analogue sites.
Golden Butterfly Pit	5.1	Non-beneficial land use	Class VIII	
Lady Isabella Pit	1.7	Non-beneficial land use	Class VIII	
Content Pit	2.1	Non-beneficial land use	Class VIII	
Content Dump	6.3	L.I.G ² / disturbed native habitat	Class VI or better	
Golden Butterfly Dump	15.2	L.I.G ² / disturbed native habitat	Class VI or better	
Content Hardstand	2.0	L.I.G ² / disturbed native habitat	Class VI or better	
Golden Butterfly Hardstand	0.5	L.I.G ² / disturbed native habitat	Class VI or better	
Sediment Dams	1.5	L.I.G ² / disturbed native habitat	Class VI or better	
Roads/ Tracks	3.5	L.I.G ² / disturbed native habitat	Class VI or better	

¹ Technical guidelines for the Environmental Management of Exploration and Mining in Queensland (DME), 1995.

² L.I.G. (Low Intensity Grazing) defined by criteria listed in Land Use Acceptance Criteria

7.3.2 Rehabilitation Criteria

The Post Mine Landuse Plan (PMLP) (Appendix A of the Plan of Operations [Barrick, 2008a]) has been prepared in accordance with Condition C2-1 of the EA. As required by EA Condition C2-2, the PMLP includes the following:

(g) *proposed revegetation criteria including:*

- (i) *species diversity, abundance and composition;*
- (ii) *projective cover;*
- (iii) *dry matter production; and*
- (iv) *stocking rates to ensure self sustaining vegetation is maintained.*

...

(h) *measurable completion criteria for each rehabilitation indicator that enables determination of rehabilitation success for each disturbance type.*

In accordance with Condition C3-3 of the EA (Section 1) the verification of rehabilitation success will be determined by the comparison with the measurable completion criteria documented in Section 8 of the PMLP (Appendix A of the Plan of Operations [Barrick, 2008a]).

8 EROSION AND FINAL COVER SYSTEM MONITORING

8.1 EROSION MONITORING

Erosion monitoring at the Project will consist of conducting an annual qualitative assessment at each of the vegetation monitoring transects listed in Section 7.1.1. In general accordance with the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland* (DME, 1995) this will include:

- field traverses to observe incidence of erosion;
- recording details of any incidence of erosion (e.g. rills and sheeting); and
- maintaining a photographic record for comparison.

In addition to the above, the following parameters will be monitored as part of the rehabilitation monitoring program at the vegetation monitoring transects to provide an indication of the potential for erosion at the Project:

- tree density;
- pasture biomass;
- pasture cover; and
- pasture species composition.

8.2 FINAL COVER SYSTEM MONITORING

The final cover system of the Content waste rock dump and the Golden Butterfly waste rock dump consists of a clay capping layer, a rock fill surface protection layer and topsoil layer, except for the western batter of the Content waste rock dump.

The performance of the final cover system at the Project is monitored indirectly via erosion, vegetation and water monitoring. These monitoring parameters provide an indirect indication of the integrity of the final cover system. Erosion and vegetation cover monitoring on the waste rock dumps will be monitored at the sites listed in Section 7.1.1 utilising the parameters identified in Section 8.1 for erosion monitoring and in Section 7.1.2 for vegetation cover monitoring.

Potential failure of the final cover system would possibly result in impacts on surface water and groundwater quality and vegetation cover performance. Accordingly, the integrity and effectiveness of the final cover systems at the Project are monitored indirectly via surface water, groundwater, vegetation and erosion monitoring (Sections 4, 6, 7 and 8).

9 REVIEW

EA Condition A2-4 is of additional relevance to this RMP and is provided below:

(A2-4) Any management or monitoring plans, systems or programs required to be developed and implemented by a condition of this environmental authority must be reviewed for effectiveness in minimising the likelihood of environmental harm as often as necessary but at least every two years and amended promptly if required.

In accordance with Condition A2-4 of the EA this RMP will be reviewed for effectiveness at least every two years and amended promptly when required.

10 REFERENCES

Barrick Gold of Australia (2008) *Croydon Gold Mine Project – Environmental Management Plan*.

Barrick Gold of Australia (2008a) *Croydon Gold Mine – Plan of Operations*.

Department of Minerals and Energy (1995) *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland*, Queensland Government.

Rehabilitation Monitoring Method

INTRODUCTION

Reclamation monitoring accounts for several mine closure elements including: vegetation establishment, plant community composition, and soil quality / stability that are critical to replacement of a productive post-mine land use. Relinquishment addresses processes, requirements, and milestones that assure stakeholders with a high degree of probability that the reclaimed land will not be problematic to the future “well-being” of the local environment. This document describes the soil surface and reclamation evaluation procedures to be used by Barrick Gold Corporation (Barrick) held mines for monitoring and analysis of reclamation performance in accordance with Barrick’s Environmental Management Systems (EMS). These procedures have been developed in accordance with Barrick’s EMS and Corporate Closure Group in Salt Lake City, Utah, USA. Unless superseded by site-specific permitting requirements, these procedures also support the process leading to eventual financial guarantee or assurance release in accordance with reclamation permit requirements for documentation of successful reclamation. Two important side-benefits of these procedures will be: 1) the timely detection of latent reclamation issues or problems along with recommendations for corrective action, and 2) a standardized means of recording information that will help preclude loss of such information due to staffing changes / turnover.

In this regard, this document details the step-wise procedures for evaluating final reclamation / revegetation of lands disturbed by mining operations under Barrick direction. This document is based on procedures developed in the United States and Australia that concentrate: first, on information control; second, on an evaluation of soils; third, on an evaluation of soil stability; fourth, on performance of revegetation (given that reclamation is designed to return the land to a productive post-mine land use); fifth, on consistent and meaningful reporting; and finally, development of and compliance with release criteria to facilitate relinquishment of any regulatory mandated financial assurances and/or liability. Key to the success of these components is the fifth step providing an effective feedback loop that conveys pertinent and/or corrective information to site managers or their successors. Once reclaimed surfaces have achieved satisfactory results, final bond relinquishment evaluations can then occur. In this regard, this document is divided into six (6) sections that address the aforementioned topics as follows: 1) Organization of existing information; 2) Evaluation of growth media; 3) Site-specific procedures for evaluating soil stability; 4) Site-specific procedures for monitoring reclamation/revegetation; 5) Reporting of findings; and 6) Procedures and criteria for a determination of final reclamation success.

It is the intent of Barrick to establish a reasonable, effective, and statistically defensible program to track the progress of soil stabilization and reclamation on areas generally closed to active mine operations. This program will track progress both during the period of vegetation establishment and development (typically 3 to 5 years after planting) and during the period that follows (after 5 years) until the financial assurance or liability is released. When implemented, this “program” will provide a scientifically defensible means to determine when units of reclaimed land will meet reclamation success criteria and can be identified as “ready for surety and liability release” (releasable). These procedures will also identify those areas, or substantive portions of areas, that are not responding sufficiently to be releasable. This latter point is one of the critical components of the monitoring program. If potentially problematic areas are not identified early in the reclamation process, the costs to Barrick in terms of both time and financial commitment will become excessive. Properly designed monitoring procedures will shed light on potentially problematic areas as well as provide a forum for the determination of corrective measures.

Step 1 Organization of Existing Information

The first step in the overall monitoring process is to collect and organize any and all existing information regarding each unit of currently reclaimed land and then complete an “as-built” sheet for those units. A reclaimed unit (or management unit) consists of a defined area based on management criteria (e.g., areas with common reclamation procedures, initiation times, defined functions such as a waste rock area, or areas with other unique designations or segregation). Often, segregation can be made based on slope, aspect, change of reclamation technique or practice, perceived problem or other informational basis, or based on land use management. Necessary information includes detailed mapping of the “unit(s)”, to document the areal extent of applied procedures with respect to the permit area and all applied reclamation metrics (procedures) as indicated on the “as-built” sheet (illustrated below). Once all currently existing reclaimed units have been documented in this manner, an “as-built” sheet should be completed for each new reclaimed unit forward in time. Copies of “as built” should be maintained in the environmental offices, preferably at multiple locations.

The “as-built” sheet is designed as a “check sheet” to facilitate recording of the most pertinent data from a unit of reclaimed land that may be necessary to facilitate a determination of problematic conditions, or simply to document the reclamation metrics that occurred. This sheet contains places for generic identifying information, person(s) responsible for final reclamation, the size of the area, pertinent physical parameters such as topography, growth media and depth, amendments, soil sample results, live shrub or tree planting information, seed mix and method of application, post-planting treatments, etc., and a place to sketch the unit along with any miscellaneous notes. Given such information, the number of “unknowns” is minimized thereby leading to a more rapid determination of the best reclamation metrics for any given site, or sub-site. Also, such an information base facilitates more rapid isolation of problematic circumstances at any given site or sub-site.

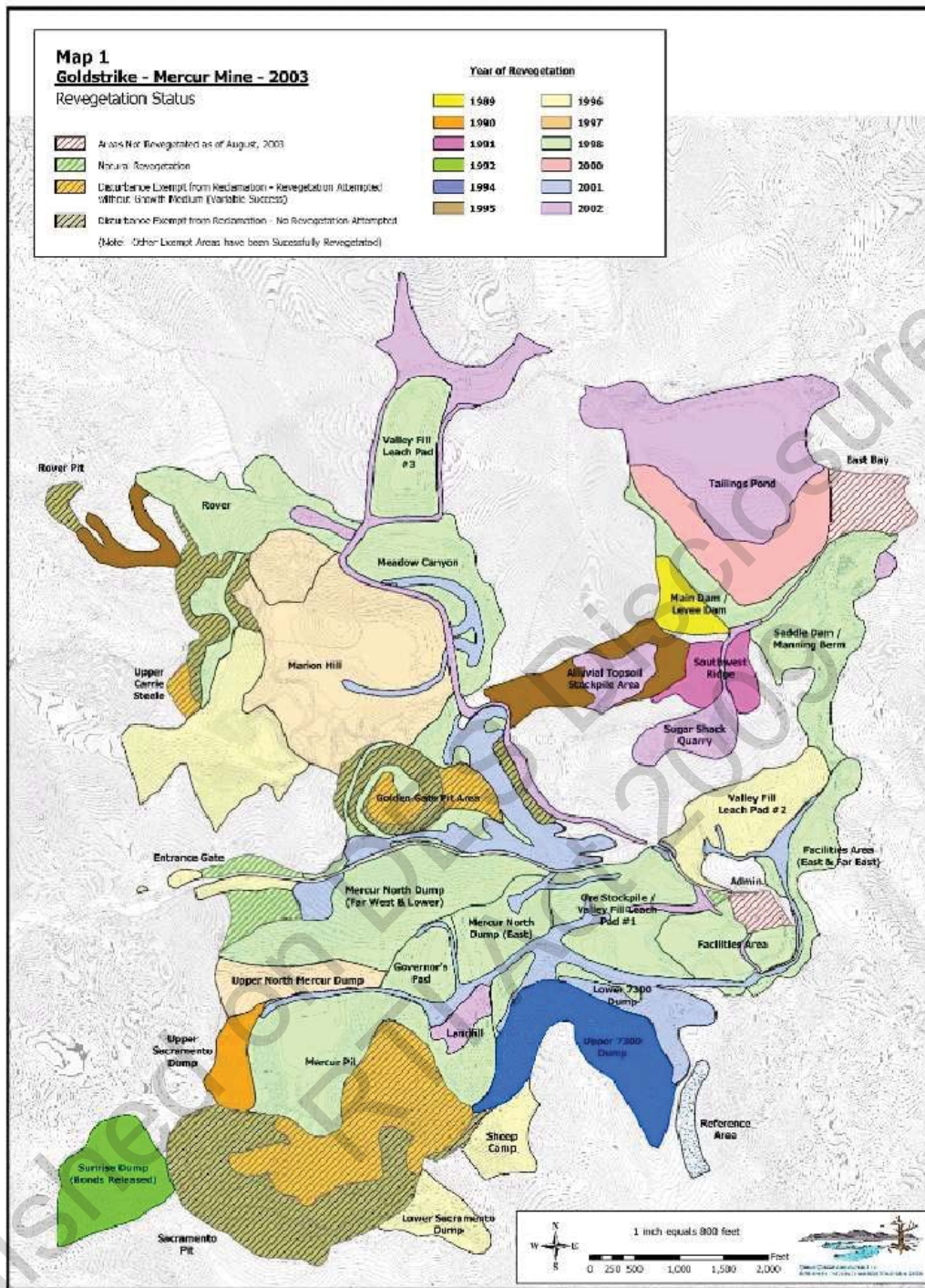
A managerial unit should not be defined too broadly. Eventual sampling will provide detailed findings on the unit and if it has not been defined properly, the utility of resulting information will be compromised. For example, if a unit is defined too broadly and contains multiple growth media types, reseeding mixes, and/or amendments, it will be difficult to isolate problematic or outstanding reclamation components. To the contrary, if a unit is defined too narrowly, monitoring budgets will be excessively high. An example of a reasonable definition would be a waste dump, covered with the same growth media, to approximately the same depth, reseeded with the same mix of species and using the same reclamation metrics, but perhaps across two separate years. In this case, any observed differences between the two years would most likely be related to precipitation and not consequential to the overall program. However, if two different growth media were utilized, segregation of the two units would be appropriate. Similarly, if five different small areas were reclaimed using the same metrics, seed mixes, etc. there would be little need to separate them as five segregate units.

Managerial units should also be represented in two additional summary formats, among others, to assist both mine and corporate management with decision-making. The first of these formats is “spatial” (map) similar to the example provided below as Map 1. Pertinent detail such as the location, relative size, year of reclamation, etc. can be presented in a readily comprehensible format. It would be most helpful to provide such mapping in a digital format, especially using software such as ArcView, but paper copies are valuable as well. The second format is a spreadsheet summary of all reclamation along with pertinent notes and schedules. An example of such a summary is provided as Table RS below where each unit is represented along with the year of reclamation, name of the unit, location and size of each unit, method of reclamation, current status, monitoring schedule, and any additional pertinent notes. When remediation is necessary, such summary information becomes highly valuable.

Reclamation Unit		Unit Code	
Location of Unit:			
Reclamation Supervisor:		Revegetation Contractor:	
		Unit Size: (Ha or Ac)	
Topography:		(yr) Growth Media (GM) / Waste Sample Results	
Aspect:	% Slope:	Parameter	0 - 15 cm 15 - cm Waste
Subsurface Material:		pH	
Regrading Notes:		E. Cond. (µmhos/cm)	
		SAR (µmhos/cm)	
		CEC	
Topsoil:	Yes / No	% Org. Mat.	
Depth of topsoil:	Month/Year of Placement:	ESP (Exch. Sod. %)	
Surface Preparation:		NO ₃ -N (ppm)	
		NH ₄ (ppm)	
Alt. Growth Media:	Yes / No	P (ppm)	
Depth of AGM:	Month/Year of Placement:	K (ppm)	
Surface Preparation:		Potash	
Soil Amendments:		Lime	
How Applied:	Shrub Plantings (Tubelings)	CaCO ₃ (%)	
When:	Method of Application:	Zn (ppm)	
First Pass Included:	Area Applied To:	Fe (ppm)	
Seed Mix / Fertilizer / Mulch / Tackifier	When Applied:	Mn (ppm)	
Second Pass Included:	Species Planted:	Mg (ppm)	
Seed Mix / Fertilizer / Mulch / Tackifier	Total Number	Cu (ppm)	
Fertilizer:		Na (ppm)	
Material Applied		Ca (ppm)	
		Ba (ppm)	
		S (ppm)	
Mulch:		Salt (EC?)	
Material Applied		% Sand	
		% Silt	
		% Clay	
		Texture	
Tackifier:		Other Notes:	
Material Applied			
Seeding / Planting: (PLS = Pure Live Seed)			
Source of Seed Mix:			
Method of Application:			
Mix Name:			
When Applied (Mo/Yr):			
Species Seeded:	Kg or lbs - PLS	Sketch of Reveged Area:	
Total:	0.00		
Post-Planting Treatment:		Page Locator No.	
Surface Treatments:			
Supplemental Fertilizer:			
Other:			

Note: Where unit size options are indicated, circle the correct designation

Reclamation "As Built" Sheet



Demonstration of Spatial Reclamation Data within a Mined Area for Ease of Reference

Demonstration of a Spreadsheet Summary to Track Reclaimed Managerial Units

Table RS (Continued)							Vegetation Monitoring (By Cedar Creek)																	
Year	Treatment Area	Description	Location	Acres	Seeding Method	Status	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1995	AA ₁	West End	AA Tails Dam - South Face	13.1	Hydro	Final		X	X	X	X	X	X	Gone in 2002										
1995	AA ₂	Middle	AA Tails Dam - South Face		Hydro	Final		X	X	X	Remed. in 1998. Gone in 1999													
1995	AA ₃	East End	AA Tails Dam - South Face		Hydro	Final		X	X	X	Remed. in 1998. Gone in 1999													
1995	AB _{1,2}	1 - North End to 3 - South End	AA Tails Dam - West Face	10.0	Hydro	Final		X	X	X	X	X	X	Remed. - See AB 2003										
1995	AC _{1,2}	1 - North End to 3 - South End	Lower Portion of South Block RDA (East Face)	7.3	Broadcast	Final		X	X	X	X	X	X	X	Exchanged to Newmont									
1995	AD _{1,2}	Truck Shop, Crushers, Admin. Bldg and Berms	Main Facilities Area	22.0	Hydro	Final	Most of this revegetation is gone																	
1995	AE	Melkie Bowl Area	Circa - Melkie Mine facilities	0.4	Hydro	Final																		
1995	AF	Melkie North Slope	Circa - Melkie Mine facilities	10.0	Broadcast	Final																		
1996	AG	Dewatering Shop Slope	West of the Guard Shack	0.4	Hydro	Final																		
1996	AH	AA Southwest Area	Northwest of the Guard Shack	0.5	Broadcast	Final								Gone										
1996	AI	Helipad Pad	North Block - SE of Melkie Facilities	7.0	Broadcast	Final							Gone											
1996	AJ	Pipeline Corridor	North of AA Block to No. Block Tailings Imp.	3.0	Hydro	Final			X	X	X	X	X	X										
1996	AK	Containment Pond - 5	Near Pipeline from AA Block to No. Block Tailings Imp.	0.4	Broadcast	Final			X	X	X	X	X	X										
1996	AL	Canyon Road Cut Banks	Access Road By Newmont's Carlin Facilities	10.0	Hydro	Final																		
1997	AM _{1,2}	1 - East End, 2 - West End	Below Pipeline - North Block Tails - S. Dam Face	6.6	Hydro	Interim				X	X	X	X	X	X									
1997	NA	Formerly a portion of N3 - redisturbed	South Melkie Area	7.0	Broadcast	Interim				X	X	X	X	X	X									
1997	AJ	Pipeline Corridor (2nd time)	North of AA Block to No. Block Tailings Imp.	1.5	Hydro	Interim				X	X	X	X	X										
1997	AN ₁₀	Discharge Pipeline/Canal (Upper Pipeline)	Boulder Valley (From TS Reservoir to Humboldt River)	58.0	Broad. & Har.	Final				Vis	X		Visual											
1997	AN ₂₀	Discharge Pipeline/Canal (Canal Area)	Boulder Valley (From TS Reservoir to Humboldt River)	154.0	Broad. & Har.	Final				Vis	X		Visual											
1997	AN ₃₀	Discharge Pipeline/Canal (Lower Pipeline)	Boulder Valley (From TS Reservoir to Humboldt River)	34.0	Broad. & Har.	Final				Vis	X		Visual											
1998	AA ₂	S Face AA Tails Dam (2nd Time)	AA Block, Tailings Facility	5.5	Broad. & Har.	Final					X	Covered by Ore Stockpile in Late 1999												
1998	AA ₃	S Face AA Tails Dam (2nd Time)	AA Block, Tailings Facility		Broad. & Har.	Final					X													
1998	AO _{1,2}	1 - East End to 5 - West End	Above Pipeline - N. Block Tails - S. Dam Face	29.5	Broad. & Har.	Interim				X	X	X	X	X	X	X								
1998	AP _{1,2}	North Face of South Block RDA	South Block Waste Disposal Area	25.0	Broad. & Har.	Final				X	X	X		Mass failure destroyed this area in Fall 2001										
1998	AP _{3,4}	North Face of South Block RDA	South Block Waste Disposal Area		Hydro	Final				X	X	X												
1999	AO _{3,2}	Disturbed areas of AO _{1,2}	Above Pipeline - North Block Tails - South Dam Face	8.0	Broad. & Har.	Interim					X	X	X	Merged with AO _{1,2}										
Jan 2000	AQ _{1,2}	Bell Creek Diversion	North of North Tailings Facility - Bell Creek Diversion	11.0	Hydro	Final					X	X	X	X	Photographic Monitoring									
Dec 2000	AR _{1,2}	1 - West End, 2 - East End (Carlin)	North Breeze - North Face	42.1	Broad. & Har.	Final							X	X	X									
Dec 2000	AR ₃	North Face - Topsoil	North Breeze - North Face	2.7	Broad. & Har.	Final							X	X	X									
Dec 2000	AS _{1,2}	1 - West Face, 2 - South Face (Carlin)	West 9 Dump Area below test plots	20.6	Broad. & Har.	Final							X	X	X	X								
Mar 2001	H _{1,2}	SW Portion - Topsoil	AA Leach Pad	250.0	Broad. & Har.	Final							X	X	X	X	X	X						
Mar 2001	H _{3,4}	Central Portion - Carlin	AA Leach Pad		Broad. & Har.	Final							X	X	X	X	X	X						
Mar 2001	H ₅	North Corner - Topsoil / Carlin Mix	AA Leach Pad		Broad. & Har.	Final							X	X	X	X	X	X						
Fall 2001	AR ₄	Upper N. Face - Middle 1/3 - Carlin	North Breeze	4.9	Broad. & Har.	Final								X	X	X								
Fall 2001	West 9 TPs	Carlin Test plots - Flat	West 9 Dump Area	20.0	Broad. & Har.	Test								Reopened in late 2002										
Dec 2002	AB _{3,4}	1 - North End, 2 - South End (Carlin)	AA Tails Dam - West Face	10.7	Broad. & Har.	Final									X	X	X	X						
Dec 2002	AT _{1,2}	1 - North Face, 2 - West Face (Topsoil)	North Block Tails Dam - Lower Portion	28.3	Broad. & Har.	Final									X	X	X	X						
Dec 2002	AU _{1,2}	1 - SE, 2 - SW, 3 - North Flat (Carlin)	South Block WRDA	15.0	Broad. & Har.	Final									X	X	X	X						
2002	AV	Topsoil Stockpile	SWE - South of Melkie Area along Haul Road	1.8	Broad. & Har.	Interim																		
2002	AX	Topsoil Stockpile	North Block Tails Dam - West Face	4.3	Broad. & Har.	Interim																		
Dec 2002	West 9 TPs	Carlin Test plots - Flat	West 9 Dump Area	20.0	Drill	Test									X	X	X	X						
2003	AY	Carlin - B units	South Block WRDA	89.8	Drill & Broadcast	Final										X	X	X						
2004	AZ	Carlin AZ2 - Topsoil AZ1	North Block Tails Dam - Lower Portion	10.4	Broadcast	Final											X	X						
2004	BA	Carlin	South Block WRDA	15.2	Drill & Broadcast	Final												X	X					

Step 2 Site-Specific Procedures for Evaluating Growth Media on a Managerial Unit of Reclaimed Land and Selection of Reference Areas

2.1 Introduction

Among other factors, successful reclamation is highly dependent upon the quality of growth media and occasionally the underlying material (spoil, tailings, etc.). If a soil has to develop under the conventions of primary succession, desirable vegetation establishment and growth may take many decades if not centuries. To the contrary, if the highest quality locally available growth media is utilized for reclamation, the conventions of secondary succession will be triggered and desirable vegetation establishment and growth will only take a few years. This factor alone will have the greatest impact on closure costs or savings. Occasionally, high quality growth media can be found at depth within overburden materials (e.g., buried alluvium).

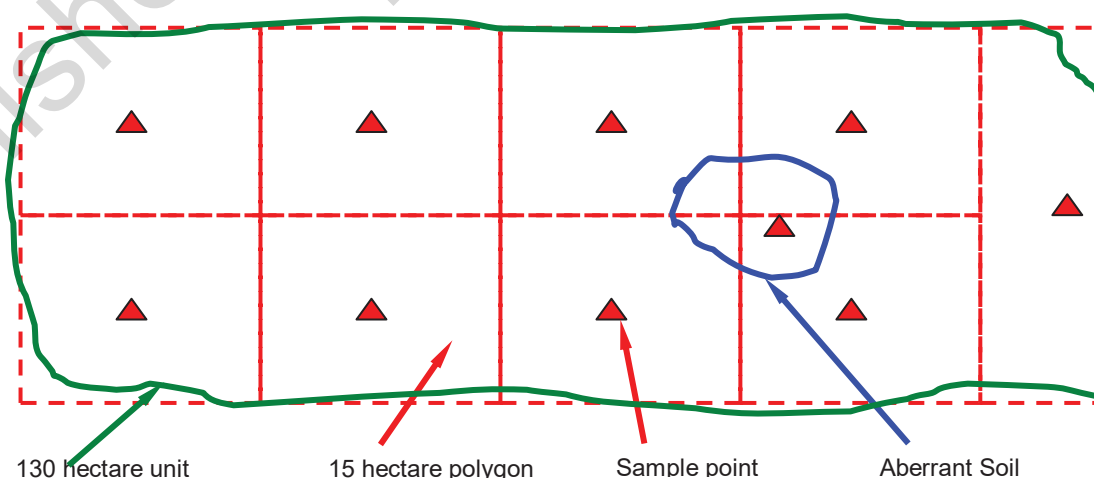
It is strongly recommended that in situ growth media be sampled and evaluated for quality prior to recovery in advance of operations. Furthermore, unless growth media to be used for reclamation is known to be adequate and non-problematic (e.g., from borrow or salvage sources that have already been validated by sampling as acceptable), then reclamation monitoring must necessarily begin with an initial evaluation of the growth media that has been distributed across the surface of a managerial unit of reclaimed land. Such an evaluation would be designed to provide data and information necessary to the development of appropriate reclamation metrics, plans, seed mixes, etc. to optimize opportunities for successful reclamation. This one-time evaluation (unless problematic pockets are found) ideally would occur prior to development of reclamation plans, but lacking such activity must occur immediately following lay-down of the material and prior to any seedbed preparation for a given unit of land.

2.2 Establish a Grid for Soil Sampling

Following lay-down and prior to any seedbed preparation, the placed growth media should be sampled on a systematic basis to determine suitability and/or need for remediation or special procedures. This process would require establishment of a grid and one sample point or composite sample per grid interval (polygon). The size of the grid polygon to be used would be determined based on the overall size of the managerial unit to be reclaimed. A typical minimum grid would be as follows:

- Units 10 hectares or less 1 sample pt. or composite sample per 5 hectare polygon
- Units between 10 and 60 hectares 1 sample pt. or composite sample per 10 hectare polygon
- Units between 60 and 300 hectares 1 sample pt. or composite sample per 15 hectare polygon
- Units larger than 300 hectares 1 sample pt. or composite sample per 20 hectare polygon

In addition to this systematic distribution of sample points, any notable areas of aberrant growth media should be identified and sampled as well. Such areas might include low points that accumulate water, demonstrate salt accumulations, exhibit potential acid generating materials, appear to be comprised of poor-growth media, exhibit excessive coarse fragment levels, etc. An illustration of this grid distribution for soil sampling is presented below along with an area of aberrant material.



Example of a Systematic Grid Distribution for Sampling Growth Media

2.3 Collect Growth Media Samples

At each sample point, a total of 2 or 3 soil samples should be collected from the vertical soil profile (solum). These would correspond to the following depths: one sample from the uppermost 15 cm of material (0 – 15 cm depth); a second sample taken across the range of the lower portion of the applied growth media (below 15 cm but above the underlying waste material); and a third sample taken from below the growth media and within the underlying waste material unless the applied growth media is greater than 60 cm in depth. If the total depth of applied growth media is about 20 cm or less, the second sample can be deleted but the waste material sample is still necessary. If the total amount of applied growth media is less than 15 cm, only the depth of growth media expressed in the profile should be collected for the upper sample (e.g., 0-10 cm for 10 cm depth). If the contact between applied growth media and underlying waste material cannot be determined with certainty, then samples should be collected from the 0 - 15 cm interval, the 15 – 30 cm interval and from the 30 – 60 cm interval or the point of auger refusal (due to rock). Individual samples should be collected across the vertical extent of the interval using a tile spade, auger, or similar instrument and placed within clean heavy-duty polyethylene bags. Each bag should be marked with indelible ink as to the mine name, reclaimed unit, grid polygon number, GPS coordinates, sample depth increment, date, collector, and any other pertinent managerial information. Additional observational data (e.g., soil structure, coarse fragment content from sieving, salt crusting, etc.) should be recorded as well. The total amount of sample material collected from each depth increment should be at least 0.5 liter, or more appropriately 1.0 liter. In addition, the depth increments for all samples / observations should be recorded for each sample site.

Prior to sieving, soil structure of the reapplied growth media should be noted for possible use with the RUSLE evaluation in Step 3. Soil structure is defined as the arrangement of soil particles into aggregates that form structural units. Soil structure can be determined by collecting a small excised sample from the uppermost 10 cm of the exposed soil profile. Careful examination of the soil particles as they are gently reviewed in the hand will result in one of the following four classifications:

- 1) Very fine granular < 1 mm
- 2) Fine granular, 1-2 mm
- 3) Medium to coarse granular, 2-5 mm
- 4) Blocky, platy, or massive, > 5 mm.

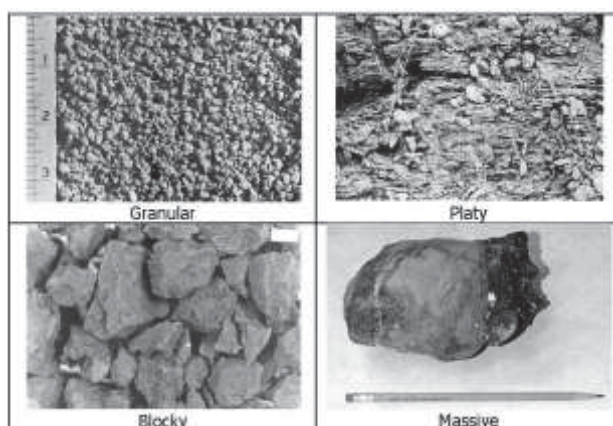
Definitions and photo examples of these terms is as follows:

Granular - This type of structure consists of small, porous aggregates that tend to be somewhat rounded in shape.

Platy - This type of structure consists of aggregates that have longer horizontal faces than vertical faces. The fragments are flat and thin.

Blocky - This type of structure consists of aggregates clinging together in nearly square or angular blocks having sharp edges. Large blocks normally do not allow rapid entry of water into the soil. This condition is mainly found in the subsoil.

Massive - This represents a soil condition where there is no evidence of aggregation. The soil particles tend to stick together in no definite pattern or arrangement.



Following an evaluation of soil structure, samples should be sieved in the field with a screen allowing passage of material less than about 5 mm (~ coarse fragment limitation). Where sieving occurs, the percent of coarse fragment content should be estimated to the nearest 5% or 10% by comparing the two piles of material (sieve passage vs. sieve collected). If $\frac{1}{4}$ of the initial sample volume is retained in the sieve, then coarse fragment content would be recorded as 25%; $\frac{1}{2}$ of the initial sample volume would be recorded as 50%; and so on. This estimate should then be recorded for future analyses and the coarse fragment fraction can be discarded. If the remaining small gravel fragments are excessively sharp (e.g., chert), then the sample should be double bagged to help prevent loss of fines.

Collected samples should then be air-dried before sealing and shipment to a qualified laboratory. Shipment to the lab should occur at the soonest practicable time after collection and drying to avoid degradation of samples or false readings. Variables to be evaluated should include: **pH**, **EC** (for saline soils), either **SAR** or **CEC / ESP** (for potentially sodic soils), **texture** (laboratory method), and basic fertility components (**N**, **P**, **K**, and percent **OM** (organic matter)). **Soil permeability** may also be requested to facilitate classification into one of six categories to aid in the RUSLE analysis. These categories are: 1) Rapid, 2) Moderate to Rapid, 3) Moderate, 4) Slow to moderate, 5) Slow, and 6) Very slow. However, this tends to be an expensive test and an alternate determination of this parameter can be estimated with fair accuracy by evaluating soil texture in conjunction with soil structure (see section 2.4 below). It can also be estimated by performing a "percolation test" in the field. Additional variables as appropriate can include: **carbonates**, **base saturation**, **water saturation percentage**, and **potentially problematic elements** (e.g., selenium, boron, etc.) where such have been indicated as problematic in the region.

If requested, certain laboratories will provide an interpretation of the results with regard to suitability as a growth media. If such an assessment is not available, laboratory results should be reviewed by a soil professional or other professional familiar with parameter ranges necessary for material to service as an adequate growth media. In certain instances, "out-of-bounds" parameters may be compensated by application of amendments (e.g. lime application for low pH soils.). If one or more samples result in overly problematic findings, the target polygon(s) can be sub-sampled using a smaller grid interval to isolate the offending source (assuming the identified problem is sufficiently severe or extensive to warrant the effort). Given these additional data, appropriate remediation can be designed and implemented as necessary with the help of either a soil or reclamation professional. One note of particular importance with regard to amendments is pertinent. If annual weeds are potentially problematic in the vicinity of the operation, amendments containing nitrogen should **NOT** be used, or should be used only under the careful supervision of a qualified professional. (Nitrogen strongly encourages weedy annuals that can then be detrimental to the establishment of desirable plants. Species native to the area are typically well adapted to deal with poor soil fertility.)

In many circumstances, offending or problematic materials can simply be buried under an adequate depth of more conducive material. In other circumstances, especially where surface drainage considerations will be impacted, problematic materials may have to be excavated and transported elsewhere for burial.

2.4 Determination of Permeability

Soil permeability is defined as the rate at which water moves through the soil, and factors affecting soil permeability include; soil compaction, soil structure, and soil texture. As indicated above, a direct determination of soil permeability can be an expensive parameter to measure in a lab, but can be determined in a more practical manner based on less expensive laboratory data using certain guidelines as presented below for selecting a suitable permeability class for reclaimed soils. For the purposes of the RUSLE application (Step 3), permeability will be classified into one of the six classes used in the RUSLE application:

- 1) Rapid
- 2) Moderate to rapid
- 3) Moderate
- 4) Slow to moderate
- 5) Slow
- 6) Very slow

Soil compaction is the first factor to consider. Compaction is typically not an issue on reclaimed soils, unless the land use has caused heavy compaction following soil lay down (such as excessive grazing by large ungulates) or on haulage roads that were not ripped before reclamation activities. Therefore, soil compaction can generally be ignored unless circumstances arise in which severe compaction has occurred. In these circumstances, permeability would be reduced by at least one classification.

Soil structure is the next factor to be considered. Soil structure on mine sites is typically granular, however, sometimes a more developed structure can be observed, especially in older reclaimed areas. If an encountered growth medium can be characterized as having a platy, blocky, or massive structure, it will shift the permeability class downward (slower) by one classification. This is a general guideline and may need to be re-evaluated at the site scale if conditions dictate.

Finally, soil texture is the variable most affecting soil permeability. Lab results from the soil texture analysis will be used in this regard for a determination of soil permeability class. The texture of soils is an indication of the different particle sizes of clay, silt, and sand that greatly impact the rate at which water moves through the profile. The table below demonstrates the permeability of different soil “separates”. However, this table represents each soil separate in its pure form, a condition that effectively does not occur on reclaimed land. Therefore, interpretation of the soil texture analysis is required. For example, if a soil texture analysis indicates that the soil is 70% silt and 30% sand, then the observer would likely classify the soil as moderately slow as opposed to slow. It must be emphasized that these are guidelines for evaluating soil permeability into classes. If aberrant conditions occur, then special considerations should be applied to address those circumstances to facilitate an accurate classification of soil permeability; and/or a professional soil scientist should be consulted¹.

Soil Separate	Particle size Diameter (mm)	Permeability
Clay	Below 0.0002	Very slow
Silt	0.05-0.002	Slow
Very fine sand	0.10-0.05	Moderately slow
Fine sand	0.25-0.10	Moderate
Medium sand	0.5-0.25	Moderately rapid
Coarse sand	>0.5	Rapid

2.5 Selection of Reference Areas

Although it may seem to be out of sequence, the selection of reference areas must necessarily occur very early in the reclamation process and certainly before stability and / or vegetation evaluations are implemented. Therefore, this discussion is placed here to emphasize that the selection of appropriate reference areas should occur at this time in the process.

Reference areas may also be termed “analog” areas or “comparison” areas, but effectively the three terms should be considered synonymous. The selection of reference areas must occur with great care and should be performed by a well-experienced reclamation specialist. Reference areas should be selected from undisturbed (by mining operations) and representative examples of local vegetation communities and physical topography that support the land use that is the target of post-mining reclamation. If the selected reference areas exhibit excessive or dense vegetation in comparison to the norm for the area, then the standard will be artificially elevated. If the selected reference areas exhibit overly sparse or disclimactic vegetation in comparison to the norm for the area, then the standard will be artificially reduced and the potential for acceptance by oversight agencies will be compromised.

At least one reference area should be selected for each separate reclaimed vegetation community that targets a specific land use. For example, if the post-mining land use (PMLU) includes grazingland for livestock on rolling topography, then a reference area should be established on rolling topography that supports palatable native grasslands. If the PMLU is heavily managed livestock grazing (pasture-rotation, etc.), then a reference area should be established on a unit of “managed pastureland”. If the post-mining land use includes wildlife habitat or open (undeveloped) rangeland (wildland), then a reference area should be established in an area supporting native grassland / shrub steppe communities (or similar), which tend to be the early seral stages of the eventual desirable community. In this latter case, care must be taken to avoid reference areas that exhibit overly disclimactic or dense stands of shrubs and trees as these life forms often take decades to mature and/or evolve (hence the need for an early seral equivalent).

The selected reference area(s) should be as “ecologically and topographically similar” to the pre-mining area, surrounding area, or area representing the desired PMLU as possible, and be based on five main considerations, as follows:

1. The reference areas should be representative of the desired PMLU or vegetation community supporting the PMLU.

¹ This procedure for collecting information on soil permeability is based on general guidelines and should be considered for adaptive development. Improvements to the protocol should be implemented on a regular basis to further refine and develop the accuracy and use of these guidelines.

2. The reference areas should occupy topography and aspects that are representative of the majority of reclaimed areas, especially with regard to slopes that may be subject to erosion.
3. The reference areas should exhibit similar physical soil conditions as reclaimed areas and therefore, should be an “approximate ecological equivalent”.
4. Excepting managed pasturelands and/or occasional invasive weeds, the reference areas should support native tree/shrub/grass plant communities similar in structure to what can be obtained on reclaimed areas in the short term (e.g. 5 – 8 years).
5. The plant communities selected for comparison should provide an appropriate and logical target for reclamation efforts.

Once reference areas have been selected, adequately sampled, and found to be appropriate by Barrick and/or their reclamation consultants, they should be submitted for approval to oversight agencies as appropriate. A field review of the selected reference areas should then be scheduled with the oversight agencies at the earliest opportunity to obtain “formal” approval. However, it is recommended that site reviews of reference areas (as well as reclaimed areas up for bond / liability relinquishment) be scheduled during the late Spring / early Summer to avoid the visual complications of litter and standing dead vegetation.

Step 3 Site-Specific Procedures for Evaluating Soil Stability

3.1 Introduction

Following Step 2, evaluations of soil stability should occur to document this parameter and collect data necessary for remediation or relinquishment. Two types of monitoring will occur for this variable, one that can be used to show trend and provide insight regarding problematic circumstances and a second that will provide increased defensibility, especially for relinquishment evaluations.

The first type of monitoring (trend) will occur coincidentally with vegetation monitoring and will be co-located with vegetation transects. Such annual monitoring is designed to provide easily collected data that can be used to show erosional stabilization trends or lack thereof as well as provide information that will indicate solutions for problematic circumstances.

The second type of monitoring (two options possible) is designed to detect problems related to relinquishment as well as to provide for a means to document erosional stability and therefore, facilitate bond relinquishment and liability release. Depending on site-specific circumstances or local preferences, the two options that could be selected are 1) Landscape Function Analysis (LFA) and 2) the Revised Universal Soil Loss Equation (RUSLE).

The annual use of LFA procedures (only the portion that addresses soil stability) or RUSLE are encouraged until site-specific data are developed that will help to shed light on the efficacy of emplaced growth media with regard to erosion / stability issues. If latent soil or stability issues remain a potential concern (following Step 2 work on soils and in association with the erosional trend monitoring), then implementation of either LFA or RUSLE procedures should continue to help determine any necessary remediation and/or help to show that stability is progressing in a positive direction where proof of such may be necessary.

The first option is an evaluation of soil stability utilizing a subset of the LFA procedure that was developed in Australia. The subset of this procedure would typically be used only in the first 2 to 4 years after seeding and would be subsequently abandoned once adequate vegetation had established to warrant implementation of Step 4. If proof of stability is then necessary for regulatory compliance or relinquishment at a later date, the necessary data will have been collected to facilitate appropriate calculations.

The second option will be an evaluation of soil stability utilizing RUSLE procedures developed over the last 6 decades in the USA, specifically version 1.06c designed for construction and mining disturbances. This procedure utilizes the most pertinent and applicable site-specific information to perform a reliable and cost-effective evaluation of erosional stability across the most potentially problematic portions of a reclaimed unit. Most of the input parameters are very easy to collect, or in many cases, are collected during other field monitoring procedures and can be used for both applications.

If option two is selected for use, documentation of soil stability need only occur at the time of bond relinquishment sampling unless stability issues are detected during interim periods. If stability issues arise, option two should be implemented annually to provide necessary data for the development of remedial measures.

3.2 Erosion Monitoring for Trend Analysis

Trend monitoring for erosional stability will be comprised of two observational procedures, one that is co-located with each vegetation sampling transect (Step 4) and one that is established and monitored independently. The first of these annual monitoring procedures (co-located with each vegetation monitoring transect) will be comprised of a ten-meter transect extended along the contour and starting at the vegetation transect starting point. Along this transect, all rills and gullies that cross the transect will be enumerated and data about each recorded. Data to be collected for all observed rills and gullies include: width (in cm), depth (in cm), current status ("active", "healing", or "indeterminate"), and if "healing", the evidence so indicating. Such evidence may include: caving sidewalls, deposition within the channel of small fraction sediments, litter accumulation, and/or plant establishment within the cross-section. In addition, the percent slope will be recorded perpendicular to the contour.

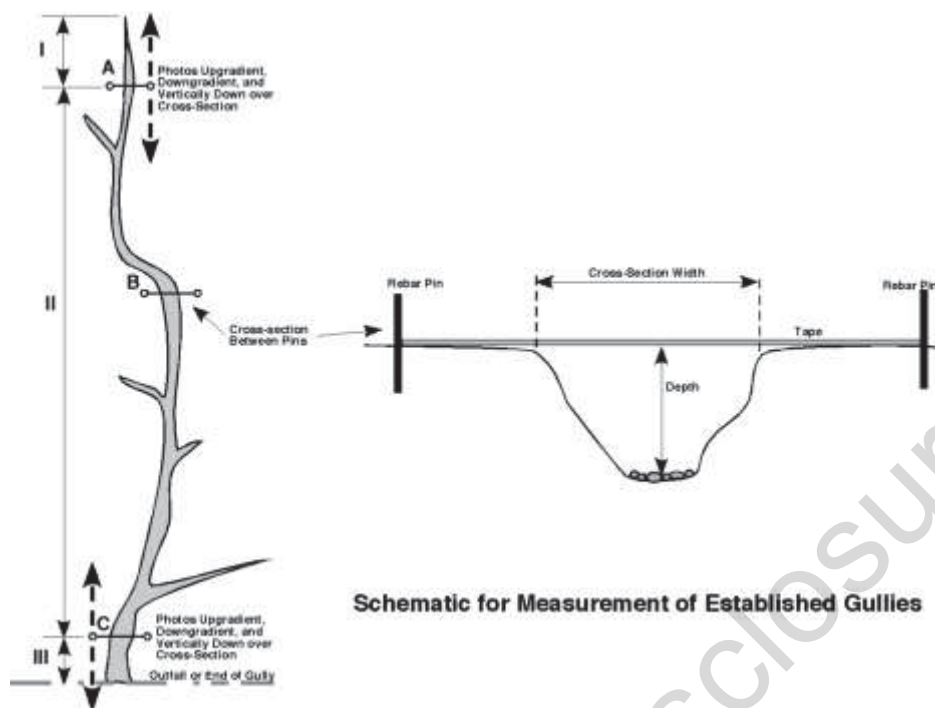
When compared over time and coupled with rock, litter, and vegetation cover data from the vegetation transect, this information will provide a strong indication of trend and factors contributing to erosional progression or stabilization. An analysis of such data will aid determination of corrective measures necessary to stabilize the soil surface or to preclude such problems by correct construction techniques for future facilities. Corrective measures may include: reduced slope angle; increased surficial rock cover (rock mulch); increased vegetation cover; need for mechanical techniques such as contour furrowing, pitting, etc.; or need for improved surface water control measures such as berms, benches, reinforced water courses, etc. Although the need for such measures may fall under the category of "common sense", the threshold at which they become necessary given site-specific circumstances is typically an unknown without such empirical data.

The second erosional observation procedure to be utilized is independent of the vegetation monitoring transects. This procedure should be used in arid environments where episodic precipitation following soil lay-down leads to gully formation before vegetation can become established (e.g. Western Australia). Once formed, regardless of "healing status", these gullies can become the focus of regulatory scrutiny. Without trend information, there is little opportunity to counter "negative opinion" without expensive mitigation.

In this regard and depending on the size and revegetated status of a target reclaimed unit, one to several gullies should be located (following an episodic event), permanently marked, and monitored once per year. If a reclaimed unit vegetates quickly and gully formation does not occur, this procedure can be omitted. To the contrary, where revegetation is slower and gullies do form early in the revegetation sequence, the following minimum number of gullies should be identified for monitoring.

- 1 gully per 10 hectares up to units 40 hectares in size;
- Units 40 to 100 hectares – 5 to 6 gullies should be identified for monitoring;
- Units larger than 100 hectares – 7 to 8 gullies should be identified for monitoring.

Once gullies are located and permanently marked in the field (including GPS coordinates), the slope (percent) should be recorded and three sets of cross-sections (A, B, & C) need to be established as indicated in the schematic below:



Schematic for Measurement of Established Gullies

The endpoints of each cross-section should be permanently marked with a length of rebar driven into the ground sufficiently distant from the edge of the gully to allow for possible changes with time (at least 0.5 meter from either edge should be sufficient for most gullies). A tape stretched across the gully as indicated in the schematic will facilitate a determination of width and depth at each location. Any other pertinent observations such as healing and the evidence thereof, should also be recorded at this time. Such evidence may include: caving sidewalls, deposition within the channel of small fraction sediments, litter accumulation, and/or plants establishing within the cross-section.

In addition, at cross-sections A and C, three photos should be exposed, one upgradient, one downgradient, and the third vertically downward over the gully from a height of about 1.5 meters. Finally, three linear distances represented by lengths I, II, and III should be recorded. The linear distance from the start of the gully to cross-section A (I) is the most likely distance to change from year to year. The distance from A to C (II) should not change, and the distance from C to the end of the gully (III) may change if the gully extends downgradient. If the gully is tributary to a collection ditch, mid-slope bench, or some other similar structure, this final distance may remain constant as well.

Special care must be taken during the collection of these measurements and photos to not step near the edge of the gully and cause the sides to collapse, especially in the vicinity of the cross-sections. Such action will adversely impact future measurements or conclusions drawn. Assuming such annual monitoring can indicate that early reclamation formed gullies tend to heal rather than remain active as vegetation establishes, then the "proof" will be available to counter negative opinion.

3.3 Erosion Monitoring for Relinquishment - Option 1 - Soil Stability Monitoring Using LFA Procedures

When using LFA procedures, use would be limited to the first few years of reclamation for a given managerial unit until sufficient vegetation has emerged to warrant the shift to vegetation monitoring and RUSLE monitoring procedures (Option 2). In most cases, LFA protocols would be implemented for a period of 2 years following seeding. If proof of increasing stability is necessary to address agency mandates or concerns LFA protocols could continue to be implemented for another 2 years coincidentally with vegetation monitoring protocols to lay the groundwork needed to document increasing stability. Another circumstance where LFA protocols would be extended for more than 2 years is where precipitation events are so intermittent or minimal that plant emergence from seed is delayed.

Finally, LFA procedures may be implemented where there is regulatory need. An example of such need would be at the time of final relinquishment on a unit of land to document (in comparison to early LFA data) that stability has been achieved.

3.3.1 Soil Stability Using Landscape Function Analysis (LFA) Procedures

Landscape Function Analysis is a procedure for the assessment of rangeland function, and is comprised of three components: a conceptual framework, a field methodology, and an interpretive framework. The conceptual framework treats landscapes as systems: defining how landscapes work in terms of sequences of processes regulating the availability of scarce resources. The field methodology uses "indicators" at landscape and patch scale to provide and structure information to satisfy the needs of the conceptual framework. The interpretational framework provides a process to identify critical thresholds in landscape function and thus provide a function-based state and transition landscape assessment.

This procedure has largely been developed by Mr. David Tongway in conjunction with the Commonwealth Scientific and Industrial Research Organisation (CSIRO) of Australia. LFA evaluates soil surface data that are combined in different groupings to reflect three major soil habitat quality indices: stability, infiltration, and nutrient cycling. However, for the purposes of this procedure, stability will be the only index addressed because if a system is stable and is exhibiting reasonably desirable vegetation, the other two parameters (infiltration and nutrient cycling) can be assumed to be occurring. Soil surface data included in stability are soil cover, litter cover, cryptogam cover, crust brokenness, erosion type & severity, deposited materials, surface resistance to disturbance, and a slake test. David Tongway and CSIRO have provided a succinct summary of Landscape Function Analysis (Tongway, 2005), much of which is presented below. In addition, a field methodology developed by Tongway and CSIRO is presented as Appendix B.

3.3.1.1 LFA – Method of Operation.

"Landscape organization" is the coarsest form of LFA data and is the first step in data collection. Data are collected on a line transect oriented in the direction of resource flow (usually down slope, but aeolian landscapes would use wind direction). Landscape features that interrupt, divert or absorb run-off and transported materials are recorded according to protocols outlined in the technical methods manual (Tongway 1994, Tongway and Hindley 1995, 2000) and the field methodology (Appendix B). Typically, zones of resource loss (source or runoff zones) are distinguished from zones of resource gain (sink or run-on zones) and their relative sizes are measured. Several indices of landscape organization can be deduced from these data. In addition, these data provide a "map" of the transect. In the second step, each zone type, a total of 10 soil surface variables, plus soil texture are assessed using the methods described in the manuals. These observations are both simple and quick after a little practice, but training from someone competent in the technique is necessary for reliable data.

3.3.1.2 LFA – Calculation of Indices.

The collected soil surface data are grouped in different combinations to reflect three major soil habitat quality indices: 1) stability or resistance to erosion, 2) infiltration/water holding capacity and 3) nutrient cycling (Figure 1). However, as stated previously, the stability index is the most useful and the only index needed for this application. Collected soil surface data are entered into pre-formatted Excel spreadsheets that generate final values that can then be interpreted (interpretive framework).

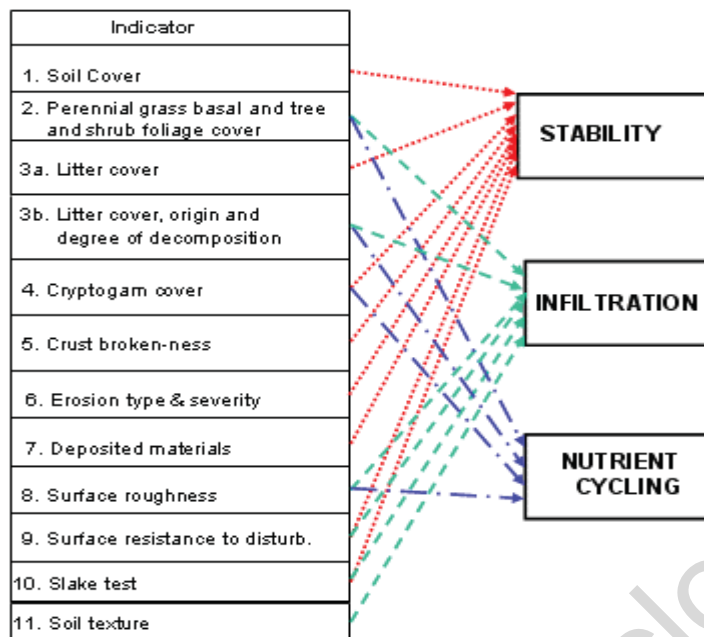


Figure 1: The combination of Soil Condition Classes to derive indices of Stability, Infiltration, and Nutrient Cycling.

3.3.1.3 LFA – Interpretational Framework.

The tabulated values need to be interpreted in the landscape context to make the most use of their information potential. With extensive experience, one might be able to place useful interpretations on each of the index values, but this is a complicated process. The most recent development in LFA is the process whereby a response surface in the form of a sigmoid curve is generated from field data (Tongway and Hindley 2000). The curve relates functional status with regard to stress and disturbance. To fit this curve, one needs data from both extremes of the available data space. The response surface (Figure 2) recognizes the upper asymptote as the potential (reference area) of the site limited by climate and parent material and the lower asymptote as the lower limit of function typically observed under first year reclamation conditions.

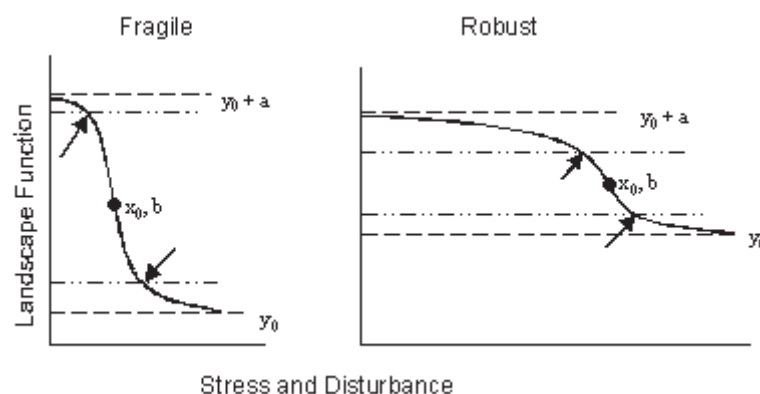


Figure 2. Examples of response curves for fragile and robust landscapes.

3.3.2 Use of Landscape Function Analysis for Success Evaluation

Landscape Function Analysis will be used for success evaluation in its typical form. The potential of the site will be established by selecting a reference area as indicated in Step 2 and obtaining data from that area. Once the reference area has been selected and deemed appropriate, then soil stability using LFA should be implemented with two transects placed in representative areas. The value obtained from these transects will be considered the goal of reclamation and the potential of the reclamation site.

The starting point (the lower asymptote as presented on Figure 2 above) should be represented by reclamation immediately after topsoiling. LFA should be implemented on a new unit of reclamation with at least two transects placed in representative areas to establish a time-0 value (t_0). Once these values have been defined, they can be fit to a sigmoid curve with each value at one of the extremes, t_0 at the bottom and the reference area at the top.

The inflection point of the sigmoid curve (represented as X_0 on Figure 2) can be calculated as approximately one-half of the difference between the two calculated LFA values (t_0 and Reference Area). A value slightly greater than this inflection point will be set as the standard or minimally acceptable level of soil stability. Monitoring of the same transects established at t_0 on a reclamation unit will provide progression along the sigmoid curve in relation to the standard. Once a unit of reclamation has passed the inflection point, it can be considered to be heading towards the potential of the site (reference area). **Therefore, the standard will be met if the soil stability index value determined by LFA for the reclaimed unit is greater than the calculated inflection point on the sigmoid curve.**

3.4 Erosion Monitoring for Relinquishment - Option 2 - Soil Stability Monitoring Using RUSLE Procedures

The RUSLE protocol will be used to determine whether the potential for soil erosion is sufficiently low, and for surface stability sufficiently high, to conclude that stability has been achieved. This protocol employs site-specific climatic, edaphic, topographic, and vegetation data to identify erosion potential. For practical use of this procedure, it must be applied after growth media characterization (Step 2) has been completed and in conjunction with vegetation monitoring (Step 4).

3.4.1 Background

Efforts to predict soil erosion from croplands mathematically were initiated in the USA approximately 60 years ago. A variety of factors were considered in attempting to develop prediction equations. All of these earlier equations were essentially regional in nature and were applicable only under limited climatic/edaphic conditions. These equations were considered useful, however, and an effort was initiated to develop an equation that would be applicable nationally under a variety of site conditions.

Work on this was begun in the mid-1950's by the Agricultural Research Service. From this work the Universal Soil Loss Equation (USLE) was developed and refined during the 1960's and 1970's. Continued refinements were made to the equation and the associated parameters based on site-specific research and general use by the public. Additional data was continually gathered in an effort to update the equation and make it more useful (Renard et al. 1992).

Based on this additional data and refinement, the RUSLE equation was developed. Though still influenced by basic agronomic values in some instances, and using the same overall parameters as the USLE, the RUSLE equation is considered to be a significant step forward in more accurately predicting the potential for erosion under a variety of conditions. Where the original USLE arrived at a potential soil erosion value through simple multiplication of selected parameter values, the RUSLE employs a computer-based model that involves sub-routines for various parameters to ultimately predict potential soil erosion.

Revisions and improvements in assessing values for the parameters that are used in RUSLE have also been made which render the model more useful. Once believed applicable only to agronomic situations, RUSLE is now considered to be applicable to disturbed lands and mine sites as well. A RUSLE application was developed specifically for use on mining reclamation (RUSLE 1.06c).

3.4.2 Application

RUSLE 1.06c is a powerful program that is capable of predicting soil loss from fields or hillslopes that have been subjected to a full spectrum of land manipulation and reclamation activities. RUSLE 1.06c can accommodate undisturbed soil, spoil, and soil-substitute material (growth medium), percent rock cover, random surface roughness, mulches, vegetation types, and mechanical equipment effects on soil roughness, hillslope shape, and surface manipulation including contour furrows, terraces, and strips of close-growing vegetation and buffers.

Though a reasonably advanced tool, it should be noted that there are limits with respect to the applicability of the model. This model predicts erosion potential as a result of sheet, rill, and inter-rill erosion. Gully erosion is not a part of the predicative capability of RUSLE. Where gully erosion may occur, the bearing that this type of erosion would have on soil stability must be judged independently. RUSLE also does not, in and of itself, predict potential sedimentation. Soil loss is predicted, but not the eventual fate of the eroded material. RUSLE is a predictive model and must be used as such in the comparative sense against values that exhibit the same level of potential accuracy. This is the intent of the application of this model as a part of the overall reclamation success protocol discussed in this document.

The RUSLE model is based on six parameters utilized to estimate or quantify the factors that affect the potential for soil erosion. The RUSLE model is as follows (Renard et al. 1992):

$$A = R \cdot K \cdot L \cdot S \cdot C \cdot P$$

Where:

A = Soil loss in tons / acre / year

R = Rainfall/runoff erosivity factor

K = Soil erodibility factor

LS = Hillslope length and steepness factors (combined as one)

C = Cover-management factor

P = Support practice factor

"R" represents the rainfall-runoff erosivity factor. The effects that climate, in terms of amount of incident precipitation, storm intensity, etc. have on erosion are accounted for by this factor. Values for this factor are developed using site-specific climatic data. Data needs for calculating the "R" factor in RUSLE 1.06c are presented by collection location.

Office Data Collection:

Site-Specific Climatic Data - Local monthly precipitation (in inches) and temperature (°F) data must be collected from either an onsite weather station or available internet resources for areas with published data that are in close proximity to the site. Larger data sets with a longer period of record will increase the accuracy of the soil loss prediction. Ideally, 30 years of monthly precipitation and temperature data will provide a strong data set. Data must be compiled by a qualified professional for entry into the RUSLE application. At present, data inputs must be in English units as opposed to Metric owing to the model's input requirements.

Field Data Collection:

None – other than from site-specific meteorological station.

The "K", or soil erodibility, factor is related to the integrated effect of rainfall, runoff, and infiltration on soil loss. It is typically considered to be the soil loss rate/unit for a specified soil as measured on a standard plot experimentally. K-factors to be used for this protocol may be taken from a standard nomograph developed for this purpose (NRCS 1993) since the surface growth medium may not directly correspond to any recognized soil series. The factors to be considered in developing the appropriate K-factor are texture, percent organic matter, soil structure, and permeability. Data needs for calculating the "K" factor in RUSLE 1.06c are presented by collection location.

Office Data Collection:

None, unless a detailed soil survey has been completed for the project area and the soil utilized for the target location can be correlated to that survey.

Field Data Collection:

Soil Texture (% sand, % silt, and % clay)

Collected as part of the growth media analysis described in Step 2. All samples collected in the growth media analysis are averaged to allow for one set of values to be entered into the RUSLE application.

Soil Organic Matter (%)

Collected as part of the growth media analysis described in Step 2. All samples collected in the growth media analysis are averaged to allow for one value to be entered into the RUSLE application.

Soil Structure

Soil structure is defined as the arrangement of soil particles into aggregates that form structural units. Collected as part of the growth media analysis described in Step 2. For the purposes of the RUSLE application soil structure is classified into one of four classes:

- 1) Very fine granular, <1 mm
- 2) Fine granular, 1-2 mm
- 3) Medium to coarse granular, 2-5 mm
- 4) Blocky, platy, or massive, >5 mm

Soil Permeability

Soil permeability is defined as the rate at which water moves through the soil and is strongly correlated with the soil texture that is collected as part of the growth media analysis described in Step 2. For the purposes of the RUSLE application permeability will be classified into one of six classes used in the RUSLE application as described elsewhere in this document: 1) Rapid, 2) Moderate to Rapid, 3) Moderate, 4) Slow to Moderate, 5) Slow, 6) Very Slow.

Percent Rock

Percent of the surface covered by rock (>5mm), collected as part of the vegetation monitoring protocol described in Steps 4 and 6. An average across the entire unit will be used to allow for one value to be entered into the RUSLE application.

Slope length (**L**) and gradient (**S**) will be combined into one factor using charts developed for this purpose. Data have shown that this method offers the best means of integrating the effects of these two factors into the equation. Slope length accounts for the effect topography has on erosion potential. Lengths should be measured in the field to supply the correct data for the L-factor and compound slopes will be defined if existing. Slope steepness, or gradient, measured as a percent, is a representation of the slope and will also typically be determined in the field to supply the most relevant data. Slope lengths and percents may also be taken from post-reclamation contour maps if the maps accurately represent site conditions. Data needs for calculating the "**LS**" factor in RUSLE 1.06c are presented by collection location.

Office Data Collection:

None - unless data are taken from detailed and accurate "as built" of reclamation features.

Field Data Collection:

Slope length (in feet) and gradient (%) should be measured in the field. The slope should be divided into segments in such a way that each segment can be considered uniform. A measuring tape or similar should be used to determine the length of each segment and a clinometer to measure the gradient (in percent or degrees but if in degrees must be converted to percent). This process should be executed on what is perceived as an average slope on the reclamation unit following an extended reconnaissance effort. The selected slope must be representative of the slopes and lengths found on the unit.

Alternately, at least five typical slopes should be measured as described above and then averaged. If one particular area exhibits excessive slope gradient or length, it may be isolated and separately analyzed to determine erosional stability.

The cover-management factor (**C**) reflects the effect of vegetation and related management practices on erosion rates. This factor will be based largely on site-specific data collected from, or which is estimated to be relevant to, each area for which reclamation success is being evaluated. The type of vegetation currently existing on site, estimated soil roughness, measured soil surface percent cover (vegetation, coarse fragments, litter, other non-erodible material) and height, measured plant canopy cover, and estimated below-ground plant biomass factors will all be used to develop the C-factor using a computer program sub-routine run. This factor may be the most influential factor in determining potential erosion from a site. Data needs for calculating the “**C**” factor in RUSLE 1.06c are presented by collection location.

Office Data Collection:

Effective root mass in the top 4 inches will be based on published life form ratios. Life form ratios will be separated by grasses, forbs, shrubs, trees, etc. The ratio of biomass to percent surface cover will be gathered from scientific literature and then weighted based on canopy cover for entry into the RUSLE application. Occasional circumstances may occur where a dominant plant does not fit into a typical life form. In such circumstances it can be researched separately and treated on an individual basis.

Field Data Collection:

% Canopy Cover

Canopy cover is the vegetative cover above the soil surface that intercepts raindrops (but does not contact the soil surface). Open spaces in a canopy, whether within the perimeter of a plant canopy or between adjacent plants, are not considered as canopy. It is for this reason, among others, that ground cover data are collected with point-intercept techniques as opposed to other techniques. These data are collected during the vegetation monitoring (Steps 4 and 6).

Average Fall Height (in feet)

Defined as the height within the canopy from which intercepted rain drops re-form into water droplets and fall to the ground; this fall distance is known as the "effective fall height." In plant communities that have more than one type of life form composing the canopy, such as on rangeland with a mixture of grasses, shrubs, and trees, a fall height should be determined for each life form. Collected as part of the vegetation monitoring protocol described in Steps 4 and 6. These fall heights will then be weighted using the canopy cover to establish an average fall height for entry into the RUSLE application.

Total % Ground (Basal) Cover (Rock and Litter)

Basal cover is material in contact with the soil that both intercepts raindrops and slows surface runoff. It includes all types of cover, such as mulches and rock fragments, live vegetation in contact with the soil surface, cryptogamic crusts (which are formed by mosses or fungi in the soil), and plant litter. Collected as part of the vegetation monitoring protocol described in Steps 4 and 6.

% Rock Cover

Collected as part of the vegetation monitoring protocol described in Steps 4 and 6. An average across the entire unit will be used to allow for one value to be entered into the RUSLE application.

% Plant Litter Surface Cover

Collected as part of the vegetation monitoring protocol described in Steps 4 and 6. An average across the entire unit will be used to allow for one value to be entered into the RUSLE application.

The “**P**”, or support practice, factor takes into account the effects of mechanical practices applied to the surface of the growth medium to increase infiltration, reduce runoff, and decrease erosion. Such practices include ripping, pitting, and contour furrowing and result in a parameter value of less than 1.0. A value of 1.0 may be appropriate where no support practices have been employed on the reclaimed area. The effects that basic tillage or fertility practices have on erosion potential are included in the cover management factor of the equation. Data needs for calculating the “**P**” factor in RUSLE 1.06c are presented by collection location.

Office Data Collection:

Gather information on reclamation activities such as contour furrowing and terracing from reclamation records (“as built”).

Field Data Collection:

Make observations regarding procedures that may have been implemented should there be no file data available as to past practices.

Following data collection and parameter development, the RUSLE model will be engaged for each area requiring an evaluation. Implementation of the RUSLE model on reclamation units will occur as an average of the entire unit². A potential soil erosion value "A" in tons/acre/year of growth medium loss will be estimated by the model. This value can then be compared to any one of three options (A, B, or C) for success evaluation:

A) The standard will be met if the soil loss value (A) determined by RUSLE for the reclaimed unit is equal to or less than the "T" value (effectively the soil genesis rate) appropriate to the site and the "trend" analysis detailed in Section 3.2 indicates stable or positive results.

The "T" value will be assigned independently based on the limiting properties of the subsurface growth medium and/or geologic material present beneath the reclaimed units. Criteria for assigning a "T" value include the physical and chemical characteristics of subsurface layers and the properties of soil moisture and temperature as influenced by climate. This process accounts for the weatherability and suitability as a growth medium of the subsurface materials (i.e. rate of genesis of suitable sub-soils). A soil scientist can be consulted to help calculate or determine the "T" values for the types of reclaimed sites to be evaluated if they are not already available in the literature or public domain.

In lay terms, the "T" value approximates the rate of soil genesis (tons/acre/year). If the potential loss of growth medium as predicted by the model ("A") is less than or equal to the "T" value, the area will be considered stable and the test passed. If the potential loss ("A") is greater than the "T" value, the area will not be considered sufficiently stable and the area will fail the success test. The addition of the need for a "stable" or "positive" trend from the analysis in Section 3.2 addresses the fact that RUSLE does not account for gully erosion.

B) The standard will be met if the soil loss value determined by RUSLE for the reclaimed unit is less than 110%³ of an established soil loss baseline value determined by RUSLE for the mine area (prior to disturbance) and the "trend" analysis detailed in Section 3.2 indicates stable or positive results.

A baseline value (A_B) will be determined by implementing RUSLE using data from the baseline soil survey (prior to mining disturbance). This method accounts for site-specific conditions including similar vegetation type, growth media, and climate.

In effect, the baseline " A_B " value approximates the rate of soil loss on the ground before mining disturbance. If the potential loss of a reclamation unit as predicted by the model ("A") is less than 110% of the baseline " A_B " value, the area will be considered stable and the test passed. If the potential loss is greater than 110% the baseline " A_B " value, the area will not be considered sufficiently stable and the area will fail the success test. The addition of the need for a "stable" or "positive" trend from the analysis in Section 3.2 addresses the fact that RUSLE does not account for gully erosion.

C) The standard will be met if the soil loss value determined by RUSLE for the reclaimed unit is less than 110%* of a soil loss value from a reference (analog) area as determined by RUSLE and the "trend" analysis detailed in Section 3.2 indicates stable or positive results.

The reference value (A_{RA}) will be collected from a reference (analog) area in the same year as the reclamation unit sampled for comparison. The selected reference area(s) should be as "ecologically and topographically similar" to the pre-mining area, surrounding area, or area representing the desired post-mining land use (PMLU) as possible, and be based on five main considerations, as follows:

² When applied in this manner this methodology does not account for small or isolated areas of potential reclamation failure. These areas must be identified and addressed separately by onsite personnel, or they can become individual units subject to investigation using the overall procedure.

*Given the vagaries of biotic and edaphic systems, the vast majority of regulatory agencies have allowed a modest level of flexibility when comparing reclamation to native or undisturbed lands. In the more restrictive circumstances, this flexibility has been limited to a 10% variance.

Rel

- The reference area(s) should be representative of the desired PMLU or vegetation community supporting the PMLU.
- The reference areas should occupy topography (slope) and aspects that are representative of the majority of reclaimed areas.
- The reference areas should exhibit similar physical soil conditions as reclaimed areas and therefore, should be an “approximate ecological equivalent”.
- Excepting managed pasturelands and/or occasional invasive weeds, the reference areas should support native tree/shrub/grass plant communities similar in structure to what can be obtained on reclaimed areas in the short term (e.g. 5 – 8 years).
- The plant communities selected for comparison should provide an appropriate and logical target for reclamation efforts.

The reference “ A_{RA} ” value approximates the rate of soil loss on a selected reference area adjacent to the mining disturbance. If the potential soil loss from a reclamation unit as predicted by the model (“A”) is less than 110% of the reference “ A_{RA} ” value, the area will be considered stable and the test passed. If the potential loss is greater than 110% the reference “ A_{RA} ” value, the area will not be considered sufficiently stable and the area will fail the success test. The addition of the need for a “stable” or “positive” trend from the analysis in Section 3.2 addresses the fact that RUSLE does not account for gully erosion.

These suggestions for success evaluation must necessarily remain dynamic as such testing for erosional stability is in its infancy. There are circumstances (e.g., the Outback of Australia) where the land surface has been subjected to the erosive forces of nature for so long a period that they are now extremely stable and the “T”, “ A_B ”, or “ A_{RA} ” values may not present a reasonable target for reclamation. In this regard, it may be possible to develop a standard similar to the “inflection point” concept presented for LFA analyses. Once several reclaimed units are sampled, data generated, and analyses made, the efficacy of the currently proposed standards versus the need for an alternate RUSLE success comparison will be further evaluated.

Step 4 Evaluate Establishing Vegetation Using Vegetation Measurement Protocols

4.1 Introduction

By using established, scientifically defensible procedures to track the progress of newly establishing vegetation communities, a determination of either latent problems or a prediction of future “releasability” will be reliably manifested. At some point, the reclaimed community will have progressed sufficiently to be “tested” and thereby trigger final bond and/or liability relinquishment on areas no longer potentially necessary for operations. The initial stage (Stage I) of vegetation monitoring will occur concurrently with the implementation of LFA stability protocols or soil sampling protocols and will consist of two components: 1) a brief qualitative evaluation of the reclaimed surface and manifested physical and biotic attributes, and 2) a brief evaluation of emergent plant density. Following this initial stage of monitoring, units that appear to be advancing will be evaluated and assessed to determine progress toward “releasable” status and/or to determine if latent problems may need attention. In this regard, Stage II vegetation monitoring protocols will be implemented for all reclamation units that have achieved sufficient vegetation growth and development to warrant the effort.

For the vast majority of circumstances Stage II monitoring will target the vegetation variable of “Ground Cover”, and because most vegetation used in reclamation does not or will not achieve heights in excess of approximately 1.5 meters over the short-term, a concentration on vegetation ground cover below 1.5 meters will be the primary emphasis. However, for older reclamation and other exceptions where ground cover due to vegetation exceeds 1.5 meters in height, a secondary procedure will be used to incorporate “overstory” cover. Additional rationale and attributes regarding the value of the ground cover variable is provided in Appendix A.

In typical circumstances, Stage II procedures would be implemented for a period of 1 to 3 years, assuming reclaimed communities are progressing as expected until either Stage III is reached or the area becomes “releasable”. Stage III is essentially a “holding” period where reclamation has achieved adequate parameters to be relinquished, but the area is not operationally ready to be released from the permit. In these instances, compliance monitoring would be initiated requiring an evaluation once every 3 years to insure that the reclaimed area has not regressed or otherwise developed any problems. In certain circumstances (such as poor growth media or rainfall), the progress of reclaimed communities may take a longer period of time and Stage II procedures may be scheduled for implementation on a biennial basis (once every two years).

4.2 Physical and Biotic Attributes and Emergent Plant Density Monitoring (Stage I)

4.2.1 Physical and Biotic Attributes

During the first growing season following seeding a reclaimed unit will be subjected to a relatively brief one-time evaluation to document plant establishment as well as other reclamation considerations. This evaluation consists of a qualified observer traversing the subject area and evaluating vegetation establishment and related physical and biotic conditions. Approximately 1 hour of qualitative review time per 20 hectares should be expended. During the traverses, the observer should note, among other items: 1) areas of poor seedling emergence, 2) pervasively weak or stressed seedlings, 3) indicators of soil fertility problems (e.g. certain anthocyanine colorations), 4) noxious weeds or invasive plant infestation, 5) evidence of unintended livestock grazing, 6) excessive erosion and type, 7) evidence of acid formation, 8) evidence of structural instability (stress fractures, piping, etc.), 9) evidence of hyper-saline soils, 10) "pockets" of the aforementioned, and 11) any other similar revegetation / reclamation related problems. Also at this time, any gullies that may have formed during rainfall events should be identified and subjected to the trend evaluation as indicated in Section 3.2.

To provide a framework for many of these observations, the qualitative data sheet on the following page could be utilized. It does not directly address all the points above, but provides a structured approach for making observations. This qualitative data sheet should also be utilized for all segregate-unit monitoring activities (Stage II and Stage III). It provides a structured checklist of additional observational attributes that often are not detected by quantitative evaluations.

4.2.2 Emergent Plant Density

In addition to the physical and biotic attributes evaluation, the surveying observer will collect semi-quantitative samples to document the emergent density of seeded species. This procedure will occur as follows. For areas up to 5 hectares in size, a total of 5 samples will be collected. For areas between 5 and 35 hectares in size, a total of 10 samples will be collected. For areas between 35 and 150 hectares in size, a total of 20 samples will be collected. Finally, for areas larger than 150 hectares in size a total of 30 samples will be collected. Each sample will consist of a group of five 0.1-m² quadrats distributed in an unbiased manner. The number of emergent plants rooted within the perimeter of each quadrat will be recorded accordingly into one of five classes: perennial grass, perennial forb, shrub/tree, annual grass, or annual forb. This procedure typically takes about 2 minutes per sample point (5 quadrats) yet yields valuable information on the success of the seeding effort. Efforts that result in fewer than 1 perennial emergent per 0.1-m² should be considered to be poor and a possible candidate for remediation. Efforts with 1 – 2 perennial emergents per 0.1-m² are considered to be fair, 2 - 3 perennial emergents per 0.1-m² are considered good, and 3 - 5 perennial emergents per 0.1-m² are considered to be very good. Finally, greater than 5 perennial emergents per 0.1-m² are considered to be excellent.

In certain droughty areas (e.g., Mojave desert of the U.S. or goldfields of Western Australia), quadrat size may need to be increased to 1-m² to facilitate emergent plant evaluation. In these areas, efforts with 1 – 2 perennial emergents per 1-m² are considered to be fair to good and 3 - 4 perennial emergents per 1-m² are considered very good to excellent.

In addition to the qualitative and emergent density surveys, the reclaimed unit should be circumnavigated on foot or with all-terrain vehicle utilizing a sub-meter GPS to field delineate the unit boundary. In this manner, any discrepancy between planned and actual area of reclamation will be documented. Such information becomes important during relinquishment activities.

RECLAIMED UNIT - QUALITATIVE OBSERVATIONAL DATA SHEET										
YEAR = _____		Mine/Project: _____		Unit Name: _____			OBSERVER = _____			
Steepest Slopes - Clinometer Angles (° of angle or %): _____ / _____ / _____ / _____						Date: _____		Photo - Y / N		
QUALITATIVE PARAMETER	Excellent	Good	Average	Fair	Poor	N/A	COMMENTS (Especially for departures below average)			
Overall Condition of Revegetation	5	4	3	2	1	X				
Quality of Growth Media (Texture / Organics / Salts)	5	4	3	2	1	X				
Plant Health and Vigor (e.g., Anthocyanine Coloration ?)	5	4	3	2	1	X				
Recruitment (e.g., Seed Production, tillering, etc.)	5	4	3	2	1	X				
Shrub Patch Diversity (Heterogeneity of Patches)	5	4	3	2	1	X				
Shrub Density (Within Patches)	5	4	3	2	1	X				
Diversity (of Species)	5	4	3	2	1	X				
Macro Diversity (Lifeform/Habitat/Layering)	5	4	3	2	1	X				
Cryptobiotic Development	5	4	3	2	1	X				
Litter Residue	5	4	3	2	1	X				
Evidence of Wildlife Use	5	4	3	2	1	X				
QUALITATIVE PARAMETER	None	Minor	Average	Major	Massive	N/A	COMMENTS (Especially for departures below average)			
Noxious Weed Population Description (Indicate Sp.)	5	4	3	2	1	X				
Annual / Invasive Weed Population Description	5	4	3	2	1	X				
Erosion - Rills (Less than 15cm (USA) or 30cm (AUS) in depth)	5	4	3	2	1	X	Type / Active / Healing / Evidence of Healing / Etc.			
Erosion - Gullies More than 15 cm (USA) or 30 cm (AUS))	5	4	3	2	1	X				
Erosion (Sheet, Aeolian, etc.)	5	4	3	2	1	X				
Soil Crusting	5	4	3	2	1	X				
Thin Areas (Cause, Amount, & Location)(1/2 acre minimum) Bare = 0-10% of Avg. Cover Thin = 10-33% of Avg. Cover	5	4	3	2	1	X				
Other Comments:										
Office Use:		Qualitative Parameters			Quantitative Samples			QA/QC Check By:		
		Score	Total	Percent	Cover Ts	WPD Belts	Prod Quads			
			/	=						

4.2.3 Recommendations

The results of the qualitative, and semi-quantitative emergent density survey will form an initial basis for recommendations for future needs of the reclaimed unit. For most efforts it is anticipated that a recommendation to proceed to Stage II monitoring will be made. Other possible recommendations may include:

1. Allow additional time for seed to emerge and re-evaluate using Stage I Protocols. The amount of additional time may be one or two years.

2. Retreat all or parts of a unit by resoiling, reseeding, fertilizing, weed control efforts, addressing acid generation or stability concerns, etc. An important concept that must be taken into account is that precipitation is not always favorable for reclamation efforts in any given year or environment, just as occurs for agricultural practices. Also, species selected, growth form, depredation by granivores, and mold or fungus may impact emergence. Therefore, as indicated above, a second or third growing season is occasionally necessary to achieve the desired seedling emergence. If however, after three growing seasons emergence is still unsatisfactory, reseeding may be necessary to replenish the seed bank. If mitigation occurs, re-monitor the following growing season using Stage I Protocols.

Advancement to Stage II monitoring would be based on the estimated amount of expressed vegetation in the target reclamation unit(s). When the amount of vegetation cover visually exceeds an estimated 10 percent of the value expressed by the appropriate reference area, then Stage II activities should commence. For example, assume the reference area exhibits a value of 50% ground cover by live vegetation. Then Stage II activities would commence when absolute ground cover by live vegetation on the reclaimed unit is approximately 5% ($50\% \times 10\% = 5\%$).

At this time, stability monitoring with LFA procedures can cease unless an additional year or two of data are desired to help show positive trend toward stabilization of the soil surface.

4.3 Quantitative Vegetation Monitoring (Stage II)

4.3.1 Ground Cover

During Stage II vegetation monitoring, evaluation will consist of a reasonably rapid quantitative evaluation of ground cover (for most circumstances) to document the level of progress. This effort will entail a qualified observer systematically establishing "ground cover" sampling transects across the reclaimed unit (using a visually-based grid as opposed to a more formal measured grid) at the following sampling intensity:

- | | |
|-------------------------------------|--------------|
| • Units 5 hectares or less | 5 Transects |
| • Units between 5 and 35 hectares | 10 Transects |
| • Units between 35 and 150 hectares | 20 Transects |
| • Units larger than 150 hectares | 30 Transects |

These transects will be systematically distributed as opposed to being randomly distributed. In this application a systematic distribution of samples is superior because it ensures sample representation from across the entire reclaimed unit (population). Also, this procedure better accounts for heterogeneous expressions of multiple seedlings or reclamation conditions by "forcing" a patterned distribution of samples which minimizes sample bias resulting from vegetated pockets being either entirely missed or overemphasized. This "forced" distribution also facilitates a second overall look at the entire reclaimed unit for the qualitative parameters discussed for Stage I (physical attributes) monitoring.

Ground cover transects will typically consist of 10-meter long 100-intercept "line-point transects" ("point-intercept transects"). There may be some instances (elevated variability) where longer transects would be appropriate, and these circumstances can be addressed on a site-specific basis. The actual sampling methods are described in detail in Step 6. As routinely documented in the heavily regulated US coal industry, this methodology, using modern laser instrumentation, facilitates the collection of the most unbiased, repeatable, precise, and cost-effective* ground cover data possible. As indicated in Section 3.2, a co-located erosion observation transect will occur with each vegetation transect.

* In typical reclamation, transects completed with laser instrumentation can be implemented by an experienced observer at a rate of 6 or 7 transects per man-hour of effort with a range of 4 to 9 depending on the diversity of vegetation and size of the reclaimed unit. Addition of the co-located erosion observation transect will slow this rate of speed by 50% +/-.

4.3.2 Woody Plant Density

In certain circumstances, ground cover will not be the best variable to monitor for tracking the success of reclamation in the short-term. Instances where this may occur include environments not conducive to herbaceous species reclamation and environments dominated by overstory forests (e.g., woodlands). In these circumstances, ground cover transects may be replaced, or reinforced, by woody plant density belts.

Woody Plant Density Belts will typically consist of 50-meter long by 2-meter wide belts whereby all live woody plants rooted within is enumerated by species. There may be instances where only the non-seedling categories of woody plants would be enumerated (seedlings tend to have high mortality rates) and these circumstances can be addressed on a site-specific basis. The actual sampling methods are described in detail in Step 6.

4.3.3 Recommendations

Depending on the results of data analyses from the quantitative surveys and interpretation of observations, appropriate management recommendations will be generated for the target unit. For most efforts on a reasonable path to growth and development, it is anticipated that a recommendation to proceed to Stage III or Bond Relinquishment (Step 6) will be forthcoming. Other possible recommendations include:

1. Allow additional time for the establishing community to mature and then re-evaluate using Stage II Protocols.
2. Retreat all or parts of a unit by reseeding, fertilizing, weed control efforts, addressing acid generation or stability concerns, etc. and continue monitoring using Stage II protocols as necessary.

Advancement to Stage III monitoring or Bond Relinquishment (Step 6) would be based on the estimated amount of expressed vegetation in the target reclamation unit(s) in comparison to the success criterion based on the appropriate reference area. When the amount of vegetation cover / density approaches (and is expected to exceed the following year) or presently exceeds the appropriate success criterion, then either Stage III or Bond Relinquishment activities may commence. Typically, a minimum period of three growing seasons is necessary before final relinquishment sampling could or should occur.

4.4 Compliance Monitoring for Units Not Operationally Ready for Release (Stage III)

Following passage of Stage II, many units of reclaimed land will not be operationally ready to be released by mine management (i.e., there may be potential need to reopen any given facility). As indicated above, if an area is not managerially or operationally ready for relinquishment, monitoring using Stage II protocols should continue to occur to validate the status of the unit and insure that no additional work or remediation is necessary. In this regard, compliance monitoring once every 3rd year should be completed until as such time as mine management indicates a particular facility is managerially or operationally ready to be released.

Step 5. Prepare Monitoring Report

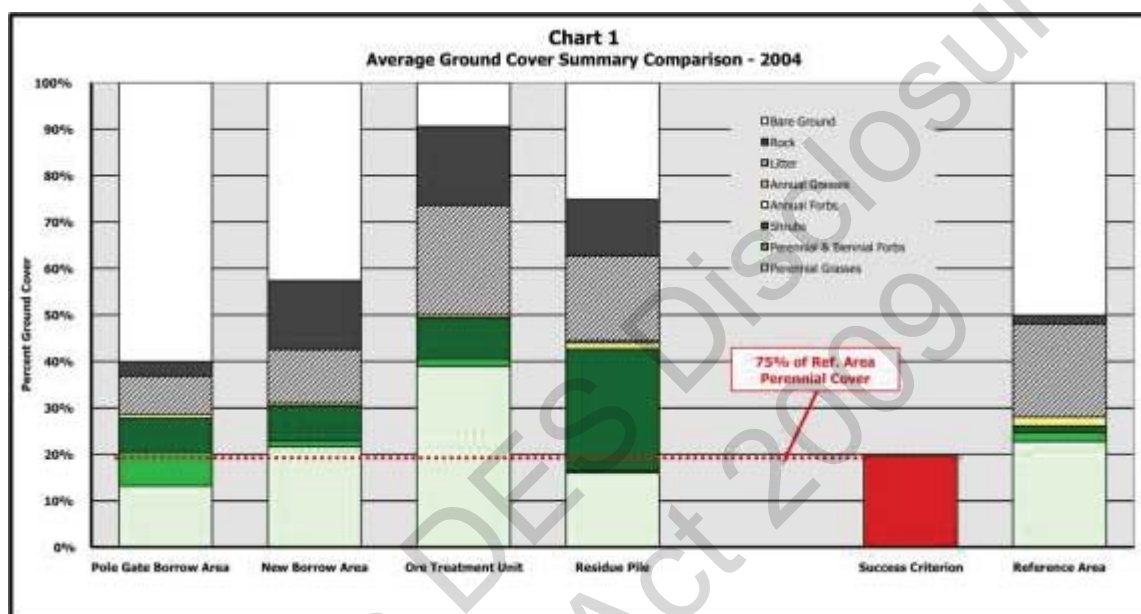
Monitoring reports should consist of three levels of communication: 1) immediate, 2) short-term, and 3) standard longer-term documentation. Immediate reporting should be used for observations of conditions (or lack thereof) that need immediate attention from environmental or reclamation department staff. Such reporting would be verbal and may consist of a site review with appropriate staff either immediately (same day) or at the end of the field evaluation period (within a few days). If conditions requiring immediate attention are not observed, then immediate verbal feedback of "nil" circumstances should still occur at the end of the field evaluation period.

Short-term reporting should be used for observations of conditions that need attention during the current field season, but do not warrant "immediate" attention. For example, poor take by seeded species over a portion of a reclamation unit that would benefit from reseeding during the current field season. Such matters could be addressed by a brief, field report of only a few pages length utilizing sketches rather than computer generated mapping for spatial information. Short-term reports should be delivered to the appropriate department staff within a matter of weeks (less than 4 would be best). Furthermore, short-term "field" reports should also include documentation of any "immediate reporting" that occurred during field work.

Rel

The third level of reporting involves the standard longer-term documentation of field activities and findings that will be prepared during the non-field season. This report will present the results of monitoring data analyses and any management recommendations in a user-friendly format. Reporting will provide a detailed description and exhibition of the methodology utilized in a manner similar to that presented within a refereed journal article that would allow an independent 3rd party to repeat the work. Results will be presented and described, by segregate unit (treatments and/or reclamation units) in text, tabular, and as possible graphic form to aid interpretation by reviewers. For example, comparisons with reference / analog area data (shown as a “threshold value”) will facilitate immediate comprehension of a reclaimed unit’s status. An example of this type of graphic follows on the next page as Chart 1.

Each full report should present three levels of information: 1) an executive summary, 2) a detailed presentation of findings (including summarized data) that targets the technical reviewer such as the mine’s reclamation staff or regulatory oversight personnel, and 3) an appendix that presents all raw data (tabulated and organized) and 1st order summaries to facilitate an independent corroboration of findings.



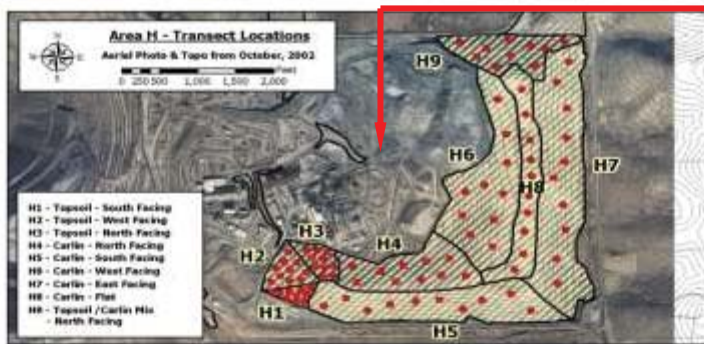
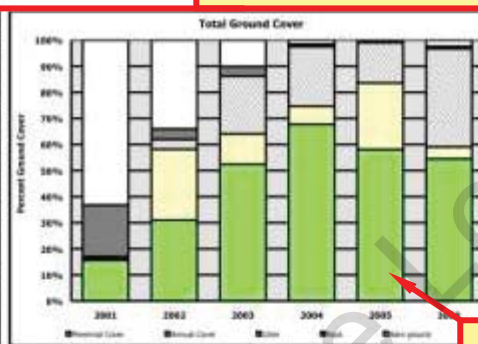
An executive summary with summary graphics (such as presented immediately above) should be developed to provide higher level management a quick synopsis of the most pertinent findings, especially with regard to reclamation units that have achieved sufficient status as to be “releasable” from the permit. All technical analyses, 2nd and 3rd order summary information, interpretation of findings, recommendations, etc. should be presented in the main body of the document along with supporting mapping and analyses. Included within this section of the report, or appended as appropriate, should be a detailed summary and compilation of all pertinent current and past data with regard to each unit of reclaimed land under investigation during that year.

These compilations (“Compendiums”) are very useful to technical managers as they present a current “snapshot” of the status of reclaimed lands as well as all pertinent historic, background, and spatial data in a one page format (see Exhibit 2 on the following page). Finally, all supporting, but non-essential raw data for the technical component of the report should be tabulated and organized and presented in an appendix to the document (see Exhibit 3).

In this manner, all managerial needs and requirements of agency permitting documentation should be satisfied. In addition to recommendations relating to financial assurance relinquishment, additional recommendations resulting from the monitoring program may include: recommendations to modify reclamation procedures and/or seed mixtures for future reclamation areas, recommendation for weed control and recommendations regarding future grazing management. A summary section will be developed as a portion of the monitoring report that includes an overall summary table and map exhibiting the reclamation status of all reclaimed areas. (See the map and table presented for Step 1.)

Exhibit 2 - Compendium – Summary of All Pertinent Data re: Each Segregate Reclamation Unit – 11x17 Format

Map of Reclamation Unit showing most current distribution of samples



Charts showing progress of Reveg. by year

Cover Summary
Area H.

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Grasses										
Agropyron cristatum	0.3	13.5	13.4	18.3	8.6	4.3				
Agropyron desertorum	0.0	0.0	0.0	0.0	0.0	0.0				
Agropyron spicatum	0.0	0.0	0.0	0.0	0.0	0.0				
Agropyron trachypodium	0.0	0.0	0.0	0.0	0.0	0.0				
Forbs										
Chrysolepis lychnoides	0.0	0.0	0.0	0.0	0.0	0.0				
Shrubs										
Artemisia tridentata	1.0	7.0	17.7	47.3	28.1	28.9				
Other										
Other	0.0	0.0	0.0	0.0	0.0	0.0				
Back Litter										
Back Litter	0.0	0.0	0.0	0.0	0.0	0.0				
Other										
Other	0.0	0.0	0.0	0.0	0.0	0.0				

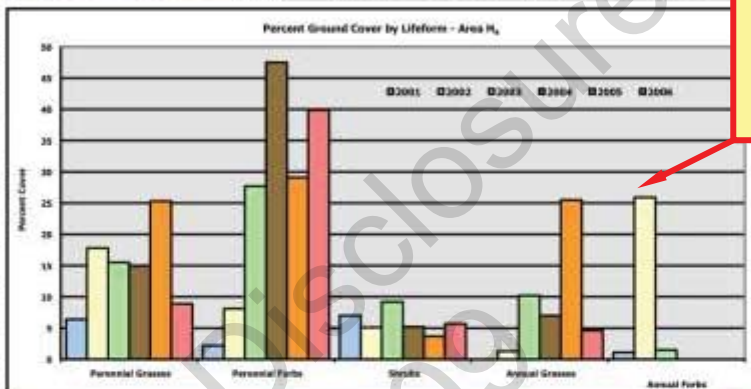


Table tracking specifics of Reveg. by species

Current Photo



Subarea: H **Treatment Area: H₉**

Revegetation Specifications

Topography: Slope: 10% to 20%
Soil Type: Topsoil / Carlin Mix
Grading Notes: 100% Topsoil / Carlin Mix

Soil Amendments: Topsoil / Carlin Mix
Soil Type: Topsoil / Carlin Mix
Soil Amendments: 100% Topsoil / Carlin Mix

Composted Fertilizer & Mulch: 100% Topsoil / Carlin Mix
Fertilizer: 100% Topsoil / Carlin Mix
Mulch: 100% Topsoil / Carlin Mix

Seeding / Planting: 100% Topsoil / Carlin Mix
Seeding: 100% Topsoil / Carlin Mix
Planting: 100% Topsoil / Carlin Mix

Species Seeded: 100% Topsoil / Carlin Mix
Species Seeded: 100% Topsoil / Carlin Mix
Species Seeded: 100% Topsoil / Carlin Mix

Post-Planting Treatment: 100% Topsoil / Carlin Mix
Post-Planting Treatment: 100% Topsoil / Carlin Mix
Post-Planting Treatment: 100% Topsoil / Carlin Mix

Precipitation History

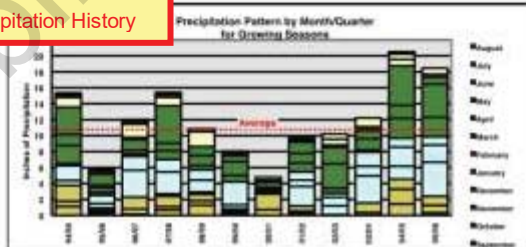


Exhibit of all Revegetation specifications and metrics, soils data, seed mixes, and related treatments.

Reveg Unit identifier & current year

2006

Step 6. Development of Site-Specific Standards for Determination of Successful Reclamation and Subsequent Financial Guarantee or Assurance Relinquishment for Mined or "Mine-Related" Areas

6.1 Introduction

This section details sampling and analysis procedures and the final reclamation success criteria (standards) for evaluation of reclamation of mine-related disturbances. These criteria and protocols are developed in accordance with Barrick's Environmental Policies and will typically meet or exceed regulatory requirements in the U.S. and elsewhere in the world. This section does not include a separate analysis for Erosional Stability (see Step 3) because either of two options may be employed. However, a demonstration of Erosional Stability as detailed in Step 3 should occur for final relinquishment to document success with regard to this variable.

In addition to identified "standards" a set of "goals" may/will be identified to assist in the evaluation and interpretation of targeted reclamation efforts. However, it is important to understand the difference between goals and standards, especially within the context of their use in this document and the reclamation permit. A "standard" is a legally binding level of reclamation performance that must be attained to trigger release of financial sureties and future liability. A "goal" is a desirable result (level of reclamation) that serves to act as guidance for reclamation activities, but has no legal bearing on the release of financial sureties or liability if attainment is not achieved. In other words, goals help to guide reclamation in the desired direction, but standards offer the minimally acceptable level that must be achieved to have a legal consequence.

Consistent with the requirements of Reclamation Permitting, final reclamation success will be evaluated through three broad concepts:

- Documentation that erosional stability has been achieved as detailed in Step 3.
- Comparison to an adequate analog or reference area(s) representative of the pre-existing vegetation community(s) and/or desirable baseline / ecological conditions which will act as surrogate for the post-mining land use;
- Evaluation of plant species present in, and/or resulting from, the proposed (and planted) seed mixes.

Total vegetative cover and composition are important factors in determining the success of reclamation efforts. However, of equal importance to reclamation success is the achievement of soil stabilization. Without soil stability, reclamation efforts may regress along the successional continuum and thereby preclude the achievement of long-term land use goals. In this regard, prior to, or concurrent with vegetation, a determination of soil stability should be documented through procedures detailed under Step 3 of this document.

The long-term goal of reclamation efforts is to establish self-sustaining biotic systems with appropriate ecological resistance and resilience. This does not necessarily mean that the reclaimed area will exactly replicate the surrounding vegetation communities, but that it will successfully support the designated post-mining land uses. In general, it would be an undesirable condition that the reclaimed area match exactly the surrounding vegetation communities, since community diversity adds significantly to overall habitat diversity for an area. As appropriate, seed mixtures designated by the reclamation plan are largely composed of species native to the region. Also as appropriate, seed mixes contain a complement of grasses, forbs, shrubs and trees to provide establishment of a diverse plant community within reclaimed areas.

6.2.1 Reclamation "Goals"

The Reclamation Plan establishes the goal of reclamation as follows:

- Perennial vegetative cover as close as possible to 100 percent of selected comparison (analog or reference) areas; or
- Perennial vegetative cover that is on a reasonable successional path to achieve as close as possible 100 percent of selected comparison (analog or reference) areas.

In certain circumstances, woody plant density may replace the term cover, and in other circumstances the term perennial may not be appropriate. However, the stated goals will suffice for most operations.

Although the goal of the reclamation program is to achieve "as close to 100% of the perennial plant cover as possible, success must be based on reasonably achievable standards that reflect the minimum levels necessary for return of the permit area to a self-sustaining ecosystem. Therefore, reclamation success will be assessed against a performance "standard" for vegetative ground cover. Reclamation efforts will be considered successful when standards have been met following at least three growing seasons since planting efforts.

6.2.2 Vegetative Ground Cover Standard (Success Criterion)

Vegetative ground cover should be utilized for the vast majority of reclamation circumstances and must meet the following criterion: The total vegetative ground cover (exclusive of annual species and litter) in the reclaimed unit equals or exceeds 60 percent of the total vegetative ground cover (exclusive of annual species and litter) of the analog or reference area.

In those environments where annuals form a significant component of the floral composition and cover, the 60 percent standard shall apply to all live (during the current growing season) vegetation (excluding noxious weeds).

6.2.3 Woody Plant Density Standard (Success Criterion)

For those circumstances where an evaluation of ground cover may be inappropriate (e.g., Death Valley, USA; tropical rainforest of Australia; or managed timberland anywhere), an alternate success criterion may be utilized as follows: The total density of woody plants in the reclaimed unit equals or exceeds 50 percent of the total density of mature age-class woody plants of the analog or reference area.

6.3 Reclamation Evaluation Procedures

Monitoring and eventual evaluation will typically involve sampling of ground cover within each reclaimed unit under consideration for financial guarantee or assurance relinquishment (and at least 3 years of age) and the appropriate analog or reference area. Species diversity information will be calculated from the ground cover data and presented for informational purposes to document goal-related composition that will then indicate ecological resilience and progress toward the desired land use. Sampling for ground cover will be accomplished utilizing the point-intercept procedure along transects of 100 intercepts each, preferably using modern instrumentation (e.g. lasers or optics).

6.3.1 Sampling

The first step of the vegetation sampling procedure is to obtain ground cover data from each reclaimed unit to be evaluated. A reclaimed unit consists of a defined area based on management criteria, such as areas with common reclamation procedures and initiation times, areas with a defined function such as a waste rock facility, or areas with other unique designations. Ground cover samples also will be obtained from the analog or reference area(s). Sampling will occur approximately during the peak standing biomass period of the year (early- to mid-summer) and sampling locations will be determined utilizing a systematic (bias-free) method with a random start⁴. This systematic procedure also provides proportionate representation from across each reclaimed unit for additional characteristics such as aspect, slope, etc.

⁴ Systematic sampling (with random initiation) is superior to other sample distribution procedures because it forces representation from across the reclaimed unit. It accounts better for heterogeneous expressions of

6.3.1.1 Sample Site Location.

The systematic procedure for sample location in both a reclaimed unit and the analog or reference area will occur in the following stepwise manner. First, a fixed point of reference will be selected for the area to facilitate location of the systematic grid in the field. Second, a systematic grid of appropriate dimensions will be selected to provide a reasonable number (e.g., 15 or 20) of coordinate intersections that could be used for the initial set of sample sites. Third, a scaled representation of the grid will be overlain on field maps of the target unit extending along north/south and east/west lines or other appropriate direction. Fourth, the initial placement of this grid will be implemented by selection of two random numbers (an X and Y distance) to be used for locating the first coordinate from a fixed point of reference, thereby making the effort unbiased. Fifth, where an excess number of potential sample points (grid intersections) is indicated by overlain maps, the excess will be randomly chosen for elimination unless it is later determined that additional samples are necessary to meet sample adequacy. If additional samples are needed, the eliminated potential sample sites will be added back in reverse order until enough samples have been collected. Sixth, utilizing compass and pace techniques or a handheld GPS, the sample points will be located in the field.

6.3.1.2 Ground Cover Determination.

Ground cover at each sampling site will be determined utilizing the point-intercept methodology as illustrated in Exhibit 1. This methodology will be applied as follows: First, a transect 10 meters in length will be extended from the starting point of each sample site toward the direction of the next site to be sampled. Then, at each one-meter interval along the transect, a "laser point bar", "optical point bar" or 10-point frame will be situated vertically above the ground surface, and a set of 10 readings recorded as to hits on vegetation (by species), litter, rock (>5mm), or bare soil. Hits will be determined at each meter interval as follows:

1. When a laser point bar is used, a battery of 10 specialized lasers situated along the bar at 10-centimeter intervals will be activated and the variable intercepted by each of the narrow (0.02") focused beams will be recorded (see Exhibit 1);
2. If an optical point bar is used, intercepts will be recorded based on the item intercepted by fine crosshairs situated within each of 10 optical scopes located at 10-centimeter intervals;
3. If a 10-point frame is used, sharpened needles will be used to determine intercepts at 10-centimeter intervals. Care will be taken to NOT record "side touches" on the pins as this will result in a significant overestimation error.

The following sampling rules should apply during data collection. Intercepts will be recorded by species for the first (typically highest below 1.5 meters) current annual (alive during the current growing season) plant part intercepted without regard to underlying intercepts or attachment to a living base. Otherwise, the intercept will be classified as litter, rock or bare soil. Rock intercepts are based on a particle size of 5 mm or larger to facilitate RUSLE evaluations, otherwise it would be classified as bare soil. To distinguish between current year senescent plant material and litter (including standing dead), the following rule should apply: 1) if the material is gray or faded tan it should be considered litter; and 2) if the material is bright yellow or beige it should be considered current annual (alive) and recorded by species. On occasion, experience with non-conforming taxa may override this rule.

When using laser or optic instruments during windy field conditions, the observer should consistently utilize one of the following techniques for determining a hit: 1) record the first item focused upon that is intercepted by the narrow laser beam or cross-hair; 2) wait a few moments and record the item intercepted for the longest time, or 3) block the wind and record the intercept. When using a pin frame, the observer must wait for the wind to subside.

With regard to gaps in the overstory, the point-intercept procedure naturally corrects for overestimations created by 2-dimensional areal (quadrat) or 1-dimensional linear (line-intercept) techniques. In this regard, the 0-dimensional point is extended along a line-of-sight until it "intercepts" something that is then recorded. Frequently points simply pass through overstory gaps until a lower plant part, litter, rock or bare soil is encountered.

multiple seedings or reclamation conditions by "forcing" a patterned distribution of samples. This method thus minimizes the risk that significant pockets will be either entirely missed or overemphasized. However, in research applications statistical analysis methods may be limited.

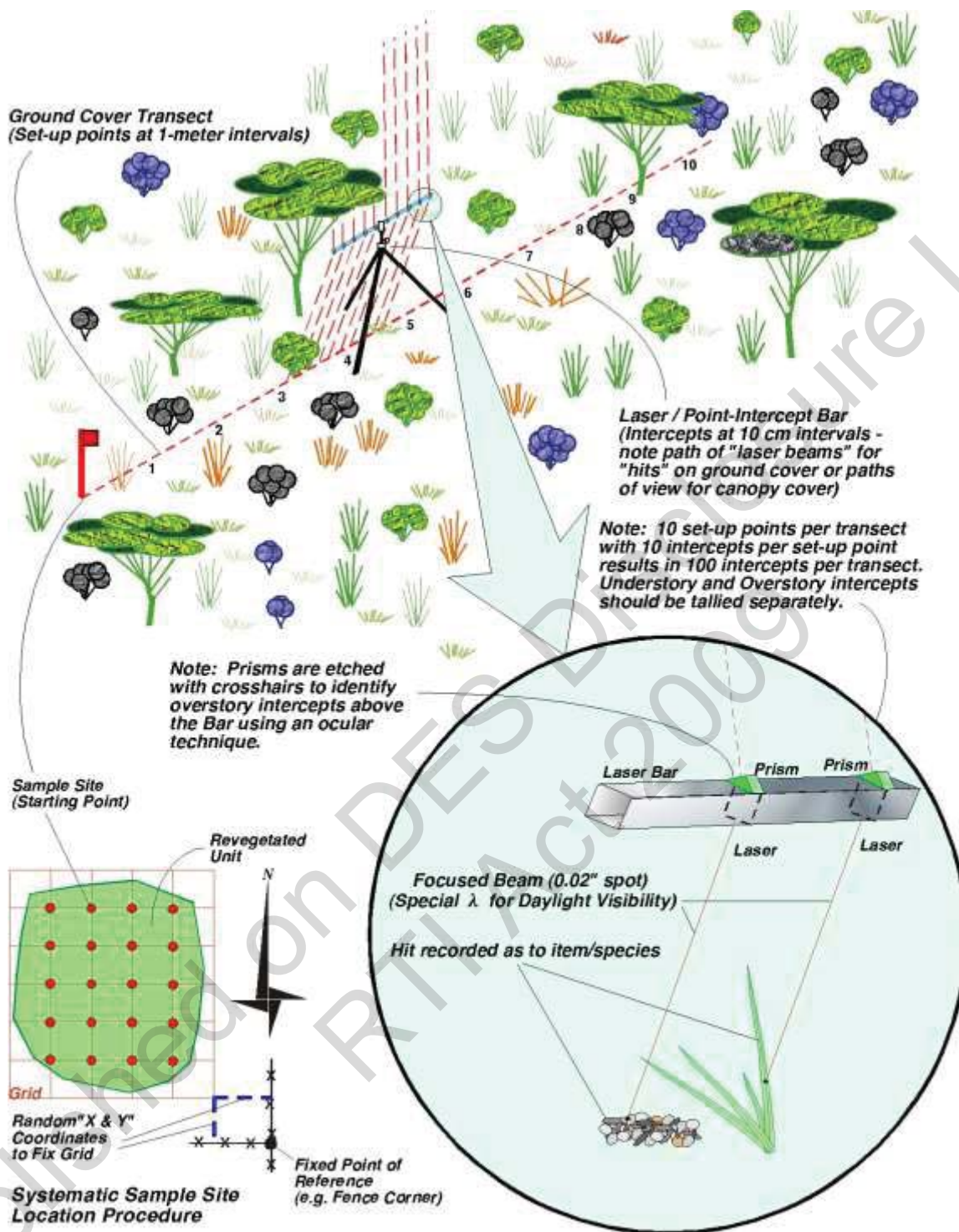


Exhibit 1

Sampling Procedure at a Systematic Sample Site Location

Regardless of instrument, a total of 100 intercepts per transect will be recorded resulting in 1 percent cover per intercept. This methodology and instrumentation (excepting the 10-point frame) facilitates the collection of the most unbiased, repeatable, precise, and cost-effective ground cover data possible.

Overstory Cover. In certain circumstances (e.g., various *Acacia* species in Australia), young reclamation can exceed 1.5 meters in height. In these instances, overstory cover should be recorded separately from the understory cover (below 1.5 meters). Point-intercepts can be collected above the ground cover equipment with the aid of prisms etched with cross-hairs (see Exhibit 1). In this regard, intercepts will be recorded by species, with all other intercepts being non-applicable (sky). The sampling rules indicated above should again be used as appropriate. To facilitate ground cover calculations, any understory hit that occurs concurrently with an overstory hit will be recorded as a 2nd intercept and will not be included in the total that must add up to 100%.

RUSLE-Specific Measures – Fall Height and Basal Cover. When a RUSLE evaluation is to occur, the following metrics will be included with the ground cover procedures to facilitate proper input variables. Following completion of each ground cover transect, an estimate of average fall height (closest 1/2 foot) and total percent basal cover should be recorded for the soil stability analysis using the RUSLE application. Average fall height is defined as the height within the canopy from which intercepted raindrops re-form into water droplets and fall to the ground; this fall distance is known as the "effective fall height." In plant communities that have more than one type of vegetation composing the canopy (e.g., both a shrub and tree stratum), a fall height should be determined for each life form. It is typically unnecessary to estimate an average fall height for grasses and forbs, as they are relatively close to the surface and rain droplets tend to follow the stems to the ground rather than reforming and falling. At the completion of each vegetation transect a visual estimate of the average fall height for shrubs encountered should be recorded as well as a separate estimate for any trees. Where necessary, a height measurement tool (rule, staff, etc.) may be utilized to obtain the estimate. The upper limit for the measurement should be the average height of the mid-point for the volume of canopy. For example, if the canopy were spherical in nature, the height would be estimated from the ground to the central radius point. If the canopy were pear shaped, the height would be determined from a point somewhat lower. Occasional circumstances may occur where a dominant plant that is not a shrub or tree would need an average fall height recorded. In such circumstances these can be recorded separately and treated on an individual basis. These fall heights will then be weighted based on canopy cover of each life form to establish an average fall height for the transect, and the fall heights for the total number of transects for a given unit will be averaged for entry into the RUSLE application.

Basal cover is the material in contact with the soil surface that both intercepts raindrops (thereby dissipating energy) and slows surface runoff. It includes all types of cover such as mulch, the living base of plants, rock fragments, plant litter (standing dead or detached vegetation) in contact with the soil surface, and cryptogamic crusts (which are formed by lichen, mosses, or fungi in the soil). In effect, it would be the surface material visible on the bare soil had a mower, set to a very low elevation, passed over the area removing all above ground biomass without disturbing the litter. Although all ground cover is determined by the point-intercept technique as described in this document, a very reasonable estimate of basal cover can be determined from the ground cover transect by using the following adjustment techniques. These techniques involve a determination of basal bare ground exposure, which is the inverse of basal cover (i.e., 100% minus the bare ground exposure results in a value for basal cover).

First, all bare ground hits along a ground cover transect would be included in this analysis.

Second, in portions of the transect dominated by grasses, especially sod-formers, and forbs, 10% of the hits would be assumed to encounter bare ground if the overstory were removed. The remaining hits would be assumed to encounter the living base of plants or ground-contact litter.

Third, the percent of exposed bare soil below shrubs and trees would be estimated following a quick visual review of the transect.

Fourth, the values from the first three steps would be tallied and subtracted from 100. This final value would be a reasonable estimate of basal cover for the transect.

An example of the aforementioned procedure would be as follows: First, the total bare ground hits observed along a given ground cover transect would be "X" (22 hits for example). Second, the grass and forb cover was determined to be "Y" (33 hits for example) but only 10% of "Y" would typically be bare ground if the overstory were removed so the value to be used would be 0.1Y (or 3.3 hits for this example). Third, a visual evaluation below the shrubs (and trees) reveals that "Z" % bare ground is visible (15% bare ground in this example).

If shrub and tree ground cover resulted in 20 hits along the ground cover transect, then bare ground would be 20 x 0.15 or 3 hits if the overstory were removed. The sum of X, Y, and Z hits in this example would be 22 + 3.3 + 3 or 28.3 (% bare ground exposure). Therefore, basal cover must be the inverse or 100 – 28.3 = 71.7 or rounded off to 72%. The 72% basal cover value would be tallied with all other transect basal cover values from the unit and the average would be used for RUSLE calculations.

6.3.1.3 Woody Plant Density Determination.

Where ground cover is inappropriate for use as a bond relinquishment mechanism, woody plant density can be determined from each sampling site through the use of large quadrats or belts. A belt should encompass at least 100 m² and would typically be 2-meters wide by 50 meters long, but can be other dimensions such as 4m x 25m. Once a convention (dimension of quadrat) is started, it must be maintained until all samples in that unit have been collected to avoid violating sampling theory assumptions. The long axis of the belt should be extended in the direction of the next site to be physically sampled.

Then within each belt all woody plants (shrubs and trees) should be enumerated by species and age class. Determination of whether or not a plant may be counted will be dependent upon the location of its main stem or root collar where it exits the ground surface with regard to belt limits. A belt transect should be sampled for each identified sample point (grid intersection) as identified in Section 6.3.1.1 above. At least 20 and preferably 30 samples should be collected from each unique management unit or analog / reference area. In addition, sample adequacy will NOT be determined for woody density belts as indicated in the next section unless it is only for informational purposes (the state of art has not provided a procedure that adequately captures woody plant population variation, therefore, calculation of sampling adequacy is not possible). Age classes recorded for the belt transects include: 1) seedling (plant of the year), 2) young (typically 2-3 years of age for shrubs or pole size or smaller for trees), 3) mature, 4) decadent (plants with less than 25% live crown), and 5) dead (assuming species is still positively recognizable).

6.3.1.4 Sampling Adequacy.

Data collection will continue within each discrete sampling unit (reclaimed unit or analog / reference area) for ground cover until a statistically adequate sample has been obtained. Adequacy of sampling will be achieved when, for each discrete unit, the number of samples actually collected (n) provides a level of precision within 10% of the true mean with 90% confidence (n_{min}), i.e., when $n_{min} \leq n$, and n_{min} is calculated as follows:

$$n_{min} = (t^2 s^2) / (0.1 \bar{x})^2$$

where: n = the number of actual samples collected with a minimum of 10 in each unit;
 t = the one-tailed value from the t distribution for 90% confidence with $n-1$ degrees of freedom;
 s^2 = the variance of the estimate as calculated from the initial samples;
 $\bar{x}$ = the mean of the estimate as calculated from the initial samples.

For environments that are arid and native vegetation is somewhat sparse (e.g., areas with less than 250 mm (10") of annual precipitation), sampling adequacy will be relaxed by sampling to within 20% of the true mean with 90% confidence. In this regard, the 0.1 in the denominator of the n_{min} equation above will be changed to 0.2.

For environments that are very arid and native vegetation is very sparse (e.g., areas with less than 150 mm (6") of annual precipitation), sampling adequacy will be further relaxed by sampling to within 20% of the true mean with 80% confidence. In this regard, the 0.1 in the denominator of the n_{min} equation above will be changed to 0.2, and the t value from the t distribution will be selected from the 80% confidence column with $n-1$ degrees of freedom (one-tailed distribution).

As indicated above for most circumstances, this formula provides an estimate of the sample mean to within 10% of the true population mean (μ) with 90% confidence. Calculations of the mean and variance will be based on "total vegetation ground cover" exclusive of litter, but including annuals. Furthermore, a minimum sample size of ten (10) samples (20 for units larger than 50 hectares) will be collected from each discrete reclaimed unit or the analog / reference area. If the initial ten (or 20) samples do not provide an adequate estimate of the mean (e.g., the inequality above is false), additional samples will be collected until the inequality is satisfied. However, in no case will more than 40 ground cover transects be collected in any given sampling unit.

6.4 Ground Cover Comparison Standard

After adequate sampling, the comparison process will be initiated by calculating the mean ground cover value for non-annual plants (non-annual ground cover, or "NAGC") for each reclaimed unit and analog / reference area. The test for reclamation success for ground cover will occur as follows.

Determine whether the mean NAGC of the reclaimed unit(s) ($\bar{x}_{(rv)}$) equals or exceeds 60 percent of the mean NAGC for the analog /reference area ($\bar{x}_{(co)}$). In other words, if the inequality $\bar{x}_{(rv)} \geq 0.6 (\bar{x}_{(co)})$ is true, then the ground cover test has been passed. In areas with less than 250 mm (10") of precipitation, annual ground cover shall not be excluded from the above comparison unless they are locally identified as noxious or invasive weeds.

6.5 Woody Plant Density Comparison Standard

For woody plant density sampling, the comparison process will be initiated by calculating the average density of woody plants for each reclaimed unit and analog / reference area. The test for reclamation success will occur as follows.

Determine whether the average woody plant density of the reclaimed unit(s) ($\bar{x}_{(rv)}$) equals or exceeds 50 percent of the average "mature" category plants from the analogue / reference area ($\bar{x}_{(co)}$). In other words, if $\bar{x}_{(rv)} \geq 0.5 (\bar{x}_{(co)})$, and $\bar{x}_{(co)}$ is comprised only of the mature category of plants, then the woody plant density test has been passed.

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CROYDON GOLD MINE
WATER MANAGEMENT STRATEGY

NOVEMBER 2014

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1 INTRODUCTION

The Croydon Gold Mine (the Project) is located to the immediate west of the Croydon township, 560 kilometres (km) west of Cairns, Queensland (QLD) (Figure 1). The Project was formerly a large low-grade gold mine and has since been closed and decommissioned. Activities at the Project include maintenance, monitoring and reclamation works (as required).

Mining Lease (ML) 5248 was granted on 4 August 1988 to Goldfields Kalgoorlie Limited. ML 5248 was later transferred to Aurion Gold Limited, before the company was acquired by Placer Dome Australia in November 2003, which was then acquired by Barrick Gold of Australia (Barrick) in 2005. Barrick holds Environmental Authority No. EPML00950913 (EA) for the Project.

This Water Management Strategy (WMS) has been prepared in accordance with EA Condition F10-1:

F7-1 A water management strategy must be prepared for inclusion in the Plan of Operations. The strategy will include:

- (a) Data collection and identify existing data requirements.*
- (b) Design and detail additional works as required.*
- (c) Implement / construct additional works.*

In accordance with EA Condition F10-1 this WMS will be included in the Croydon Gold Mine Plan of Operations. This WMS has been prepared with the assistance of Metago Environmental Engineers.

The remainder of this WMS is structured as follows:

Section 2: Provides a review of the drainage for the Project.

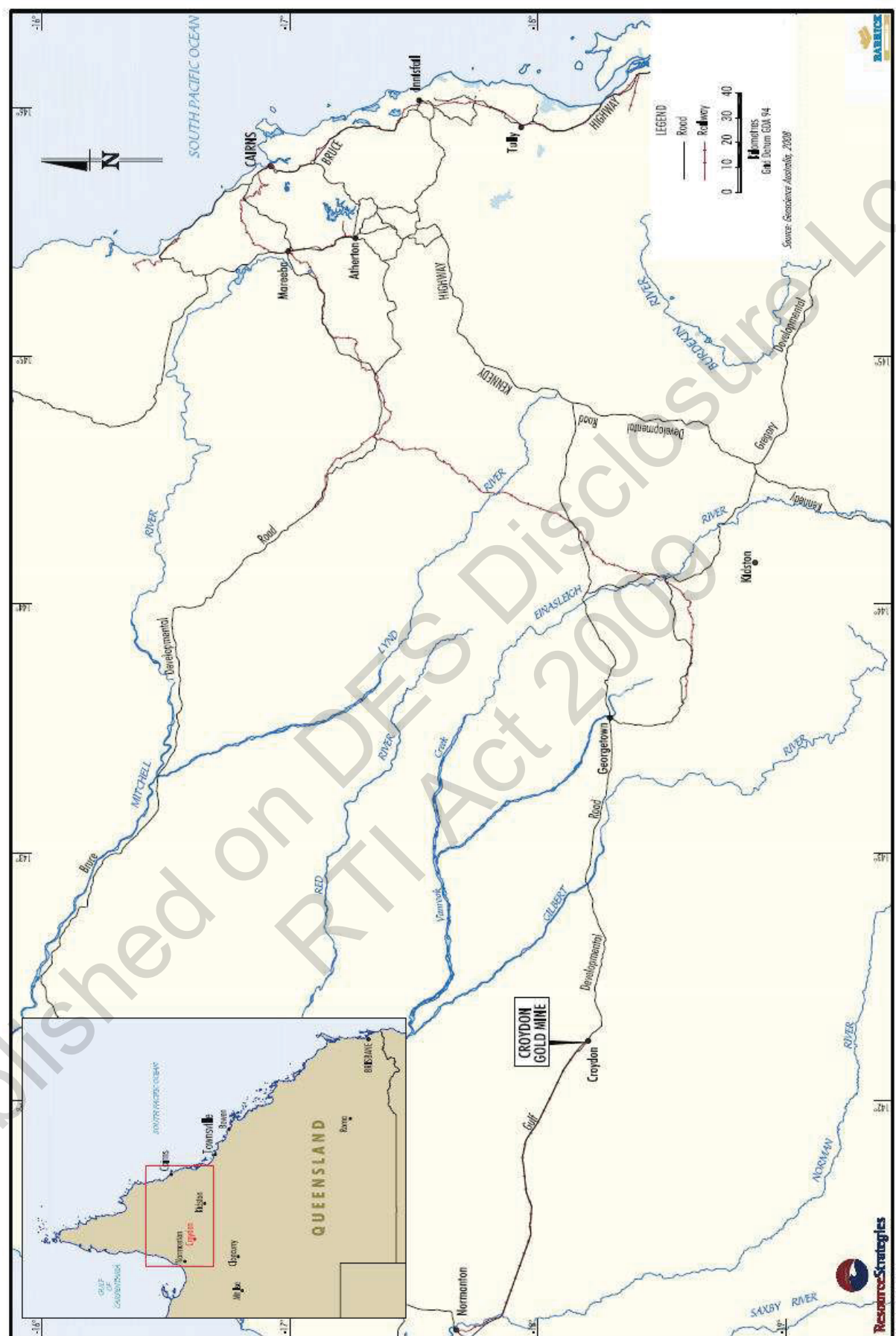
Section 3: Describes the proposed drainage management plans for the post-mining final landforms.

Section 4: Identifies the monitoring program for this WMS.

Section 5: Outlines the water requirements for the Project.

Section 6: Describes the review process for this WMS.

Section 7: Lists the references cited in this WMS.



2 DRAINAGE REVIEW

2.1 POST-MINING FINAL LANDFORMS

The mining-related landforms on ML 5248 comprise of waste rock dumps, open pits and infrastructure areas (i.e. abandonment bunds, hardstand areas, water management structures and roads/tracks) surrounding the open pits and waste rock dumps.

Specifically they include (Figure 2):

- Golden Butterfly Pit;
- Golden Butterfly North Pit;
- Golden Butterfly waste rock dump;
- Content Pit;
- Content waste rock dump;
- Lady Isabella Pit;
- abandonment bunds across the access ramps of the four open pits;
- hardstand areas adjacent to the Content and Golden Butterfly waste rock dumps;
- water diversion bunds and sediment dams adjacent to the Content and Golden Butterfly waste rock dumps; and
- roads and tracks.

Schematic diagrams of the final landforms, inclusive of drainage features, are provided in Figure 3. The final landform concept is to achieve a stable post-mining landform that is able to meet the identified post-mining landuse and rehabilitation objectives.

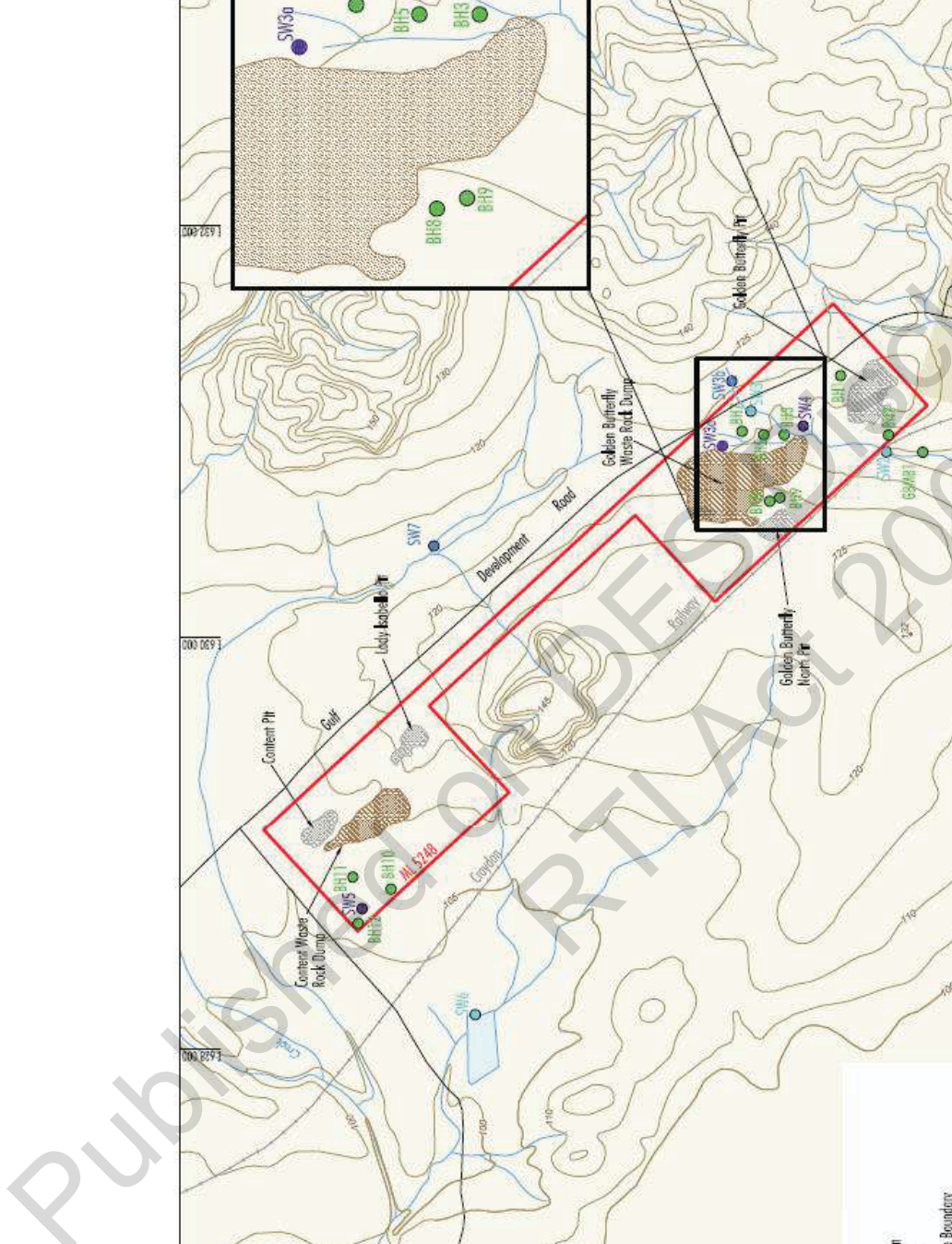
2.2 GENERAL RELIEF

The Project is located on the edge of the Gulf Country in Northern Queensland. There is little to no elevation difference across ML 5248 with the only significant natural landform a low (approximately 25 metre) hill located between the two mined areas (Figure 2). The south-eastern section of ML 5248 (i.e. the Golden Butterfly mining area) is within the upper catchment of Slaughteryard Creek and has a single shallow drainage line that flows from north to south across ML 5248.

The north-western section of ML 5248 (i.e. Content and Lady Isabella mining areas) lies within the Belmore Creek catchment with a very gentle slope (1:140) to the north-west with no defined drainage network. Sheetflow is the dominant hydrological runoff mechanism.

2.3 SURFACE HYDROLOGY

The Project receives highly seasonal rainfall and therefore all local creeks are ephemeral. The only permanent source of surface water (other than water within the open pits) is within the borrow pit located off ML 5248 on Belmore Creek to the west of the Content mining area (Figure 2). No hydrological flow gauging records exist for the ML 5248 area. However given the highly seasonal nature of rainfall in the area, it is expected that runoff in local creeks and drainage lines cease relatively soon after storm events.



The topographic map shows the study area with contour lines indicating elevation. A river is depicted in blue, and a road is shown in black. The map includes a scale bar and a north arrow.

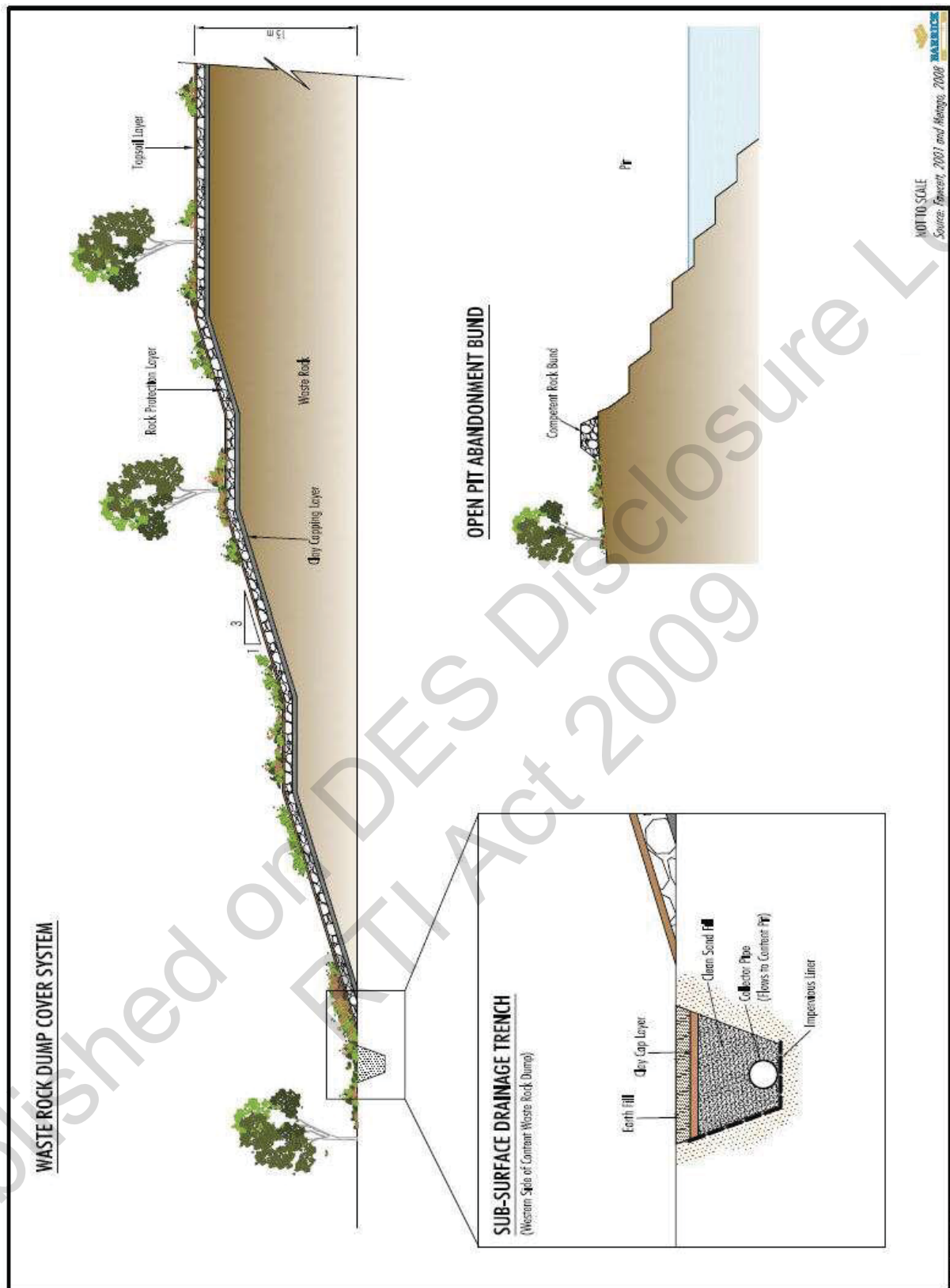


Figure 3: Waste Rock Dump Cover System and Open Pit Abandonment Bund Schematic Cross Sections

In the northern section of ML 5248 seasonal surface water runoff does contribute to the surface water storage in Belmore Creek borrow pit (SW6). In the southern section ML 5248 seasonal surface runoff probably provides some recharge to the shallow alluvial aquifer located along the lower section of Slaughteryard Creek (the original town borefield). However the western tributary that originates on the ML 5248 area constitutes a very small component of the overall Slaughteryard Creek catchment. Figure 4 identifies the surface water drainage flow on ML 5248. A summary of the most recent surface water quality data from 2000 to 2011 is provided in Attachment A.

All four mine pits now contain pit lakes. Pit lake water quality data for each pit lake is provided in Attachment A, with pit lake water quality time series graphs presented in Attachment B. The Golden Butterfly Pit Lake has low pH and raised levels of sulphate, aluminium, arsenic, cadmium, copper, nickel and zinc. Both the Content and Lady Isabella Pits have water quality that meets ANZECC (2000) stock water quality guidelines except for pH, which is below the lower limit, and in the case of Lady Isabella Pit cadmium concentration is also above ANZECC (2000) stock water quality guidelines. Consequently, the Content and Lady Isabella pit lakes are considered potential stock water supplies. Reference to the time series graphs in Attachment B clearly show an improving trend in water quality versus time within these pits.

Water quality in Golden Butterfly North Pit Lake is considered of good quality and meets ANZECC (2000) livestock drinking water quality guidelines. The Golden Butterfly North Pit does receive a limited amount of surface runoff from the area to the immediate north-east. Water from this pit lake has in the recent past been used by the Croydon Shire Council for irrigation of town recreational areas.

An investigation conducted by HLA-Envirosciences (2001b) showed that historic rainfall and evaporation data indicate a relatively large deficit due to the short wet season and high evaporation during most of the year. The investigation concluded that even in the wettest years there is no risk of the open pit lakes overtopping. The pits therefore represent groundwater sinks with limited capacity to influence groundwater quality much beyond the immediate footprint of the pit.

The consecutive unprecedented rainfall totals experienced since 2008/2009 support this conclusion in regards to the Golden Butterfly and Golden Butterfly North Pits. However, the overtopping and discharge from the Content Pit during early 2011 obviously shows that the conceptual hydrogeological model in terms of the Content Pit and Lady Isabella Pit, in view of the additional rainfall data currently available, inadequately describes the physical situation. Section 6 details the hydrological data collection and modelling to be undertaken to provide a validated predictive representation of the Content Pit and Lady Isabella Pits to inform management options.

2.4 HYDROGEOLOGY

ML 5248 contains no springs or groundwater supported surface drainage features. Groundwater occurs in deep fractured rock aquifers, but is not utilised as a water resource on or adjacent to ML 5248. Any aquifers linked to the main mineralised zones might be expected to have raised levels of metals and sulphate. This assumption is supported by water quality analysis from the monitoring bores located in this area. It is likely that water quality will vary significantly between individual fractured rock aquifers, with limited hydrogeological linkage between aquifers. These aquifers would therefore not be considered as potential potable water supplies, irrespective of potential yields.

The original Croydon town borefield, decommissioned more than 12 years ago, is located within Slaughteryard Creek approximately one kilometre south-west of Golden Butterfly Pit. No bore logs or water quality data is available for these bores which are known to have been relatively shallow, exploiting both an unconfined alluvial aquifer and deeper fractured rock aquifers in the underlying sandstone units. Bore yields were never more than 1.25 litres per second (L/sec) and over time dropped to less than 0.25 L/sec resulting in their abandonment (Croydon Shire Council, pers. com., April, 2008).

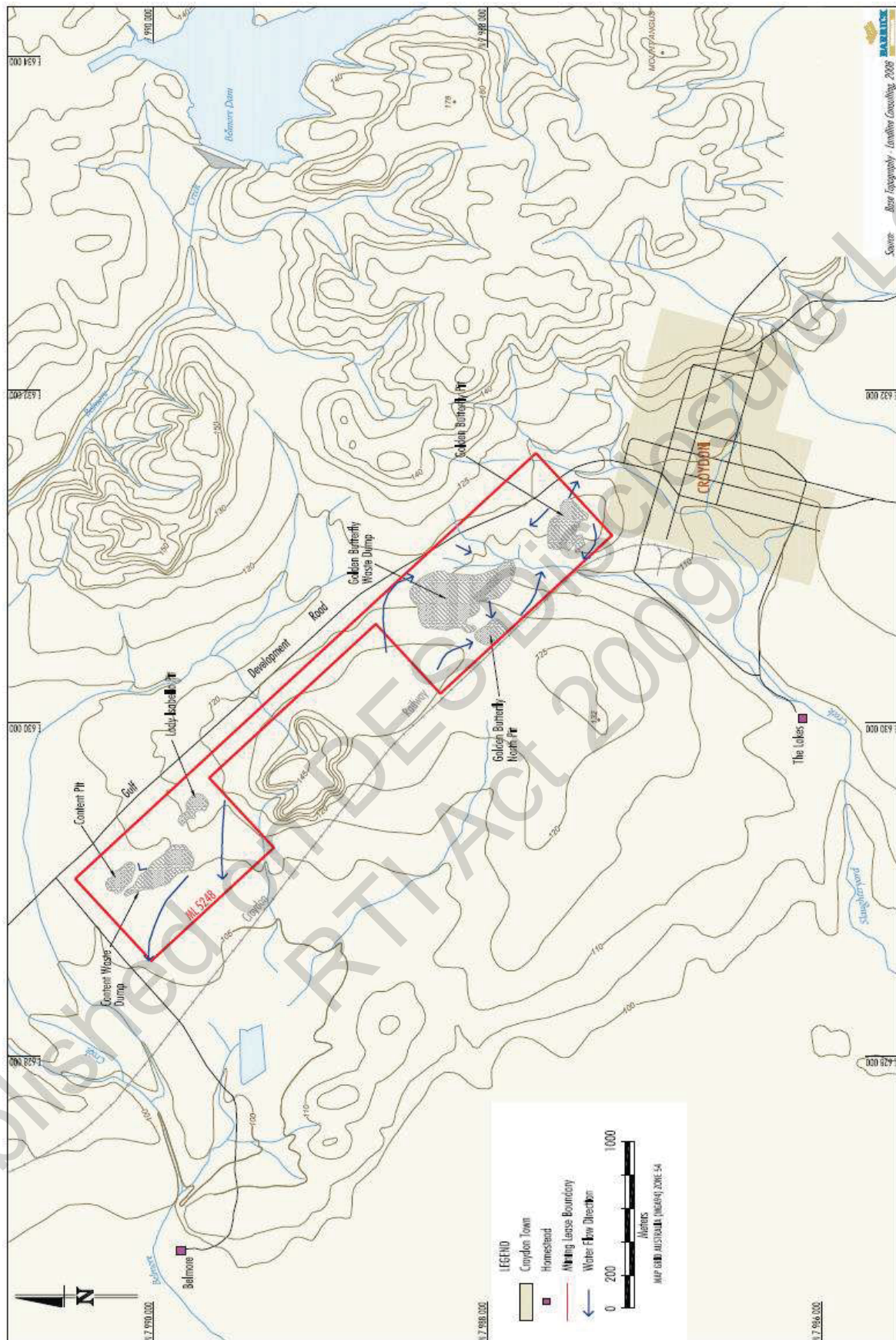


Figure 4: Site Drainage

An attempt was made at an artificial recharge scheme, but this was soon abandoned due to contamination as a result of acid mine drainage (AMD) from the Golden Butterfly waste rock dump and hardstand area. The source of AMD was removed during the 1996/1997 reclamation works and any contaminated soil within the creek removed (HLA-Envirosciences, 2001b).

Two shallow wells (1.2 metres diameter and 15 metres deep) located on the eastern side of the borefield are still used for irrigation of the town oval. The water quality is considered acceptable but has high iron content and requires lime dosing. A series of monitoring bores located between the old town borefield and ML 5248 have been monitored over 14 years and continue to show no influence (i.e. hydrogeological linkage) between Golden Butterfly Pit and the borefield. A summary of the most recent groundwater quality data from 2000 to 2011 is provided in Attachment A.

3 DRAINAGE MANAGEMENT PLAN

Drainage management strategies are proposed for all post-mining related landforms. It is considered these management strategies could impact drainage patterns within ML 5248.

3.1 GOLDEN BUTTERFLY WASTE ROCK DUMP

The Golden Butterfly waste rock dump was capped with an engineered cover system consisting of a clay capping layer, a rock fill surface protection layer and topsoil layer during the reclamation works conducted in 1996/1997. During periods of extreme rainfall any excess water from the waste rock dump surface is engineered to spill down rock lined drains that follow the original haul ramp to discharge to the western tributary of Slaughteryard Creek.

In addition an open seepage collection trench was excavated along the eastern toe of the waste rock dump. Water monitoring has been conducted at this trench for more than 14 years and no seepage or contaminant discharge has been observed. The trench also collects surface runoff from the natural catchment to the east of the waste rock dump and channels this water into the western tributary of Slaughteryard Creek. Additional details of the reclamation works conducted in 1996/1997 are provided in the Post Mine Landuse Plan (Appendix A of the Plan of Operations [Barrick, 2008a]).

Proposed Drainage Management Strategy

No further drainage management measures are considered necessary for the Golden Butterfly waste rock dump area. However, surface water and groundwater monitoring will be continued in accordance with the Rehabilitation Monitoring Program (Attachment A of Appendix A of the Plan of Operations [Barrick, 2008a]).

3.2 CONTENT WASTE ROCK DUMP

The Content waste rock dump was capped with an engineered cover system consisting of a clay capping layer and a rock fill surface protection layer during the reclamation works conducted in 1996/1997. At the time the rehabilitation and revegetation status of the waste rock dump western batter was considered adequate and no capping was constructed on this section of the waste rock dump (HLA-Envirosciences, 2001a).

The northern most section of the waste rock dump upper surface was not levelled to the same degree as the remainder of the dump. Subsequently some surface ponding has been noted to occur during extreme rainfall events. General erosion control works were conducted to the north-western part of the waste rock dump in 2009/2010. Several small gullies were beginning to form on the upper crest where water was concentrated in deep vehicle rut marks and localised depressions. Back fill material, sourced from the Golden Butterfly waste rock dump east haul ramp, was utilised to fill these localised depressions to reduce infiltration through the waste rock dump. No excavation was conducted on the top surface of the waste rock dump to avoid potential impacts to the integrity of the clay capping layer. Subsequent rainfall and surface runoff has not caused a recurrence and no further general erosion control works on the Content Waste Rock Dump are currently planned. Continual regular review will be undertaken to ascertain if potential problems are developing in order to schedule any necessary remedial action.

Proposed Drainage Management Strategy

No further drainage management measures are considered necessary for the Content waste rock dump area. However, surface water and groundwater monitoring will be continued in accordance with the Rehabilitation Monitoring Program (Attachment A of Appendix A of the Plan of Operations [Barrick, 2008a]).

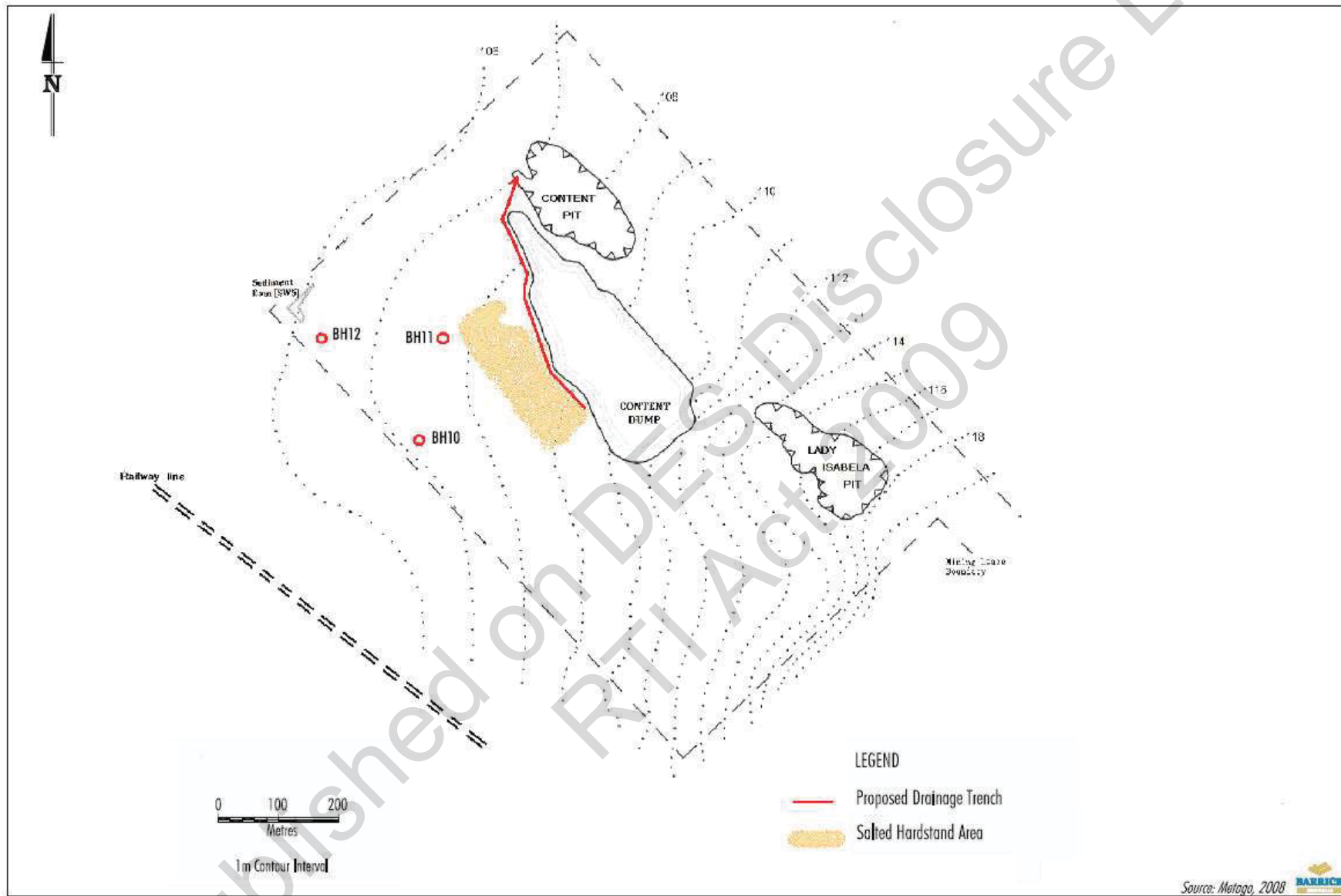


Figure 5: Proposed Reclamation Work on Content Waste Rock Dump

Three additional groundwater monitoring bores (BH10, BH11 and BH12) (Figure 5) were constructed to the west of Content waste rock dump to monitor the performance of the proposed works. Continual review of the groundwater hydrology to enable refining of the hydrogeological model may result in additional bores in the area of the Content waste rock dump to provide better resolution groundwater level data.

3.3 GOLDEN BUTTERFLY PIT

Water levels in the Golden Butterfly Pit Lake are slowly rising and are expected after several decades to reach equilibrium well below the upper pit crest (Barrick, 2008). A water balance conducted by HLAEnvirosciences (2001b) indicates that based on historic rainfall and evaporation data there is no risk of the Golden Butterfly Pit overflowing even during the wettest rainfall cycles. The consecutive unprecedented rainfall totals experienced since 2008/2009 support this conclusion in regards to the Golden Butterfly and Golden Butterfly North Pits.

The abandonment bund restricts any surface water discharge into the pit from surrounding areas. The pit represents a groundwater sink with limited capacity to influence groundwater quality much beyond the immediate footprint of the pit. The upper section of the access ramp to the pit has been engineered to restrict any vehicle access and the abandonment bund has been extended across the access ramp (Figure 3). The extension of the abandonment bund further reduces the amount of surface water reporting to the Golden Butterfly Pit. A water level gauging station has been installed so that pit water levels may be regularly monitored.

Proposed Drainage Management Strategy

Groundwater monitoring will be conducted in accordance with the Rehabilitation Monitoring Program (Attachment A of Appendix A of the Plan of Operations [Barrick, 2008a]).

3.4 GOLDEN BUTTERFLY NORTH PIT

The water quality in the Golden Butterfly North Pit is expected to remain fresh for some time however it is considered that the water will become brackish and even saline with time (i.e. 100s of years). The pit represents a groundwater sink with limited capacity to influence groundwater quality much beyond the immediate footprint of the void. Two bores (a deep and shallow bore) (BH8 and BH9) (Figure 2) have been drilled between the pit and Golden Butterfly waste rock dump and the Golden Butterfly North Pit to identify seepage which may be migrating towards the pit lake from the waste rock dump. Although the pit lake water quality is considered as a potential water resource, vehicle access to the pit has been restricted for safety reasons.

The upper section of the access ramp to the pit has been engineered to restrict vehicle access and the abandonment bund has been extended across the access ramp with a gate installed (Figure 3). The extension of the abandonment bund further reduces the amount of surface water reporting to the Golden Butterfly North Pit. A water level gauging station has been installed so that pit water levels may be monitored.

Proposed Drainage Management Strategy

Groundwater monitoring will be conducted in accordance with the Rehabilitation Monitoring Program (Attachment A of Appendix A of the Plan of Operations [Barrick, 2008a]).

3.5 CONTENT PIT

An investigation conducted by HLA-Envirosciences (2001b) showed that historic rainfall and evaporation data indicate a relatively large deficit due to the short wet season and high evaporation during most of the year. The investigation concluded that even in the wettest years there is no risk of the open pit lakes overflowing.

The 2008/2009 and 2009/2010 wet seasons resulted in extraordinary rainfall totals. In recognition of the possibility of a discharge from the Content Pit, Barrick had undertaken short-term remediation works involving the transfer from water from the Content Pit to the Golden Butterfly Pit to minimise the risk of the Content Pit overtopping during the 2010/2011 wet season. The water level of the Content Pit was decreased by approximately four (4) meters during November and December 2010 (with a subsequent increase of one (1) meter in the Golden Butterfly Pit). Nevertheless, on the 29th March 2011 the Content Pit began discharging water which continued until the 13th April 2011 when no flow was observed to be entering receiving streams. This event obviously shows that the conceptual hydrogeological model in terms of the Content Pit, in view of the additional rainfall data currently available, inadequately describes the physical situation.

A possible addition to the hydrogeological model for the Content Pit is the inclusion of a hydraulic connection with the Lady Isabella Pit. The Lady Isabella Pit when full is approximately five meters higher in elevation than the Content Pit discharge level. This elevation difference provides a hydraulic driving force which with the relative close proximity of the Lady Isabella Pit to the Content Pit and possible connecting fracture zones and or fault lines enabling water flow. Section 6 details the hydrological data collection and modelling to be undertaken to provide a validated predictive representation of the Content Pit and Lady Isabella Pits to better inform management options.

The upper section of the access ramp to the pit has been engineered to restrict vehicle access and the abandonment bund has been extended across the access ramp with a gate installed (Figure 3). The extension of the abandonment bund further reduces the amount of surface water reporting to the Content Pit. Additional diversion drains were installed during 2009/2010 to ensure surface water flow in the vicinity of the Content Pit is maintained as much as possible to avoid ponding which may increase groundwater infiltration and possible input to the Content Pit lake.

Proposed Drainage Management Strategy

A water level gauging station was installed so that pit water levels may be monitored. Groundwater monitoring will be conducted in accordance with the Rehabilitation Monitoring Program (Attachment A of Appendix A of the Plan of Operations [Barrick, 2008a]).

3.6 LADY ISABELLA PIT

An investigation conducted by HLA-Envirosciences (2001b) showed that historic rainfall and evaporation data indicate a relatively large deficit due to the short wet season and high evaporation during most of the year. The investigation concluded that even in the wettest years there is no risk of the open pit lakes overtopping.

The 2008/2009 and 2009/2010 wet seasons had extraordinary rainfall totals which resulted in the Lady Isabella Pit being full to capacity during early 2011, but with no overtopping and discharge observed. This event obviously shows that the conceptual hydrogeological model in terms of the Lady Isabella Pit, in view of the additional rainfall data currently available, inadequately describes the physical situation.

A possible addition to the hydrogeological model for the Lady Isabella Pit is the inclusion of a hydraulic connection with the Content Pit. The Lady Isabella Pit when full is approximately five meters higher in elevation than the Content Pit discharge level. This elevation difference provides a hydraulic driving force which with the relative close proximity of the Lady Isabella Pit to the Content Pit and possible connecting fracture zones and or fault lines enabling water flow. Section 6 details the hydrological data collection and modelling to be undertaken to provide a validated predictive representation of the Content Pit and Lady Isabella Pits to better inform management options.

Proposed Drainage Management Strategy

The upper section of the access ramp to the pit has been engineered to restrict vehicle access and the abandonment bund has been extended across the access ramp (Figure 3). The extension of the abandonment bund further reduces the amount of surface water reporting to the Lady Isabella Pit. A water level gauging station has been installed so that pit water levels may be monitored. Groundwater monitoring will be conducted in accordance with the groundwater monitoring program. Details are provided in the Rehabilitation Monitoring Program (Attachment A of Appendix A of the Plan of Operations [Barrick, 2008a]).

3.7 STOCK WATERING DAM

The stock watering dam (i.e. SW4 surface water monitoring site) (Figure 2) is located to the north of Golden Butterfly Pit and captures runoff from the natural catchment to the immediate east of the mining area. Any spillage from this facility is directed into the western tributary of Slaughteryard Creek.

Proposed Drainage Management Strategy

No further drainage management measures are considered necessary for site SW4. However, surface water and groundwater monitoring will be continued in accordance with the Rehabilitation Monitoring Program (Attachment A of Appendix A of the Plan of Operations [Barrick, 2008a]).

4 MONITORING PROGRAM

All surface water and groundwater monitoring will be conducted in accordance with the Rehabilitation Monitoring Program which is provided in Attachment A of Appendix A of the Plan of Operations (Barrick, 2008a).

5 PROJECT WATER REQUIREMENTS

As the Project is decommissioned/closed no water is currently required on-site. In the event a water supply is required during the proposed reclamation works, water would be sourced from the Golden Butterfly North Pit.

6 HYDROLOGICAL MODELLING

Details of the existing conceptual and mathematical modelling of the hydrological environment of the Croydon site are provided in the Post Mine Landuse Plan (Barrick, 2011). An investigation conducted by HLA-Envirosciences (2001b) showed that historic rainfall and evaporation data indicate a relatively large deficit due to the short wet season and high evaporation during most of the year. The investigation concluded that even in the wettest years there is no risk of the open pit lakes overtopping. The consecutive unprecedented rainfall totals experienced since 2008/2009 support this conclusion in regards to the Golden Butterfly and Golden Butterfly North Pits (see Figure 6). However, the overtopping of the Content Pit and the filling to capacity of the Lady Isabella Pit in 2011 obviously shows that the conceptual hydrogeological model in terms of these two pits, in view of the additional rainfall data currently available, inadequately describes the physical situation.

As previously discussed (Section 2.3) the Content Pit and Lady Isabella Pit show improving trends in pit lake water quality and are potential stock water supplies (see Attachment A and B for pit lake water quality summaries) whereas the Golden Butterfly Pit contains water of poor quality. Therefore, the existing hydrological model, confirmed by physical observation of pit lake levels, deals adequately with the pit lake that has a significant water quality issue. Nevertheless, the Content Pit and Lady Isabella Pit Lakes do not currently meet ANZECC (2000) stock water quality guidelines for pH (and in the case of Lady Isabella Pit for cadmium, which is marginally above the limit with a decreasing

trend). Therefore, a program of hydrological data collection and modelling will be undertaken to provide a validated predictive representation of the Content Pit and Lady Isabella Pits to better inform management options.

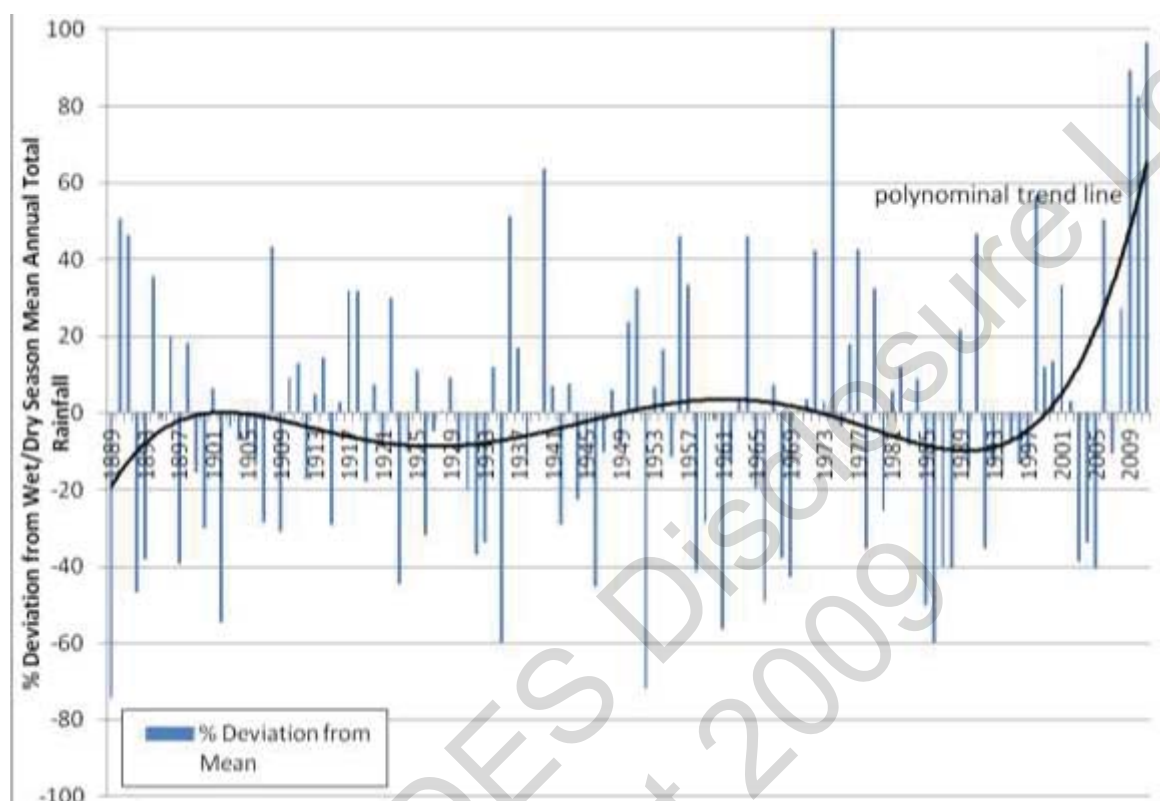


Figure 6: Croydon wet/dry season rainfall, %deviation from annual mean

The use of computer modelling has obvious benefits in providing information to form the basis of management decisions regarding water quantity and quality considering the complexities of the systems being considered. However, the level of abstraction required in order to provide this summary management information can also mask underlying knowledge gaps and or inaccurate assumptions. “The output from a model is only as good as the input data ... If the data are of low quality, the output will be poor no matter how sophisticated the model ... If the model’s structure poorly approximates the operation of the real system, the output will always be poor no matter how good the input data.” (Thompson, 1999).

In view of this, a data review of available information from the Croydon site was undertaken by Australasian Groundwater & Environmental Consultants Pty Ltd (AGE, 2011). The review concluded that direct rainfall alone does not explain the significant water level rises in the Content Pit and Lady Isabella Pit, and noted the following:

- A groundwater contribution must be occurring.
- Ponding of water, groundwater flow along the ore zone, or groundwater flow from the waste rock dumps, are considered unlikely causes of pit overflow.
- There is little subsurface and groundwater information available for the Content and Lady Isabella Pits areas
- The influence and presence of possible historic mine workings is currently unknown, but potentially significant; and
- The nature of the ferricrete layer needs better understanding due to influences on infiltration.

Therefore, in order to refine the existing conceptual hydrogeological model additional information beyond what has been identified during the initial data review is required, including:

- Characterisation of local geological structures (particularly the ferricrete layer);
- Characterisation of aquifer physical properties (e.g. permeability);
- Characterisation of local water levels and other groundwater investigations; and
- Location of historical mine shafts.

Such information collection, collation and interpretation is necessarily the preliminary step prior to selecting an appropriate computer modelling approach. The actual modelling (i.e. the computer code and output) will aim to identify any long term risk of pit overtopping and estimate likely frequencies and volumes of any such events. The final void water balance models for the various pits will utilise available contour data (for catchment area estimation) and open pit depth-volume data. Rainfall data would be developed from the available Bureau of Meteorology database. Key to the water balance model will be estimates of groundwater inflow/outflow provided by the initial groundwater investigation based upon the refined conceptual hydrogeological discussed previously. Model calibration will be based upon monitored pit void water levels.

In order to provide additional information to assist in refining the conceptual hydrological model, a series of water level monitoring stations have been installed during November 2011 in each of the pit lakes at Croydon. Each of these stations is fitted with a pressure sensor transducer connected to a data logger with solar powered battery supply. Additionally, in the event of a further discharge from the Content Pit, a measuring flume has been installed in the v-drain which will direct any outflow from the Content Pit. Further, a tipping bucket rain gauge with datalogger has been installed at the Content Pit. This will provide detailed rainfall intensity data to augment the Bureau of Meteorology data.

7 REVIEW

EA Condition F7-2 is of additional relevance to this WMS and is provided below:

F7-2 An annual review of the water management strategy must be submitted by November each year.

In accordance with EA Condition F7-2 this WMS will be reviewed, and if necessary updated, annually. This review will be submitted to the EPA by November of each year.

8 REFERENCES

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HLA-Envirosciences (2001b) *Water Level Analysis of Golden Butterfly Pit – Croydon Gold Mine*. Report prepared for Goldfields Limited, May, 2001.

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ATTACHMENT A

WATER QUALITY SUMMARY TABLES

Table 1: Water Quality Summary of Surface Water Monitoring Sites 2000- 2014

Parameter	Sample Site													
	SW1		SW2		SW3		SW3b		SW4		SW5		SW6	
	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average
pH (pH units)	6.2-9.2	7.20	5.7-9.1	6.78	6.2-8.00	6.96	5.3-6.76	6.16	6.4-9.3	7.45	3.5-6.75	4.3	5.3-9.0	7.4
EC (µS/cm)	77-610	245	64-301	144	38-450	116	17-97	54	38-770	159	32-1400	473	24-480	105
S04 (mg/L)	12-100	44	18-96	42	9-140	25.3	5-23	12.4	8-150	32	6-810	210	<1-43	12.6
Cu (mg/L)	0.004-0.063	0.019	<0.001 – 0.022	0.01	0.001-0.05	0.02	0.001-0.03	0.01	0.002-0.020	0.008	<0.001-2.5	0.38	0.001-0.158	0.018
Pb (mg/L)	<0.001-0.004	0.002*	0.001-0.01	<0.002*	<0.002-0.004	<0.002*	<0.002-0.004	<0.002*	0.001-0.012	0.004	<0.002-0.006	<0.002*	<0.002-0.047	0.006*
Ni (mg/L)	<0.002-0.003	0.002	<0.001 – 0.011	0.004	<0.001-0.03	0.02	<0.001-0.03	0.01	<0.001-0.025	0.010	<0.001-1.0	0.20	<0.001-0.025	0.017
Al (mg/L)	0.06-2.7	0.55	0.01-18	1.08	<0.05-3.5	0.41	<0.01-0.62	0.12	0.03-11.0	0.93	0.11-77	9.8	0.025-350	9.1
Zn (mg/L)	0.008-0.03	0.018	<0.005 – 0.07	0.04	0.003-0.17	0.02	0.01-0.03	0.01	<0.005-0.110	0.020	<0.005-6.0	0.95	<0.005-0.073	0.019
Co (mg/L)	<0.005-0.05	<0.05*	<0.001-0.003	0.002	<0.001-0.03	0.3	<0.001-0.03	0.01	<0.001-0.05	<0.05*	<0.001-1.0	0.21	<0.001-0.025	0.020
Cd (mg/L)	<0.0002-0.00025	<0.0002*	<0.0001-0.0002	0.0001	<0.0001-0.0003	0.0001	<0.0001-0.0003	0.0001	<0.0001-0.0002	0.0001	<0.0001-0.24	0.036	<0.0001-0.0004	0.0001
Fe (mg/L)	0.33-2.7	1.19	0.27-1.2	0.69	0.73-5.2	2.05	0.33-1.2	0.77	0.42-5.1	1.30	0.08-0.39	0.24	0.57-13	2.6
Mn (mg/L)	<0.05-0.24	<0.05*	<0.05-0.014	0.08*	<0.05-1.9	<0.05*	<0.05-0.07	<0.05*	<0.05-0.14	<0.05*	0.31-10	3.69	<0.05-0.14	<0.05*
As (mg/L)	<0.005-0.033	0.010	<0.001 – 0.055	0.02	0.002-0.07	0.01	<0.001-0.018	0.004	0.003-0.04	0.01	0.002-0.02	0.004	<0.001-0.011	0.003

Notes: * indicates median, below detection results have been replaced with half the relevant detection limit to calculate averages.

Table 2: Pit Lake Water Quality 2000-2014

Parameter	Sample Site							
	Golden Butterfly		Golden Butterfly North		Content		Lady Isabella	
	Range	Average	Range	Average	Range	Average	Range	Average
pH (pH units)	2.3-2.8	2.5	5.8-7.7	6.8	3.3-4.3	3.8	3.4-4.6	3.7
EC (µS/cm)	2910-12000	5971	60-370	270	737-1800	1135	491-1300	891
SO₄ (mg/L)	1910-8000	5130	11-92	69	300-780	483	180-610	372
Cu (mg/L)	3.3-24	14.1	<0.005-<0.05	<0.05*	0.048-0.28	0.12	0.13-1.4	0.69
Pb (mg/L)	<0.002-<0.005	<0.005*	<0.001-<0.002	<0.002*	<0.001-<0.002	<0.002*	0.002-0.007	0.003
Ni (mg/L)	1.56-8.5	5.10	<0.004-<0.05	<0.05*	0.087-0.32	0.18	0.14-0.77	0.39
Al (mg/L)	122-700	436	0.025-0.73	0.20	1.31-7.0	3.1	2.98-20	9.8
Zn (mg/L)	2.4-36	19.2	<0.005-0.05	0.011	0.23-1.1	0.58	0.82-5.8	2.98
Co (mg/L)	1.24-7.3	3.5	<0.005-<0.05	<0.05*	0.09-0.29	0.14	0.109-0.53	0.25
Cd (mg/L)	0.055-0.34	0.19	<0.0001-0.0002	<0.0002*	0.0021-0.023	0.006	0.013-0.19	0.08
Fe (mg/L)	240-450	356	<0.05-0.18	0.06*	0.69-1.5	0.95	<0.05-0.66	0.23*
Mn (mg/L)	56-110	79	<0.05-0.17	<0.05*	3.7-5.2	4.4	3.3-6.3	4.7
As (mg/L)	0.34-1.3	0.71	<0.005-0.01	<0.005*	<0.005-0.058	0.015	<0.003-0.013	0.004

Notes: * indicates median, below detection results have been replaced with half the relevant detection limit to calculate averages.

Table 3: Groundwater Quality – Confined Fractured Rock Aquifer 1995 - 2009

Parameter	Sample Site																	
	BH1		BH2		BH3		BH4		BH5		BH6		BH7		GBMB1		GBMB2	
	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median	Range (n)	Average Median
pH (pH units)	6.1-7.9 (42)	7.2 7.2	3.3-6.5 (41)	3.7 3.6	5.5-7.7 (35)	6.41 6.4	6.9-8.6	7.4	7.3-7.8 (13)	7.5 7.5	6.9-7.5	7.15	6.4-7.1	6.8	6.4-7	6.7	6.9-7.7	7.3
EC (µS/cm)	985-2260 (42)	1298 1300	740-1300 (41)	1016 980	110-3000 (35)	604 340	4800- 7200	5611	4900-6800 (13)	5550 5600	480-2200	933	6400- 8700	7472	160-760	591	2200- 2700	2491
SO ₄ (mg/L)	310-1160 (42)	471 460	260-850 (40)	442 435	20-990 (35)	172 100	1200- 1800	1522	1400-2000 (13)	1733 1800	59-530	172	1400- 2600	1950	36-190	120	630-790	703
Cu (mg/L)	<0.001-0.05 (16)	0.008 0.005	0.002-0.05 (15)	0.011 0.005	0.001-0.025 (13)	0.009 0.005	<0.001- <0.05	<0.01	<0.001-0.03 (13)	0.007 0.005	0.009- 0.02	0.01	<0.003- 0.03	<0.01	0.001- 0.01	<0.01	<0.001- <0.05	<0.01
Pb (mg/L)	<0.001-0.35 (13)	0.031 0.001	<0.001- 0.15 (13)	0.051 0.046	<0.001- 0.072 (11)	0.013 0.001	<0.001- 0.006	<0.002	<0.001-0.24 (11)	0.023 0.001	<0.002- 0.056	0.009	<0.001- 0.35	<0.002	<0.002- 0.003	<0.002	<0.002- 0.02	0.002
Ni (mg/L)	0.002-0.025 (16)	0.016 0.025	0.025-0.09 (15)	0.056 0.05	<0.001- 0.025 (10)	0.014 0.0145	<0.002- <0.05	<0.05	<0.001-0.025 (13)	0.016 0.025	0.002- <0.05	<0.05	0.004- <0.05	<0.05	0.02- <0.05	<0.05	<0.002- <0.05	<0.05
Al (mg/L)	0.02-0.25 (15)	0.045 0.025	0.16-2.7 (14)	1.54 1.65	0.07-2.1 (10)	0.49 0.33	<0.05- 0.37	<0.05	<0.01-0.29 (13)	0.049 0.025	0.14-6.8	2.35	<0.05- 0.16	<0.05	<0.05- 0.092	<0.05	<0.05- 0.21	<0.05
Zn (mg/L)	0.01-0.18 (16)	0.053 0.038	0.043-1.06 (15)	0.40 0.36	<0.005 2.9 (13)	0.24 0.015	0.008- 0.04	0.017	0.0025-0.032 (13)	0.0127 0.012	0.005- 0.055	0.021	0.029- 0.15	0.072	0.012- 0.047	0.024	0.011- 0.056	0.028
Co (mg/L)	<0.001- 0.025 (11)	0.016 0.025	0.018- 0.045 (11)	0.018 0.025	<0.001- 0.025 (9)	0.015 0.025	<0.005- <0.05	<0.05	<0.001-<0.05	<0.05	<0.005- <0.05	<0.05	<0.005- 0.07	<0.05	<0.05- <0.05	<0.05	<0.005- <0.05	<0.05
Cd (mg/L)	<0.0001- 0.0025 (16)	0.0003 0.0001	<0.0001- 0.0025 (15)	0.0007 0.0007	<0.0001- 0.0009 (13)	0.0002 0.0001	<0.0001- 0.0003	<0.0002	<0.0005- 0.0004 (13)	<0.0005 0.0001	<0.0001- <0.0002	<0.0002	0.0002- 0.002	0.00085	<0.0001- 0.0067	0.0005	<0.0001- 0.0003	<0.0002*
Fe (mg/L)	<0.05-3.2 (32)	0.436 0.1	0.025-27 (32)	4.54 1.3	0.025-1.75 (29)	0.33 0.25	<0.05- <0.05	<0.05	<0.05-0.09 (5)	<0.05	0.06-3.1	1.4	<0.05- 0.27	<0.05	<0.05- 0.08	<0.05	<0.05- <0.05	<0.05
Mn (mg/L)	<0.05-1.19 (8)	0.247 0.075	0.95-1.97 (8)	1.23 1.1	0.0025- 0.025 (4)	0.019 0.025	<0.05- <0.05	<0.05	<0.05-0.06 (7)	0.034 0.025	<0.05- 0.68	0.06	<0.05- 1.9	<0.05	0.26-1.4	0.83	0.67-1.2	0.90
As (mg/L)	0.01-0.022 (16)	0.014 0.014	<0.001- 0.09 (15)	0.008 0.025	<0.003-0.03 (13)	0.010 0.009	<0.005- 0.003	<0.005	<0.05-0.009 (13)	0.012 0.007	0.013- 0.048	0.026	<0.005- 0.007	<0.005	0.007- 0.034	0.02	<0.003- 0.023	<0.005

* Below detection limit results have been substituted with a value of half of the detection limit

Table 4: Groundwater Quality – Unconfined Alluvial Aquifer 2001 - 2014

Parameter	Sample Site							
	GBMB3		GBMB4		GBMB5		GBMB6	
	Range	Average	Range	Average	Range	Average	Range	Average
pH (pH units)	5.7-6.8	6.2	5.9-6.5	6.1	5.6-7.1	6.0	5.7-7.1	6.2
EC ($\mu\text{S}/\text{cm}$)	52-110	79.4	260-350	308	68-490	114	66-580	152
SO_4 (mg/L)	3-13	6.3	17-38	28.8	2-13	4.4	3-19	7.1
Cu (mg/L)	0.001-0.01	<0.01*	<0.001-<0.05	<0.01*	<0.001-0.01	<0.01*	<0.001-<0.05	<0.01*
Pb (mg/L)	0.002-0.018	0.008	<0.001-0.008	<0.002*	<0.001-0.004	<0.002*	<0.001-0.31	<0.002*
Ni (mg/L)	<0.002-<0.05	<0.05*	<0.002-<0.05	<0.05*	<0.002-<0.05	<0.05*	<0.002-<0.05	<0.05*
Al (mg/L)	0.07-4.8	0.99	<0.05-0.29	<0.05*	<0.05-0.05	<0.05*	<0.05-0.69	<0.05*
Zn (mg/L)	0.017-0.11	0.052	0.006-0.18	0.043	0.01-.015	0.08	<0.005-0.092	0.025*
Co (mg/L)	<0.005-<0.05	<0.05*	<0.005-<0.05	<0.05*	<0.005-<0.05	<0.05*	<0.005-<0.05	<0.05*
Cd (mg/L)	<0.0002-<0.0002	<0.0002*	<0.0001-0.0018	<0.0002*	<0.0001-<0.0002	<0.0002*	<0.0001-<0.0002	<0.0002*
Fe (mg/L)	0.53-3	1.8	<0.05-6.6	0.18*	<0.05-<0.05	<0.05	<0.05-0.39	<0.05*
Mn (mg/L)	<0.05-0.15	0.05*	<0.05-.07	<0.05*	<0.05-0.26	<0.05*	<0.05-.037	<0.05*
As (mg/L)	0.003-0.012	<0.005*	<0.003-0.007	<0.005*	<0.003-0.091	<0.005*	<0.005-0.15	0.005

* indicates Median.

Table 5: Groundwater monitoring results 2010 – 2014

Site	Date	pH	EC (µS/cm)	Fluoride (mg/L)	Sulfate (mg/L)	Aluminium (mg/L)	Arsenic (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Zinc (mg/L)
BH01	29/03/2010	7.94	1420	3.7	473	0.01	0.013	<0.05	<0.0001	<0.01	<0.001	0.004	<0.0001	<0.001	<0.01	0.049
BH01	22/08/2011	8	1390	4	497	0.04	0.014	<0.05	<0.0001	<0.001	<0.001	0.002	<0.0001	<0.001	<0.01	0.023
BH01	20/09/2011	7.62	1410	3.7	476	<0.01	0.01	<0.05	<0.0001	<0.001	<0.001	0.001	<0.0001	<0.001	<0.01	0.013
BH01	07/09/2012	7.55	1390	3.6	384	<0.01	0.013	<0.05	<0.0001	0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	0.011
BH01	24/06/2013	7.82	1420	3.9	485	<0.01	0.015	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	0.011
BH01	31/7/2014	7.58	1360	4.7	563	<0.01	0.015	<0.05	<0.0001	<0.001	<0.001	0.003	<0.0001	<0.001	<0.01	0.026
BH02	20/11/2010	3.69	940	0.8	374	0.99	0.001	<0.05	0.0001	<0.010	0.017	0.003	<0.0001	0.027	<0.01	0.204
BH02	22/08/2011	3.7	934	1.4	383	0.96	<0.001	<0.05	0.0001	<0.001	0.016	0.01	<0.0001	0.026	<0.01	0.171
BH02	20/09/2011	3.69	989	1.2	380	1.05	0.001	<0.05	0.0004	<0.001	0.019	0.015	<0.0001	0.034	<0.01	0.183
BH02	08/07/2012	3.67	982	1.3	362	1.06	0.001	<0.05	0.0002	0.002	0.016	0.014	<0.0001	0.027	<0.01	0.153
BH02	24/06/2013	3.73	995	1.2	353	1.46	<0.001	<0.05	0.0002	<0.001	0.017	0.021	<0.0001	0.029	<0.01	0.236
BH02	31/7/2014	4.04	931	1.5	415	1.45	0.004	<0.05	0.0001	<0.001	0.016	0.026	<0.0001	0.028	<0.01	0.198
BH03	20/11/2010	8	746	3.6	148	0.43	0.01	<0.05	<0.0001	<0.010	<0.001	0.003	<0.0001	<0.001	<0.01	0.031
BH03	23/08/2011	7.08	454	2.9	92	0.17	0.008	<0.05	<0.0001	<0.001	0.003	0.003	<0.0001	0.002	<0.01	0.007
BH03	20/09/2011	7.09	499	3	95	0.23	0.031	<0.05	<0.0001	<0.001	0.006	0.002	<0.0001	0.002	<0.01	0.007
BH03	08/07/2012	7.12	474	2.6	100	0.03	0.008	<0.05	<0.0001	0.002	<0.001	0.003	<0.0001	0.002	<0.01	<0.005
BH03	24/06/2013	6.97	317	2	70	3.04	0.009	<0.05	<0.0001	<0.001	<0.001	0.004	<0.0001	0.001	<0.01	0.005
BH03	31/7/2014	6.83	800	5.3	188	0.36	0.086	<0.05	<0.0001	<0.001	0.006	0.002	<0.0001	<0.001	<0.01	0.006
BH05	20/11/2010	8.37	5500	6.6	1930	<0.01	0.005	<0.05	0.0003	<0.010	<0.001	0.004	<0.0001	<0.001	<0.01	0.02
BH05	23/08/2011	7.59	5600	7.7	2000	0.02	0.005	<0.05	0.0005	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	0.01
BH05	20/09/2011	7.05	6490	4.4	2050	<0.01	0.006	<0.05	0.0022	<0.001	<0.001	0.001	<0.0001	0.005	<0.01	0.065
BH05	08/07/2012	7.42	5420	6.7	1980	<0.01	0.004	<0.05	0.0005	0.003	<0.001	<0.001	<0.0001	<0.001	<0.01	0.011
BH05	24/06/2013	7.4	5140	7	1780	<0.01	0.004	<0.05	0.0004	<0.001	<0.001	0.001	<0.0001	<0.001	<0.01	0.015
BH05	31/7/2014	7.43	5170	10.9	2080	<0.01	0.005	<0.05	0.0003	<0.001	<0.001	0.002	<0.0001	<0.001	<0.01	0.008
BH06	20/11/2010	8.3	642	8.3	67	0.29	0.047	<0.05	<0.0001	<0.010	<0.001	0.016	<0.0001	0.003	<0.01	<0.005
BH06	08/07/2012	7.42	568	9.2	64	0.03	0.013	<0.05	<0.0001	0.002	<0.001	0.015	<0.0001	0.001	<0.01	<0.005
BH06	24/06/2013	7.42	776	10.3	96	1.36	0.014	<0.05	<0.0001	<0.001	0.001	0.009	<0.0001	0.002	<0.01	0.01
BH06	31/7/2014	7.29	1500	15.2	320	3.14	0.018	<0.05	<0.0001	<0.001	0.002	0.005	<0.0001	0.003	<0.01	0.006
BH07	20/11/2010	8	5290	6.3	1540	0.02	0.008	<0.05	0.0032	<0.010	0.005	0.051	<0.0001	0.026	<0.01	0.241
BH07	23/08/2011	7.12	5120	7.4	1540	0.03	0.004	<0.05	0.0002	<0.001	0.013	0.001	<0.0001	0.012	<0.01	0.031

Site	Date	pH	EC (µS/cm)	Fluoride (mg/L)	Sulfate (mg/L)	Aluminium (mg/L)	Arsenic (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Zinc (mg/L)
BH07	20/09/2011	6.81	5000	6.9	1470	0.02	0.013	<0.05	0.0002	<0.001	0.014	0.001	<0.0001	0.013	<0.01	0.052
BH07	08/07/2012	6.9	5070	7	1570	0.02	0.005	<0.05	0.0005	0.002	0.015	0.004	<0.0001	0.015	<0.01	0.038
BH07	24/06/2013	7.44	5250	10	1440	<0.01	0.049	<0.05	<0.0001	<0.001	0.004	<0.001	<0.0001	0.002	<0.01	0.01
BH07	31/7/2014	7.25	5360	12.8	1740	<0.01	0.017	<0.05	<0.0001	<0.001	0.003	0.002	<0.0001	0.002	<0.01	0.024
BH08	20/11/2010	7.5	118	0.5	13	0.04	0.018	<0.05	<0.0001	<0.010	<0.001	<0.001	<0.0001	0.001	<0.01	0.056
BH08	22/08/2011	5.31	110	<0.1	12	0.02	0.003	<0.05	<0.0001	<0.001	0.001	0.005	<0.0001	0.002	<0.01	0.045
BH08	20/09/2011	5.39	118	0.1	12	0.02	0.002	<0.05	<0.0001	<0.001	0.002	0.002	<0.0001	0.002	<0.01	0.02
BH08	08/07/2012	6.06	123	0.2	15	0.03	0.006	<0.05	0.0001	0.002	0.002	0.005	<0.0001	0.003	<0.01	0.029
BH08	24/06/2013	6.14	154	0.8	24	0.04	0.013	<0.05	0.0001	<0.001	<0.001	0.002	<0.0001	0.004	<0.01	0.04
BH08	31/7/2014	6.56	210	1.4	35	<0.01	0.022	<0.05	<0.0001	<0.001	<0.001	0.004	<0.0001	0.005	<0.01	0.04
BH09	20/11/2010	6.56	104	<0.1	<1	0.29	<0.001	<0.05	<0.0001	<0.010	<0.001	<0.001	<0.0001	<0.001	<0.01	0.027
BH09	22/08/2011	5.39	99	<0.1	1	0.03	<0.001	<0.05	<0.0001	<0.001	<0.001	0.002	<0.0001	<0.001	<0.01	0.013
BH09	20/09/2011	5.45	98	<0.1	1	0.02	<0.001	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	<0.005
BH09	08/07/2012	5.27	113	<0.1	1	0.03	<0.001	<0.05	<0.0001	0.002	<0.001	0.003	<0.0001	<0.001	<0.01	0.008
BH09	24/06/2013	5.13	114	0.2	2	0.04	<0.001	<0.05	<0.0001	<0.001	<0.001	0.003	<0.0001	<0.001	<0.01	0.016
BH09	31/7/2014	5.64	107	<0.1	2	<0.01	0.002	<0.05	<0.0001	<0.001	<0.001	0.008	<0.0001	<0.001	<0.01	0.017
BH10	20/11/2010	7.92	2670	2.4	1280	<0.01	0.02	<0.05	<0.0001	<0.010	0.02	0.002	<0.0001	0.006	<0.01	0.035
BH10	22/08/2011	7.36	2700	2.9	1260	<0.01	0.012	<0.05	<0.0001	<0.001	0.019	0.001	<0.0001	0.005	<0.01	0.03
BH10	20/09/2011	7.16	2680	2.9	1190	<0.01	0.004	<0.05	0.0001	<0.001	0.007	0.001	<0.0001	0.008	<0.01	0.078
BH10	08/07/2012	7.15	2730	3	1290	<0.01	0.003	<0.05	<0.0001	0.002	0.014	0.002	<0.0001	0.005	<0.01	0.015
BH10	24/06/2013	7.28	2580	3.2	1250	<0.01	0.008	<0.05	<0.0001	<0.001	0.003	0.002	<0.0001	0.008	<0.01	0.043
BH10	31/7/2014	7.26	2530	3.7	1230	<0.01	0.047	<0.05	<0.0001	<0.001	0.015	0.002	<0.0001	0.007	<0.01	0.015
BH11	20/11/2010	8.1	370	2.4	51	<0.01	0.054	<0.05	<0.0001	<0.010	<0.001	0.002	<0.0001	0.002	<0.01	0.043
BH11	22/08/2011	7.47	358	2.9	51	0.01	0.058	<0.05	<0.0001	<0.001	<0.001	0.001	<0.0001	<0.001	<0.01	0.005
BH11	20/09/2011	7.13	353	2.9	49	<0.01	0.054	<0.05	<0.0001	<0.001	<0.001	0.002	<0.0001	0.001	<0.01	0.008
BH11	08/07/2012	7.04	429	3	49	0.01	0.059	<0.05	<0.0001	0.002	<0.001	0.005	<0.0001	0.001	<0.01	0.016
BH11	24/06/2013	7.62	331	3.2	54	<0.01	0.064	<0.05	<0.0001	<0.001	<0.001	0.001	<0.0001	<0.001	<0.01	0.006
BH11	31/7/2014	7.37	343	3.8	53	<0.01	0.082	<0.05	<0.0001	<0.001	<0.001	0.004	<0.0001	<0.001	<0.01	0.008
BH12	20/11/2010	8.44	1400	4.2	186	<0.01	0.024	<0.05	<0.0001	<0.010	<0.001	<0.001	<0.0001	<0.001	<0.01	0.025
BH12	22/08/2011	7.69	1380	4.9	182	<0.01	0.019	<0.05	<0.0001	<0.001	<0.001	0.001	<0.0001	<0.001	<0.01	0.022
BH12	20/09/2011	7.4	1390	4.6	173	<0.01	0.017	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	<0.005

Site	Date	pH	EC (µS/cm)	Fluoride (mg/L)	Sulfate (mg/L)	Aluminium (mg/L)	Arsenic (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Zinc (mg/L)
BH12	08/07/2012	7.39	1490	4.6	191	<0.01	0.019	<0.05	<0.0001	0.003	<0.001	0.002	<0.0001	<0.001	<0.01	0.008
BH12	24/06/2013	7.53	1450	4.6	174	0.01	0.017	<0.05	<0.0001	<0.001	<0.001	0.004	<0.0001	0.004	<0.01	0.014
BH12	31/7/2014	7.39	1540	5.2	200	<0.01	0.094	<0.05	<0.0001	<0.001	0.015	0.002	<0.0001	0.003	<0.01	0.009
SY1	20/11/2010	7.01	51	<0.1	<1	0.04	0.002	<0.05	<0.0001	<0.010	0.001	<0.001	<0.0001	<0.001	<0.01	0.04
SY1	23/08/2011	6.02	60	<0.1	<1	<0.01	0.003	<0.05	<0.0001	<0.001	0.003	<0.001	<0.0001	0.001	<0.01	0.009
SY1	20/09/2011	5.81	55	<0.1	<1	0.02	<0.001	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	0.001	<0.01	0.009
SY1	08/07/2012	5.63	64	<0.1	2	0.01	<0.001	<0.05	<0.0001	0.002	0.002	0.002	<0.0001	<0.001	<0.01	0.011
SY1	24/06/2013	5.7	58	0.2	1	0.01	<0.001	<0.05	<0.0001	<0.001	0.001	0.002	<0.0001	0.001	<0.01	0.02
SY1	31/7/2014	6.66	65	<0.1	2	<0.01	0.001	<0.05	<0.0001	<0.001	0.001	0.004	<0.0001	<0.001	<0.01	0.016
GBMB1	20/11/2010	7.91	533	1.7	110	<0.01	0.012	<0.05	<0.0001	<0.010	<0.001	0.002	<0.0001	<0.001	<0.01	0.035
GBMB1	23/08/2011	7.62	498	1.7	81	0.03	0.037	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	<0.005
GBMB1	20/09/2011	6.67	694	2.2	165	0.01	<0.001	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	<0.005
GBMB1	08/07/2012	7.21	716	2.3	150	0.01	0.027	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	0.016
GBMB1	24/06/2013	7.2	632	2	133	0.02	0.015	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.01	0.013
GBMB1	31/7/2014	7.17	580	2.4	143	<0.01	0.019	<0.05	<0.0001	<0.001	<0.001	0.002	<0.0001	<0.001	<0.01	0.014
GBMB3	11/07/2010	6.71	233	<0.1	1	0.15	0.009	<0.05	<0.0001	<0.010	<0.001	0.003	<0.0001	<0.001	<0.01	0.114
GBMB3	23/08/2011	6.25	103	<0.1	<1	0.07	0.016	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	<0.001	<0.01	0.006
GBMB3	20/09/2011	5.84	61	<0.1	<1	0.21	0.016	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	0.001	<0.01	0.014
GBMB3	08/07/2012	5.88	53	<0.1	<1	3.76	0.003	<0.05	<0.0001	0.002	0.001	<0.001	<0.0001	0.002	<0.01	0.5
GBMB3	24/06/2013	7.2	501	0.4	4	0.71	0.013	<0.05	<0.0001	<0.001	<0.001	0.002	<0.0001	0.001	<0.01	0.02
GBMB3	31/7/2014	6.52	218	<0.1	1	2.2	0.038	<0.05	<0.0001	<0.001	0.007	0.001	<0.0001	0.004	<0.01	0.018
GBMB6	11/07/2010	6.21	138	0.1	2	<0.01	0.03	<0.05	<0.0001	<0.010	0.001	0.002	<0.0001	0.002	<0.01	0.143
GBMB6	23/08/2011	6.9	247	0.2	1	<0.01	0.096	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	0.002	<0.01	<0.005
GBMB6	20/09/2011	6.2	158	0.2	2	<0.01	0.087	<0.05	<0.0001	<0.001	0.001	<0.001	<0.0001	0.002	<0.01	<0.005
GBMB6	08/07/2012	6.9	276	0.3	<1	<0.01	0.093	<0.05	<0.0001	0.003	0.002	<0.001	<0.0001	0.003	<0.01	0.006
GBMB6	24/06/2013	7.19	498	0.6	1	<0.01	0.079	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	0.002	<0.01	0.005
GBMB6	31/7/2014	6.93	233	<0.1	<1	<0.01	0.116	<0.05	<0.0001	<0.001	0.002	<0.001	<0.0001	0.002	<0.01	0.016
EA Trigger Level		6.0 to 7.5	250			0.055	0.013	0.37	0.0002	0.001	0.0014	0.0014	0.0006	0.011	0.011	0.008
EA Contaminant Limit		5 to 9	5970	2	1000	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

ATTACHMENT B

WATER QUALITY GRAPHS

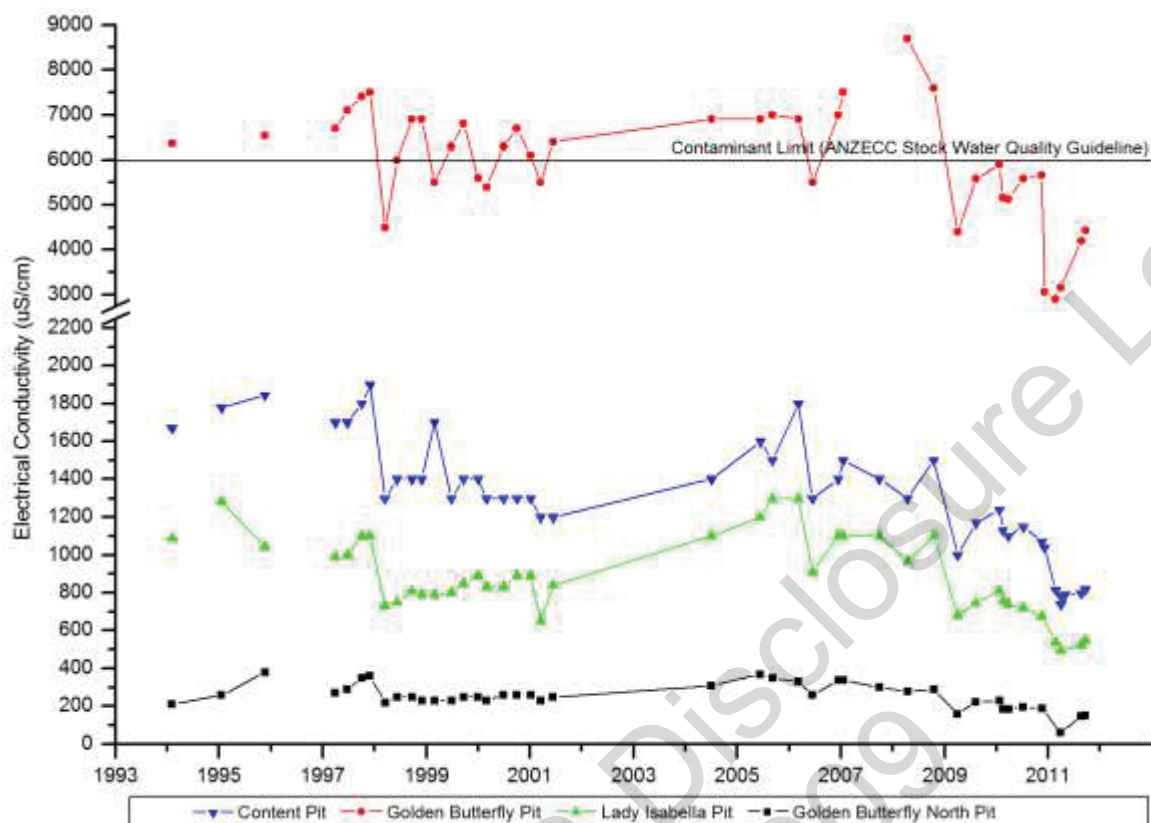


Figure 7: Croydon Pit Lake Electrical Conductivity Time Series Graph

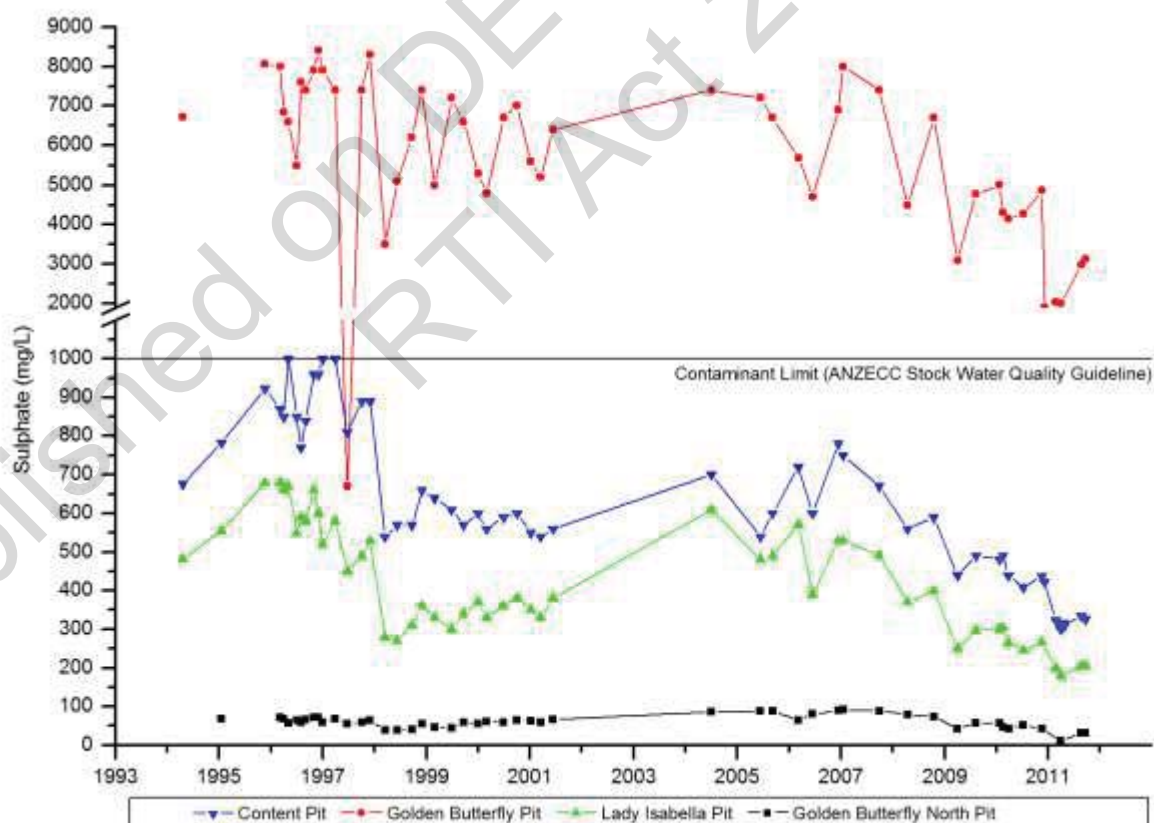


Figure 8: Croydon Pit Lake Sulfate Concentration Time Series Graph

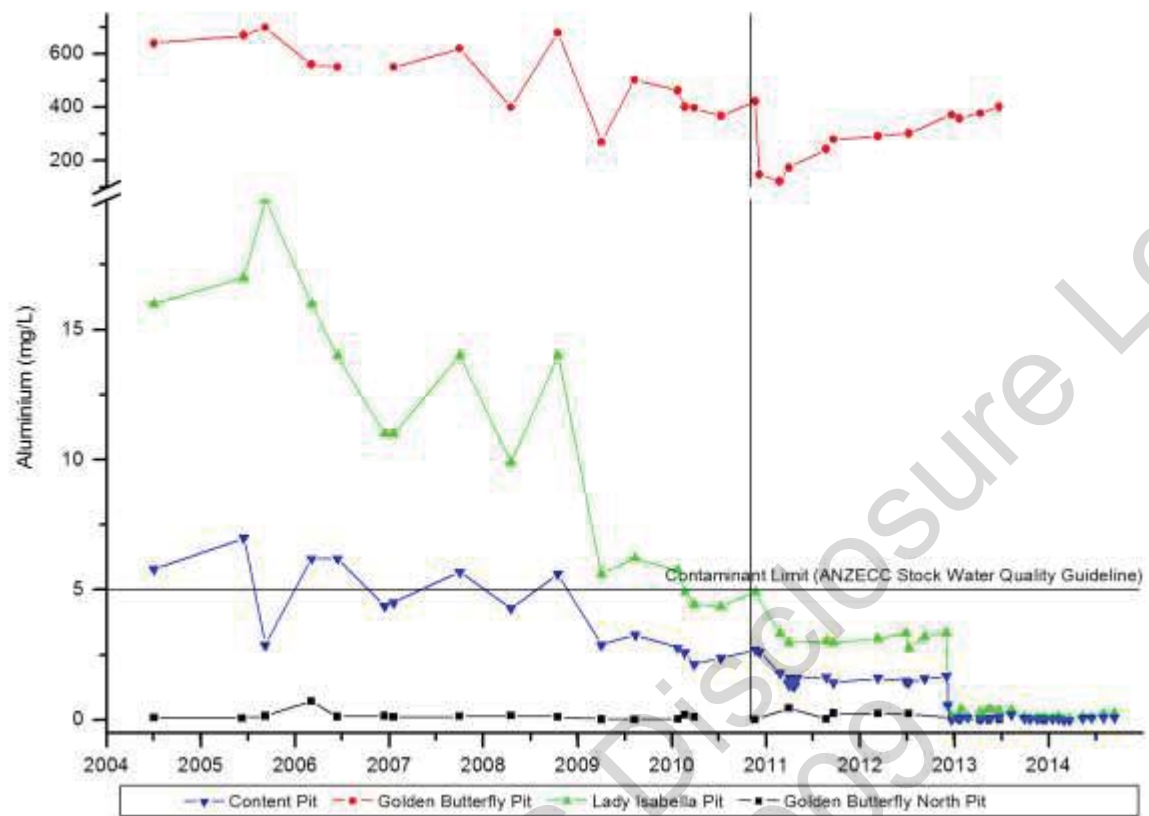


Figure 9: Croydon Pit Lake Aluminium Concentration Time Series Graph

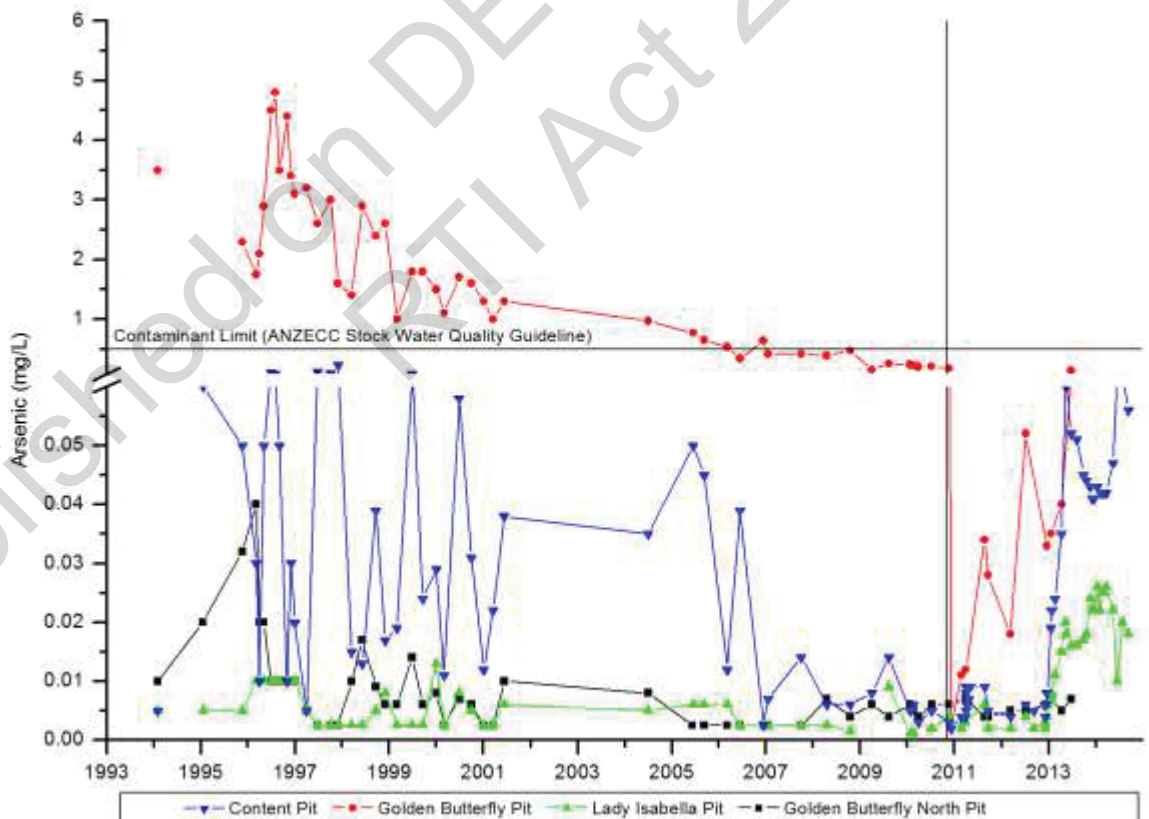


Figure 10: Croydon Pit Lake Arsenic Concentration Time Series Graph

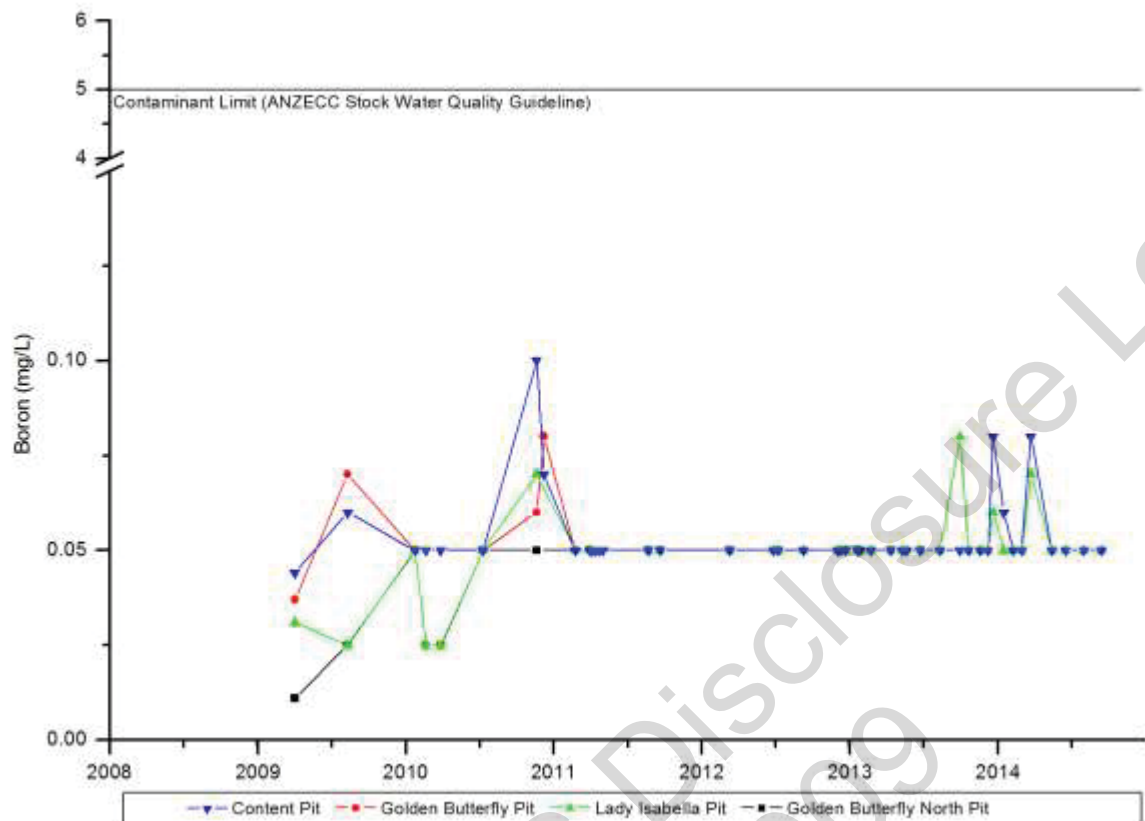


Figure 11: Croydon Pit Lake Boron Concentration Time Series Graph

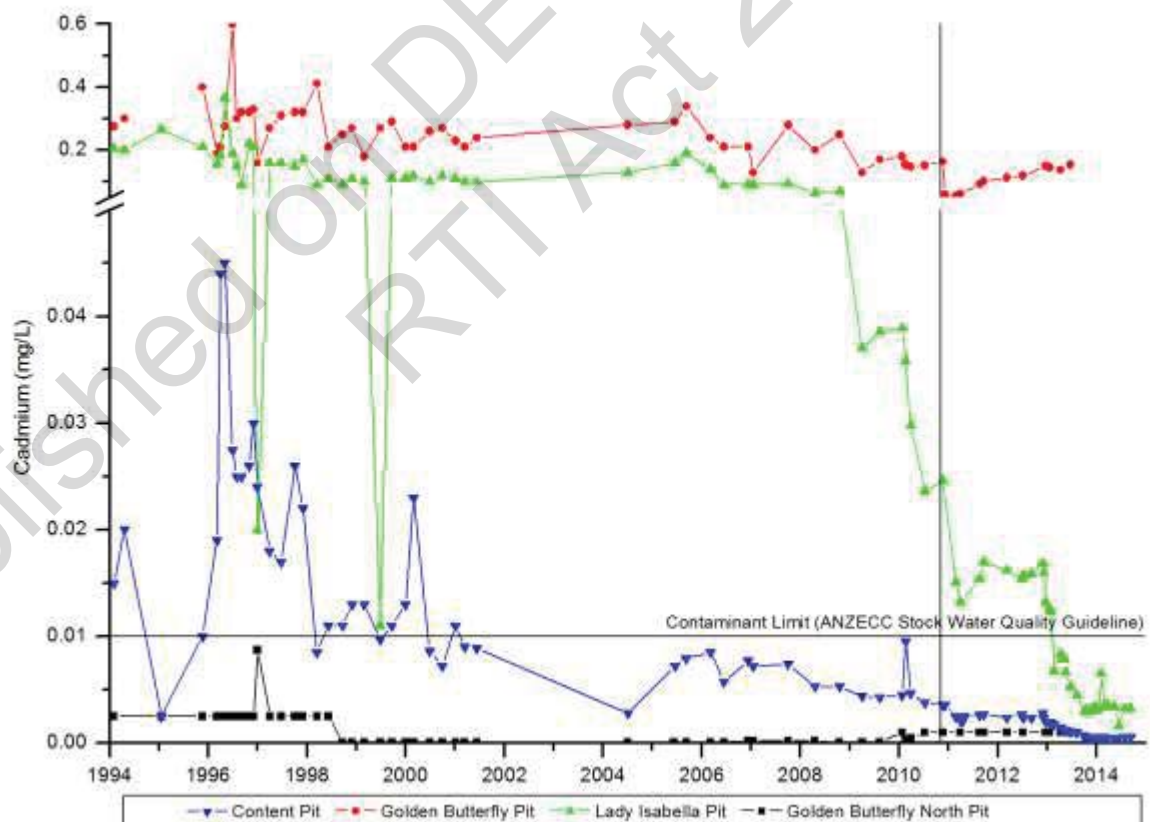


Figure 12: Croydon Pit Lake Cadmium Concentration Time Series Graph

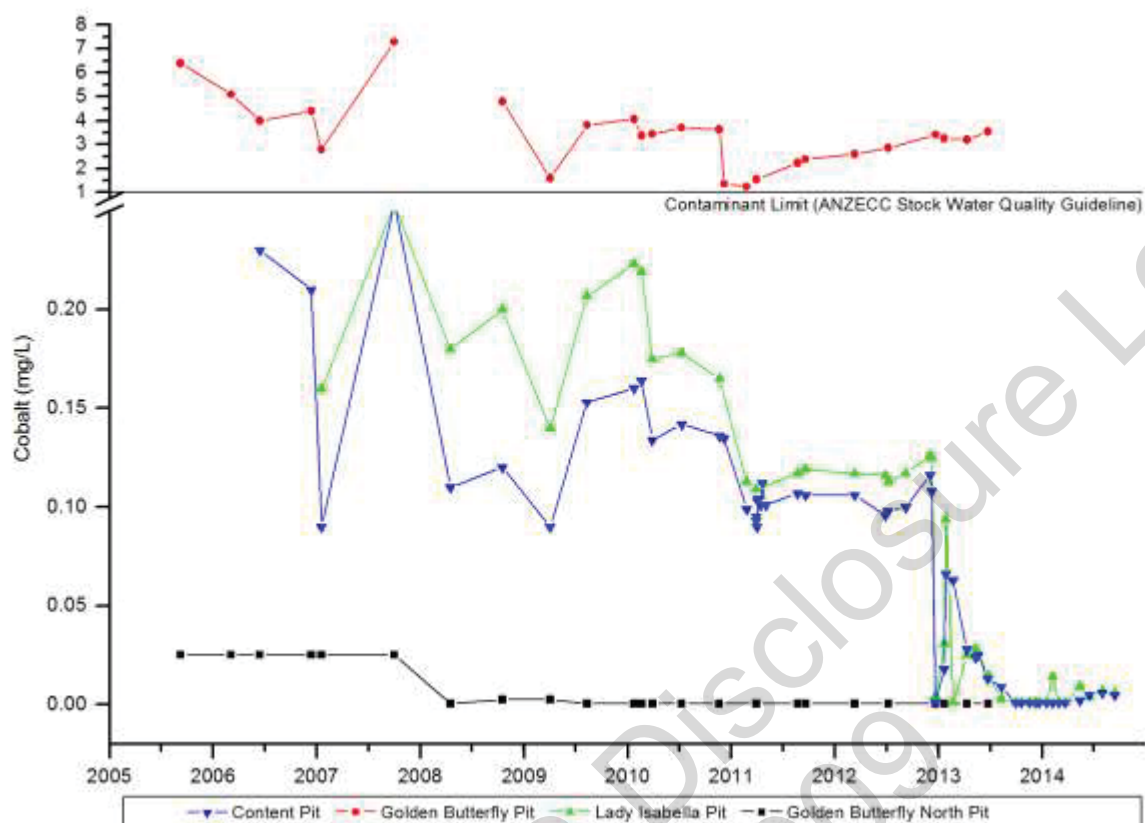


Figure 13: Croydon Pit Lake Cobalt Concentration Time Series Graph

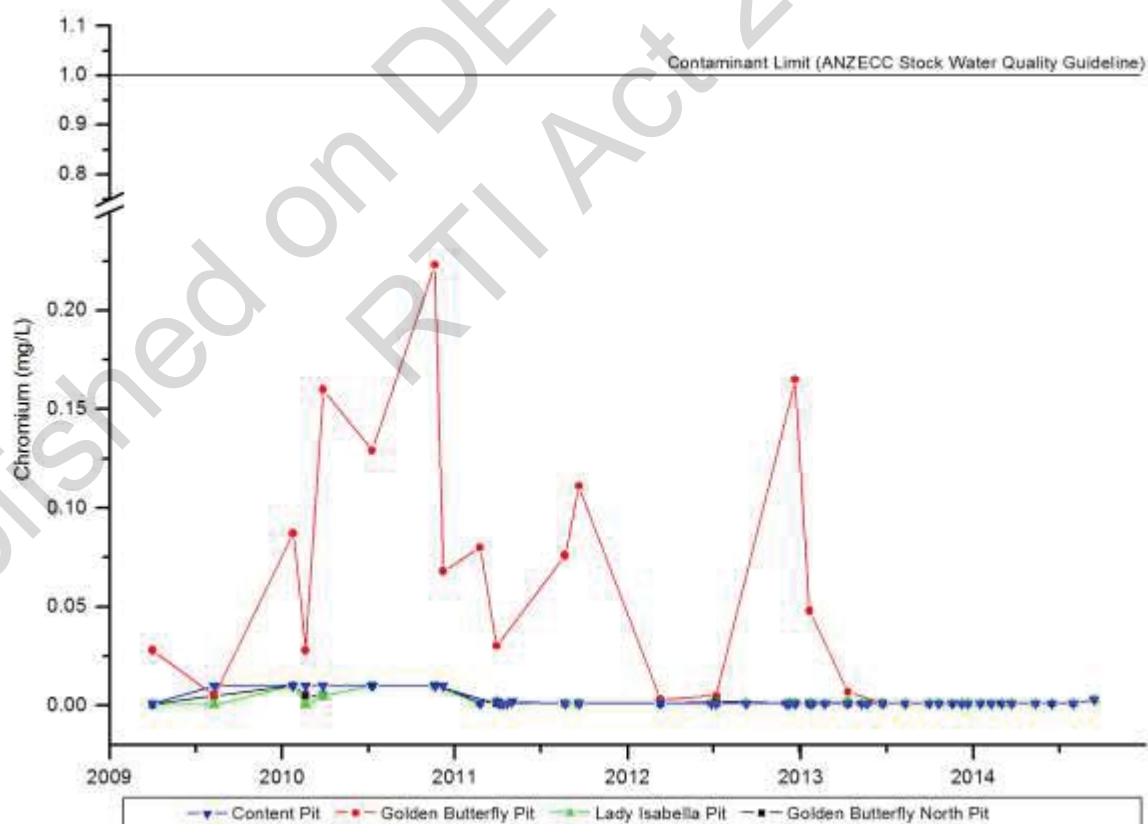


Figure 14: Croydon Pit Lake Chromium Concentration Time Series Graph

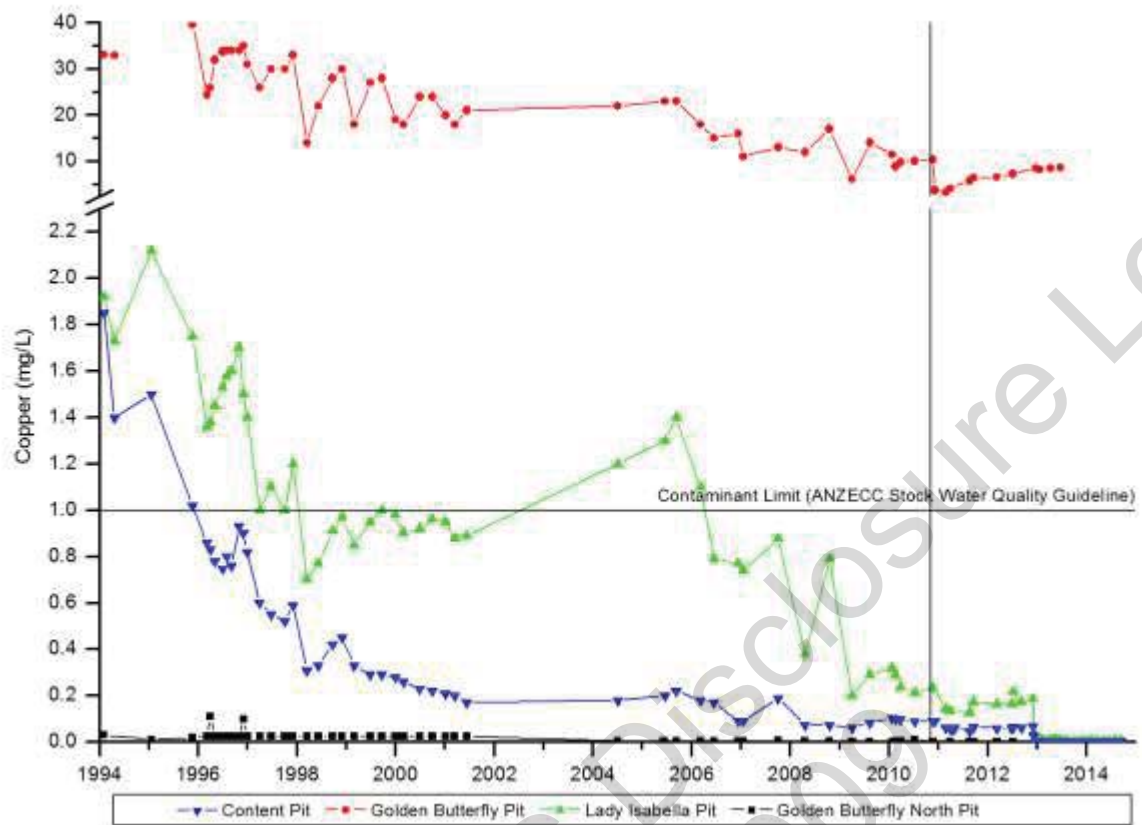


Figure 15: Croydon Pit Lake Copper Concentration Time Series Graph

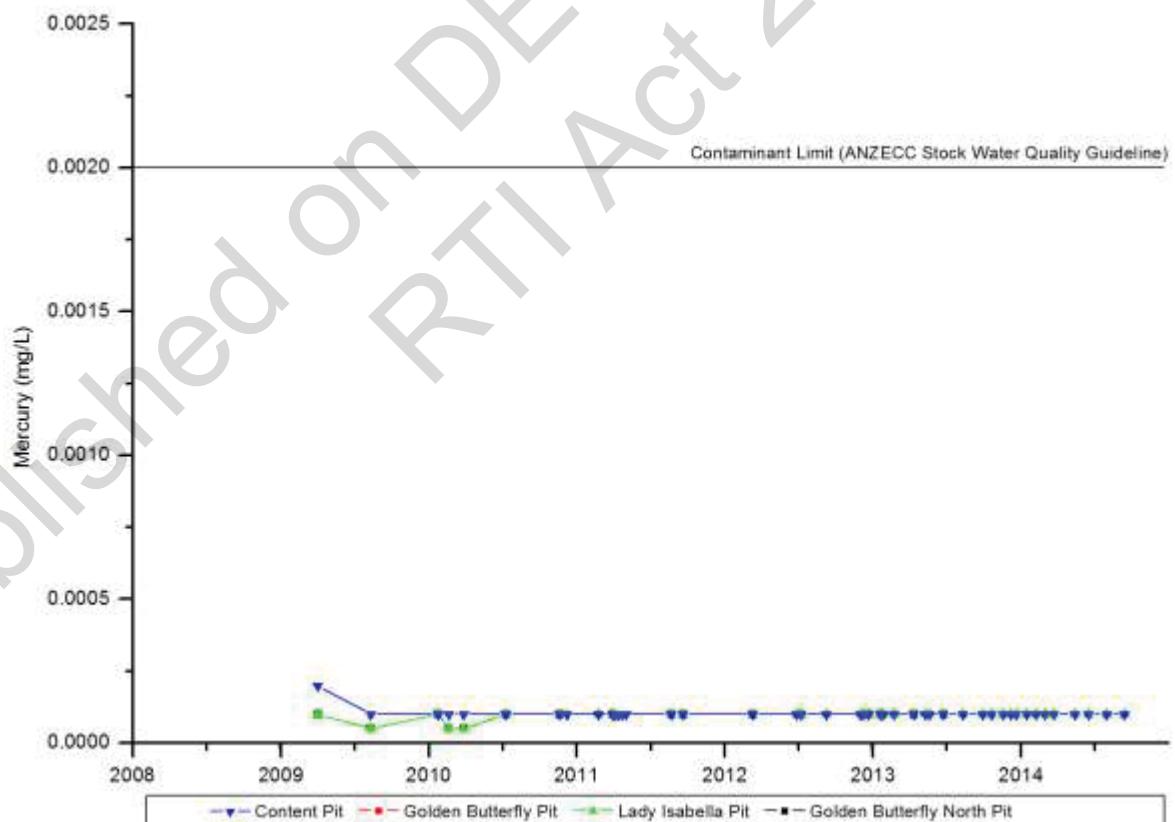


Figure 16: Croydon Pit Lake Mercury Concentration Time Series Graph

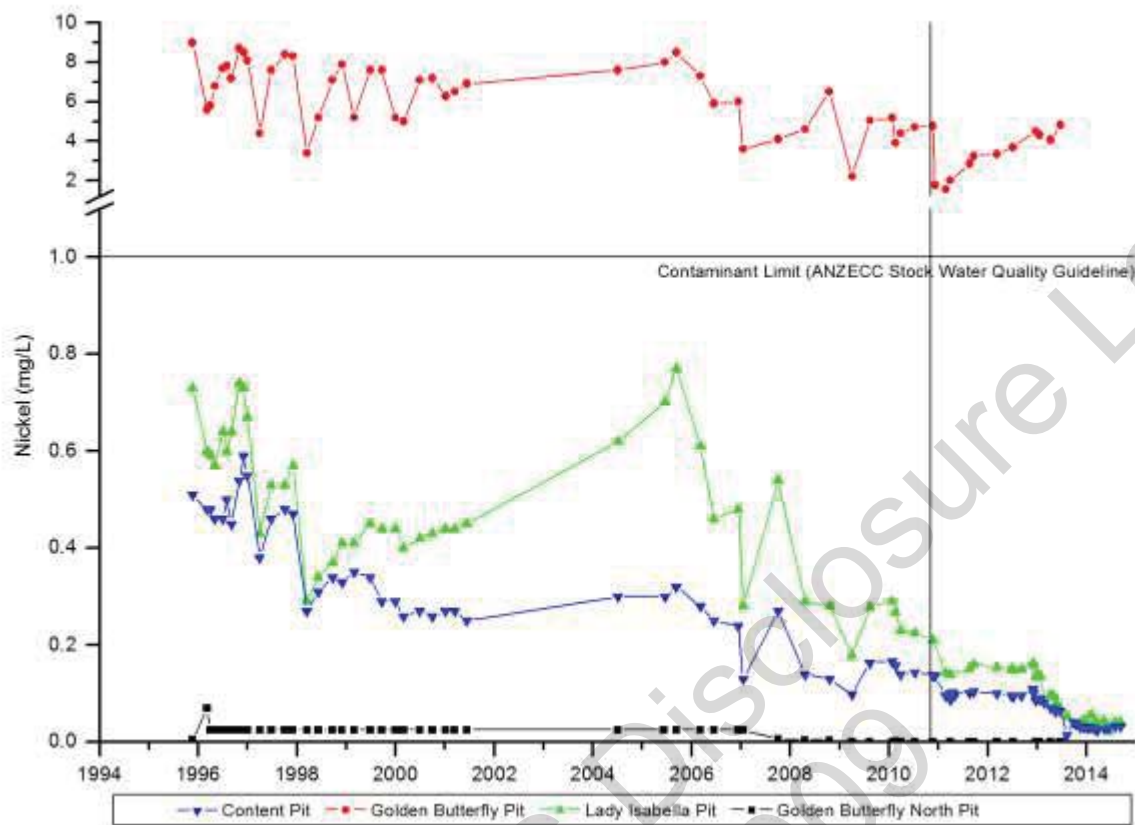


Figure 17: Croydon Pit Lake Nickel Concentration Time Series Graph

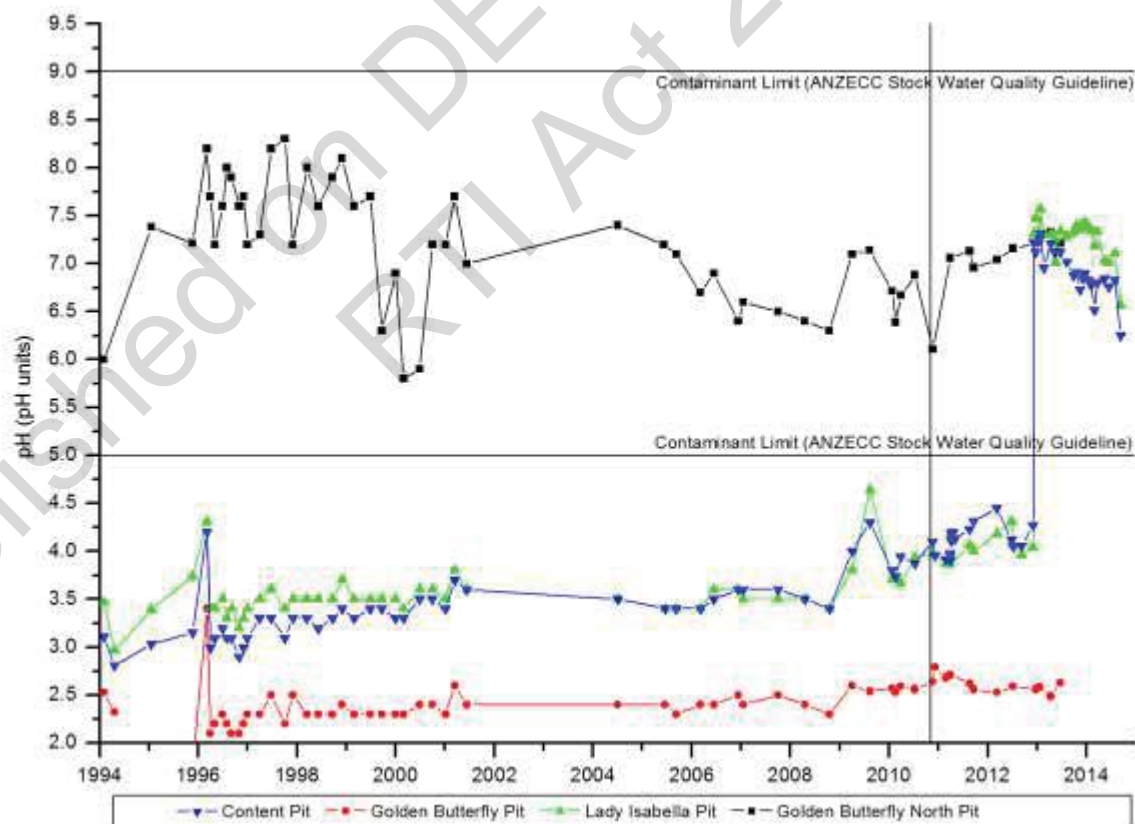


Figure 18: Croydon Pit Lake pH Time Series Graph

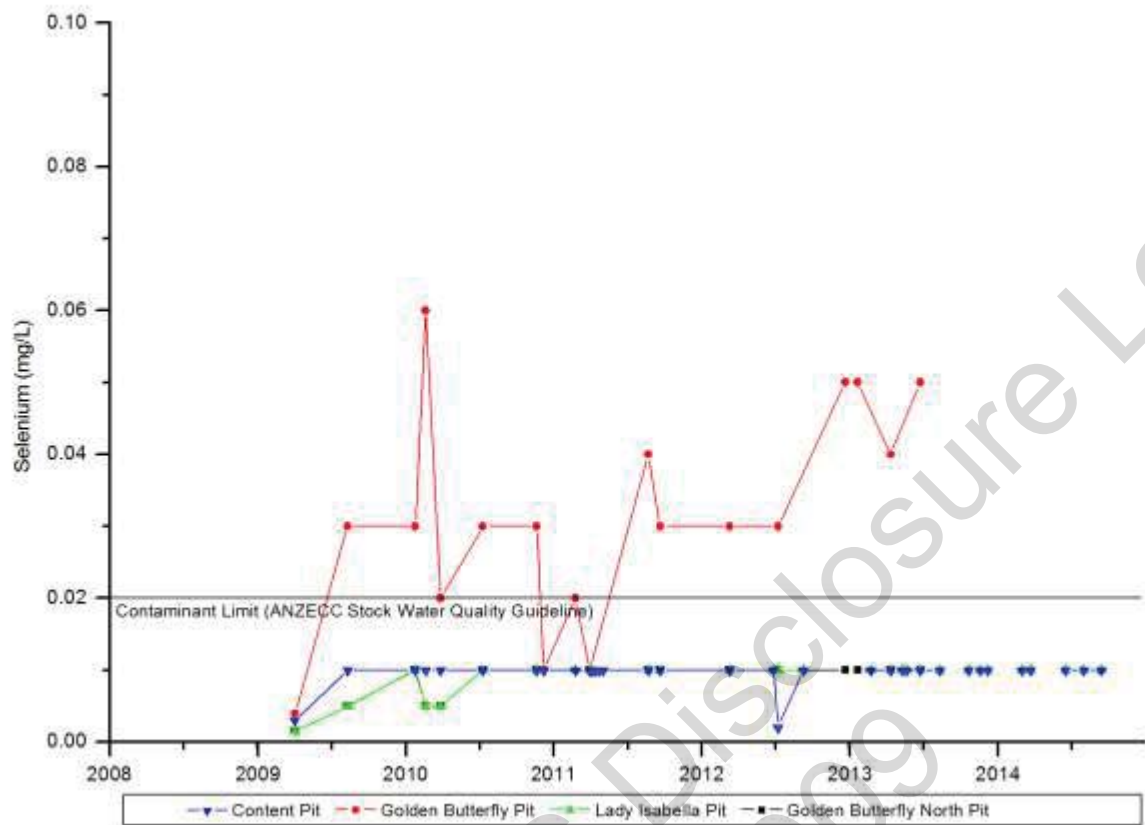


Figure 19: Croydon Pit Lake Selenium Concentration Time Series Graph

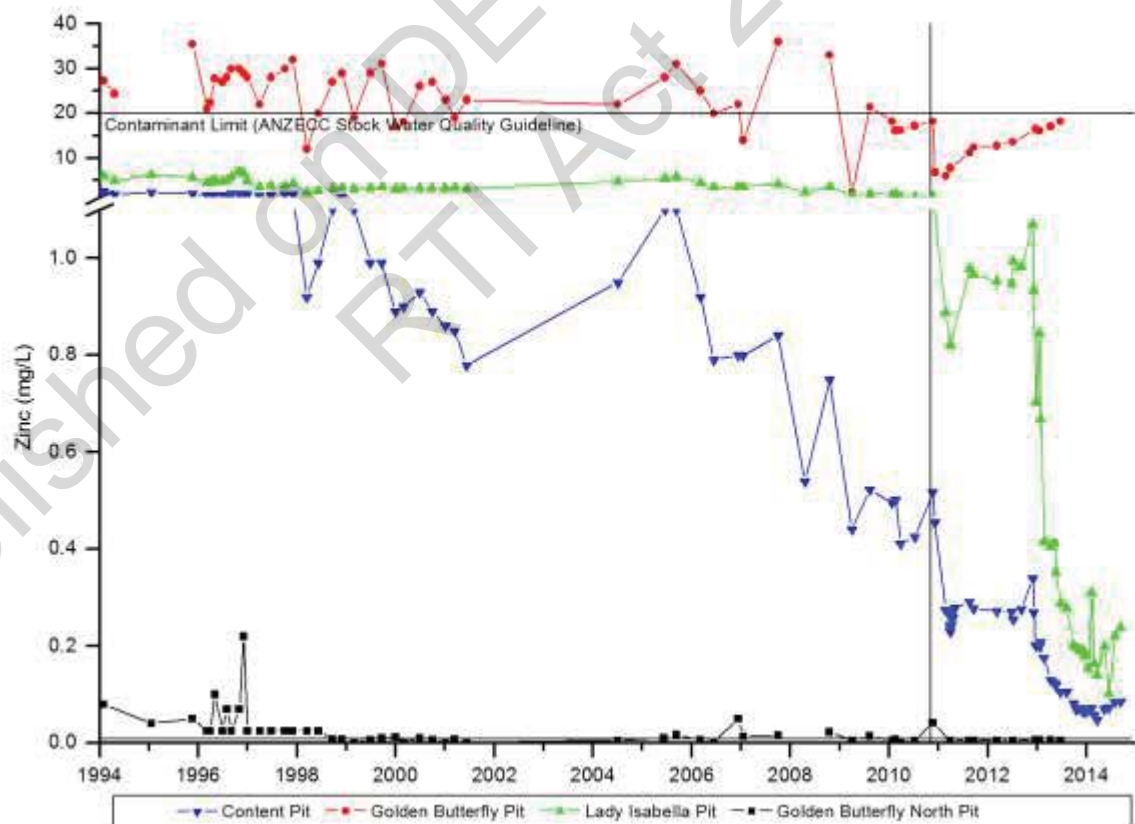


Figure 20: Croydon Pit Lake Zinc Concentration Time Series Graph



BARRICK GOLD OF AUSTRALIA LIMITED Tel: (618) 9212 5777
A.B.N. 19 008 143 137 Fax: (618) 9322 5700
Level 10
2 Mill Street
Locked Bag 12
CLOISTERS SQUARE WA 6850
PERTH WA AUSTRALIA

4 November 2011

Queensland Government
Department of Environment and Resource Management
PO Box 2066
CAIRNS QLD 4870

Attention: Neil Maver

Project: Croydon Gold Mine

Subject: Environmental Investigation

Dear Neil,

Please find enclosed for your records the Barrick Australia Pacific (Barrick) *Croydon Gold Mine Environmental Investigation*. This report has been prepared to investigate the potential risk to Belmore Creek and its relevant tributaries in the vicinity of the Croydon Gold Mine as a result of the Content Pit surface water outflow on 30 March to 2 May 2011.

As described in Barrick's follow-up written advice submitted to the DERM on 1 August 2011, the assessments within the report have been conducted in accordance with the Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000) risk-based decision framework.

The assessments within the *Croydon Gold Mine Environmental Investigation* indicate that the Content Pit surface water outflow posed a low risk to the existing slightly to moderately disturbed condition of Belmore Creek and its relevant tributaries in the vicinity of the CGM. Therefore, in accordance with the ANZECC and ARMCANZ (2000) risk-based decision framework, no remediation measures are considered necessary.

Pit lake water level monitoring and observations during the 2011 dry season have indicated that the water level of the Content Pit has lowered, therefore increasing the storage capacity of the open pit. Notwithstanding, should above average rainfall conditions occur during the 2011/2012 wet season, a reduction in the storage capacity of the Content Pit is likely and surface water outflows may occur.

Based on the conclusion of the *Croydon Gold Mine Environmental Investigation* and recent Content Pit lake water quality results (which demonstrates no deterioration of pit lake water quality during the 2011 dry season), should a surface water outflow occur from the Content Pit during the 2011/2012 wet season, Barrick expects the water quality of the outflow would be similar to that reported within the *Croydon Gold Mine Environmental Investigation* (i.e. with no receiving water contaminant limit exceedances of relevant metals). Therefore, Barrick would expect the outflow would pose a low risk to the existing slightly to moderately disturbed condition of Belmore Creek and its relevant tributaries in the vicinity of the CGM.

Notwithstanding, Barrick will continue to implement an additional monitoring programme during the 2011/2012 wet season. The monitoring programme would include surface water quality and stream sediment quality monitoring and a continuation of aquatic habitat and macroinvertebrate monitoring at locations in Belmore Creek upstream and downstream of the CGM.

Please do not hesitate to call me on CTPI 49-Sch4 if you should have any queries regarding the above.

Yours sincerely

BARRICK AUSTRALIA PACIFIC LIMITED

CTPI 49-Sch4

CTPI 49-Sch4

Reclamation and Closure Manager

CC. Dean Sharpe

Form

Mining

Application to amend an environmental authority (mining activities) for a level 1 mining project

OFFICIAL USE ONLY

DATE RECEIVED:

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FILE REF:

--

PROJECT REF:

--

COMPLETE FORM

☐

CORRECT AA

☐

COMPLETE FEE

☐

ADMINISTERING REGION:

--

ENTERED BY [SIGNATURE]:

--

DATE:

--	--

This form is to be used when applying for an amendment of an environmental authority for a level 1 mining project under s. 240 of the *Environmental Protection Act 1994*.

The holder of an environmental authority (mining activities) may use this form to:

- add a new mining tenement to an existing environmental authority;
- increase the surface area of a tenement;
- include additional activities or change the scale or type of activities;
- request an amendment to the conditions of an existing environmental authority;
- request an amendment to an environmental authority to reflect a change in the relevant standard environmental conditions;
- remove one or more existing holders of an environmental authority;
- as part of an application for the transfer of environmental authority, the proposed transferee is seeking an amendment to the authority;
- to nominate a principal holder.

(The principal holder under the *Environmental Protection Act 1984* should also be the principal holder under the *Mineral Resources Act 1989*.)

Do not use this form:

- to correct a clerical or formal error. The administering authority can make the correction as long as the proposed amendment does not adversely affect the interests of the environmental authority holder, or anyone else.

To amend a financial assurance, if there are no other amendments to your environmental authority, use the form Application for Amendment or Discharge of Financial Assurance for an Environmental Authority (Mining Activities) (EM2104¹).

If you are applying for a new mining tenement to be added to an existing environmental authority, or requesting additional surface area for an existing environmental authority, please submit this form, together with the required fee, to the Mining Registrar.

For all other applications, please submit the completed form, together with the required fee, to the administering authority.

¹ This is the publication number, which can be used as a search term to find the latest version of the publication at <www.ehp.qld.gov.au>.

Rele

Specific information requirements

Question 1 – Applicants

The applicants for, and/or holders of a relevant mining tenement for a mining project must also be the applicants for and/or holders of the associated environmental authority (EA).

Joint holders may appoint one of the applicants as the principal applicant (for submitting and receiving notices etc) by completing Attachment A.

1. Environmental authority (EA) holder name(s)

NAME & ABN/ACN:

Barrick (Kalgoorlie) Limited A.B.N. 12 009 712 092

NAME & ABN/ACN:

NAME & ABN/ACN:

Question 2

Ensure that Attachment A is completed.

2. Principal holder name (where applicable)

NAME & ABN/ACN:

Question 3 – Contact person

Where the holder or principal holder is a company, identify a responsible person to act as signatory of this application.

3. Contact person for this application

NAME:

CTPI 49-Sch4

POSITION:

Reclamation and Closure Manager

REGISTERED BUSINESS ADDRESS:

Level 9 Brookfield Place, 125 St Georges Terrace, PERTH WA 6000

FULL POSTAL ADDRESS:

Level 9 Brookfield Place, 125 St Georges Terrace, PERTH WA 6000

PHONE:

()

FAX:

MOBILE PHONE:

CTPI 49-Sch4

EMAIL:

CTPI 49-Sch4@barrick.com

Application to amend an environmental authority (mining activities) for a level 1 mining project

Environmental authority to be amended

Question 4

EA details may be found on the existing authority, relevant tenement approval or quoted in other correspondence received from the administering authority.

If you cannot locate the authority number, please contact the administering authority.

Where the Mining Registrar has previously issued a project number, provide that number.

4. EA details

PROJECT NUMBER (WHERE ISSUED):
PROJECT NAME: Croydon
ENVIRONMENTAL AUTHORITY NUMBER MIN100401906
TENEMENT TYPE AND NUMBER (E.G. ML1234): Mining Lease, ML5248

Question 5 – Removing holders

This application form cannot be used to include a person as a new holder of the authority. Use the form titled Application to Transfer an Environmental Authority (Mining Activities) (EM568).

If the person to be removed is the holder of a relevant mining tenement, it is likely that the administering authority may require that person to remain a holder of the authority.

The holders of the EA must be the same people as are holders of the associated tenements.

5. Do you wish to remove one or more existing holders from the EA?

- ☐ Yes → List the existing holders of the EA to be removed from the authority

HOLDER(S) NAME:

If this is the only purpose of the amendment application, no further information is required → go to Question 18

- ☒ No → Go to Question 6

Question 6

The maps for identifying strategic cropping land (SCL) and potential SCL can be found on the EHP website at www.ehp.qld.gov.au/licences-permits/maps_of_environmentally_sensitive_areas.php.

6. Are any of the current or proposed mining tenements over land that is designated as strategic cropping land (SCL) or potential SCL as shown on a SCL trigger map?

- ☐ Yes → Go to Question 7
- ☒ No → Go to Question 8

Application to amend an environmental authority (mining activities) for a level 1 mining project

Question 7

An application for an SCL compliance certificate provides a streamlined assessment pathway for resource activities that pose a low risk to adversely impacting on SCL or potential SCL. You must be able to comply with the SCL standard conditions code for resource activities to apply for an SCL compliance certificate.

If you cannot comply with SCL standard conditions code for resource activities, you must apply for an SCL protection decision.

The SCL application forms and SCL standard conditions code for resource activities are available on the EHP website.

An environmental authority can not be issued unless an SCL compliance certificate has been given or an SCL protection decision has been made.

Question 8

The amendment is not limited to the existing conditions of the EA. Holders may apply to have additional conditions included in the EA.

7. How will, or have, you considered *Strategic Cropping Land Act 2011* requirements?

- ☐ Considered under the SCL standard conditions code for resource activities.
- ☐ I/We have already applied for a compliance certificate:
Ref No.
- ☐ I/We will be applying for a compliance certificate.
- ☐ Considered under a SCL protection decision
- ☐ I/We have already applied for a protection decision:
Ref No.
- ☐ I/We will be applying for a protection decision.

8. What is the purpose for seeking an amendment to the environmental authority?

- To include additional activities or a change in the scale or type of activities → Go to Question 9
- To amend conditions of an existing authority → Go to Question 10
- As part of an application for the transfer of an EA where the proposed transferee is seeking an amendment of the EA → Go to Question 17
- To increase surface area of the tenement, or to add a new mining tenement to the existing EA (provide details in the below sections).

TENEMENT TYPE AND NUMBER (E.G. MLA1234):

- ☐ Other.

PLEASE SPECIFY:

Application to amend an environmental authority (mining activities) for a level 1 mining project

Question 9 – Activities

Please include information on any additional tenements, an increase in surface area, an increase in rate of production or disturbance, or the building of additional infrastructure.

The application may be refused on the grounds that it would be more appropriate for the applicant to seek the amendment by replacement of the EA.

9. Do you intend to carry out additional activities and/or change the scale or type of activities that make up the project?

☐ Yes → Please provide details below

PLEASE SPECIFY:

LIST ADDITIONAL TENEMENT(S):

PLEASE ATTACH DETAILED INFORMATION OUTLINING THE CHANGES TO THE ACTIVITIES THAT MAKE UP THE PROJECT

Tick to indicate attachments: ☐

☐ No → Go to Question 10

Question 10 – Conditions

Holders may apply to have additional conditions included in the EA. However, the administering authority may grant the application only if it considers the amendment necessary or desirable.

10. Do you wish to amend one or more conditions of your EA?

☒ Yes → Go to Question 11

☐ No → Go to Question 14

Question 11

A condition of an EA requiring a financial assurance cannot be amended or discharged using this form, or under the amendment provisions of chapter 5, part 8 of the EP Act.

11. Identify the EA condition(s) to be amended

CONDITION NUMBER(S):

Clause F1-1

IF YOU REQUIRE ADDITIONAL SPACE, PLEASE ATTACH A SEPARATE SHEET

Tick to indicate attachments: ☐

Rele

Application to amend an environmental authority (mining activities) for a level 1 mining project

Question 12

If you require additional space, please attach a separate sheet

12. Explain why the conditions listed in Question 11 cannot be met**EXPLANATION:**

Extreme rainfall can produce discharge from the Content Pit Lake which has been treated to be within stock watering guidelines. Consequent dilution in the receiving environment and high flow conditions in Belmore Creek result in no discernible environmental impact. However, clause F1-1 effectively prohibits any discharge under any circumstances.

Tick to indicate attachments:

**Question 13**

Please provide supporting information to ensure the activities do not cause material or serious environmental harm.

If you require additional space, please attach a separate sheet

13. Propose replacement condition(s)**NEW CONDITION(S):**

Clause F1-1 to be amended to provide for discharge from the Content Pit and Lady Isabella Pit lakes under the appropriate flow conditions in the receiving Belmore Creek.

Tick to indicate attachments:

**Question 14 – Financial assurance**

As a result of the amendment process, the holder of the EA must provide financial assurance as required by the Codes of environmental compliance.

For further details, see the guideline Calculating Financial Assurance for Mining Projects (EM585) and the relevant code of environmental compliance. Electronic copies are available at <www.ehp.qld.gov.au>

Financial assurance is calculated as follows:

- (i) for mining leases, from a schedule of disturbance and rehabilitation in the plan of operations
- (ii) for exploration permits and mineral development licences, by reference to the schedule of rehabilitation costs in the Code of Environmental Compliance for Exploration and Mineral Development Projects
- (iii) total financial assurance for the mining project is obtained by adding the financial assurances in (i) and (ii) above.

14. Indicate the amount of financial assurance to be held for the amended EA for the mining project:

Total amount of financial assurance proposed to be held:

\$

Tick to indicate attachment:



The proposed amount of financial assurance will be reviewed by the administering authority and may be altered at the discretion of the administering authority if it is not consistent with the area of disturbance and rehabilitation requirements.

Application to amend an environmental authority (mining activities) for a level 1 mining project

Questions 15 - 17

Include the GST component when stating the amount proposed to be held/lodged, and the amounts currently held where relevant (adding the GST component if it has not been previously submitted).

15. In the table below, insert the appropriate amounts and form of financial assurance in relation to the EP Act.

	Amount of financial assurance	Form of financial assurance ³
Amount proposed to be held in Question 14	\$	
Amount currently held ¹	\$	
Difference between the amount proposed and the amount currently held ²	\$	

¹ Insert the amount and form of financial assurance that is currently held by the administering authority under the EP Act (i.e. not including tenement security required by the Mining Registrar under the *Mineral Resources Act 1989*).

² A negative amount is the amount of financial assurance to be returned by the administering authority (Question 17 applies). A positive amount is the additional financial assurance (including GST) to be submitted to the administering authority (Question 16 applies).

³ The administering authority will require financial assurance either as cash or as an unconditional guarantee from a suitable financial institution.

16. Where a financial assurance is to be amended and lodged with this application, please identify the person(s), company/companies or institution providing the financial assurance on behalf of the (proposed) authority holder(s), nominate the amount and the manner in which the financial assurance is being provided.

NAME(S) & ABN/ACN: N/A	AMOUNT \$:	MANNER HELD: ☐ cash ☐ financial institution unconditional guarantee
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Questions 17

Where a financial assurance is to be returned to a company or financial institution, provide the Australian Business Number (ABN) or the Australian Company Number (ACN) for that company/institution.

17. Where a financial assurance is to be discharged and returned to a person(s), company/companies or financial institution, please identify the person, company or institution, nominate the amount to be returned and the manner in which the financial assurance is currently held.

NAME(S) & ABN/ACN: N/A	AMOUNT \$:	MANNER HELD: ☐ cash ☐ financial institution unconditional guarantee
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Rel

Application to amend an environmental authority (mining activities) for a level 1 mining project

Question 18

Please read carefully through the certification opposite and tick all of the boxes if appropriate, before signing.

Privacy statement

The Department of Environment and Heritage Protection is committed to protecting the privacy, accuracy and security of your personal information in accordance with the *Information Privacy Act 2009*. The information will be accessed only by authorised employees within the department for the purposes of processing this application to amend an environmental authority, as authorised under s. 240 of the *Environmental Protection Act 1994*. To enable the processing of this application, information may be given to the Department of Natural Resources and Mines. Your personal information will not be disclosed to any other third parties without your consent or unless authorised or required by law. All information supplied on or with this form may be made available to others upon request, subject to provisions of the *Right to Information Act 2009* and *Evidence Act 1977*. For queries about privacy matters email: AdminReview@ehp.qld.gov.au or telephone: (07) 3896 3705.

18. Applicant certification

- ☒ I/we, being the person(s)/entity identified at Question 1, hereby apply to amend the EA stated at Question 4 as detailed in this application.
- ☒ I/we solemnly and sincerely declare that the information provided is true and correct to the best of my/our knowledge and I/we make this solemn declaration conscientiously believing the same to be true.
- ☒ I/we understand that all information supplied on or with this application form may be made available upon request, subject to the provisions of the *Right to Information Act 2009* and/or administrative access arrangements of the administering authority.
- ☒ I/we understand that suitability inquiries may be made of any applicant.
- ☒ I/we enclose the required amendment application fee² of \$ 276
- ☐ I/we am/are authorised to sign on behalf of the applicant(s), and commit this person/entity in all matters relevant to this application.
- ☒ I/we am/are aware that under s. 480 of the *Environmental Protection Act 1994*, it is an offence to give the administering authority information that I/we know is false, misleading or incomplete in any material particular.
- ☒ I/we understand that an incomplete application (including applications that do not include the fee) may be invalid. Invalid applications will be returned without processing and will only be processed if resubmitted with all invalid CTPI 49-Sch4

SIGNATURE :

NAME AND POSITION OF SIGNATORY:

CTPI 49-Sch4

Reclamation Closure Manager

DATE:

10/12/12

² See the information sheet Fees for Permits for Environmentally Relevant Activities (ERAs) (EM33), available at www.ehp.qld.gov.au or through Permit and Licence Management, phone 13 QGOV (13 74 68).

Application to amend an environmental authority (mining activities) for a level 1 mining project

Applicant checklist

- ☒ Application form completed and signed
- ☒ Fees paid or enclosed (if applicable)
- ☒ Supporting information or accreditation attached (if applicable)

Please return the completed application form with the required fee to either:

Permit and Licence Management
Department of Environment and Heritage Protection
GPO Box 2454
BRISBANE QLD 4001

The relevant district office of the:
Mining Registrar
Department of Natural Resources and Mines

Enquiries:

Permit and Licence Management
Phone: 13 QGOV (13 74 68)
Fax: (07) 3896 3342
Email: palm@ehp.qld.gov.au

Application to amend an environmental authority (mining activities) for a level 1 mining project

Attachment A

Appointment of principal holder

We, being joint holders/applicants for this amendment application, hereby appoint

PRINT NAME OF PRINCIPAL APPLICANT:

as the Principal Holder for this EA until otherwise revoked by us or the EA is surrendered.

List all joint applicants

APPLICANT NAME / COMPANY:		
SIGNATORY NAME & POSITION:	SIGNATURE:	DATE:
APPLICANT NAME / COMPANY:		
SIGNATORY NAME & POSITION:	SIGNATURE:	DATE:
APPLICANT NAME / COMPANY:		
SIGNATORY NAME & POSITION:	SIGNATURE:	DATE:
APPLICANT NAME / COMPANY:		
SIGNATORY NAME & POSITION:	SIGNATURE:	DATE:

The administering authority may accept an application for EA made for all the joint holders by a person who is a joint holder if satisfied the person is authorised to make the application for each of the joint holders.

In deciding an application for the EA, the administering authority must consider any suitability report obtained for the application.



CROYDON GOLD MINE
ENVIRONMENTAL INVESTIGATION

NOVEMBER 2011
Project No. BAR-06-01
Document No. 00415164

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1 INTRODUCTION

The Croydon Gold Mine (the CGM) is located to the immediate west of the Croydon township, 560 kilometres (km) west of Cairns, Queensland (QLD) (Figure 1). The CGM was formerly a low-grade gold mine and has since been closed and decommissioned. Activities at the CGM include maintenance, monitoring, investigations and reclamation works (as required).

Mining Lease (ML) 5248 was granted on 4 August 1988 to Goldfields Kalgoorlie Limited. ML 5248 was later transferred to Aurion Gold Limited, before the company was acquired by Placer Dome Australia in November 2003, which was then acquired by Barrick Australia Pacific Limited (Barrick) in 2005. Barrick holds Environmental Authority (EA) No. MIN100401906 for the CGM.

1.1 BACKGROUND

General

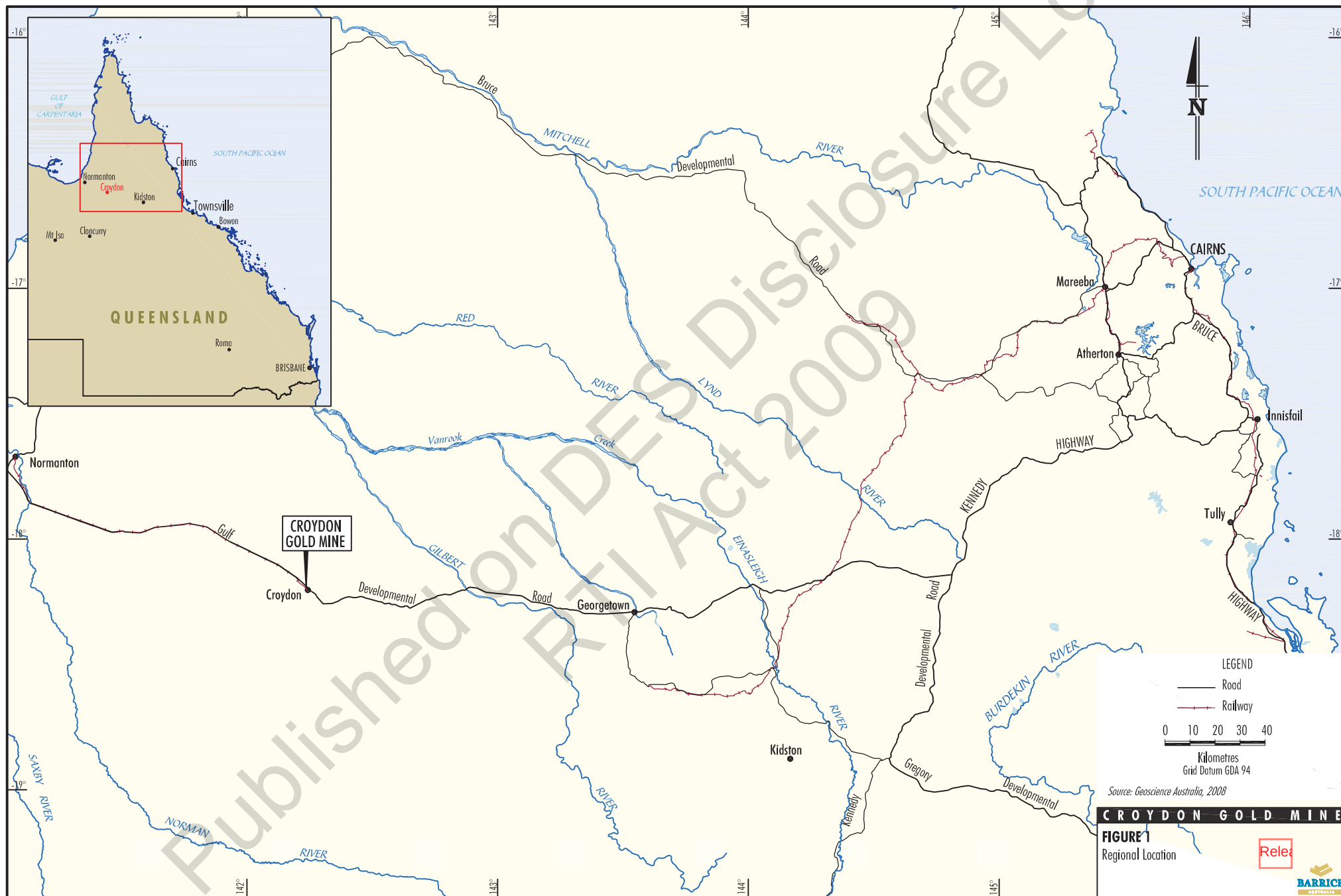
Extensive gold mining at the CGM commenced in the late 1880s for approximately 30 years, before recommencing in 1987. Operational mining ceased in 1990 and the CGM was decommissioned by late 1993 (Barrick, 2008). Reclamation performance was audited in 1996/1997 and significant additional reclamation works were subsequently undertaken (Barrick, 2008).

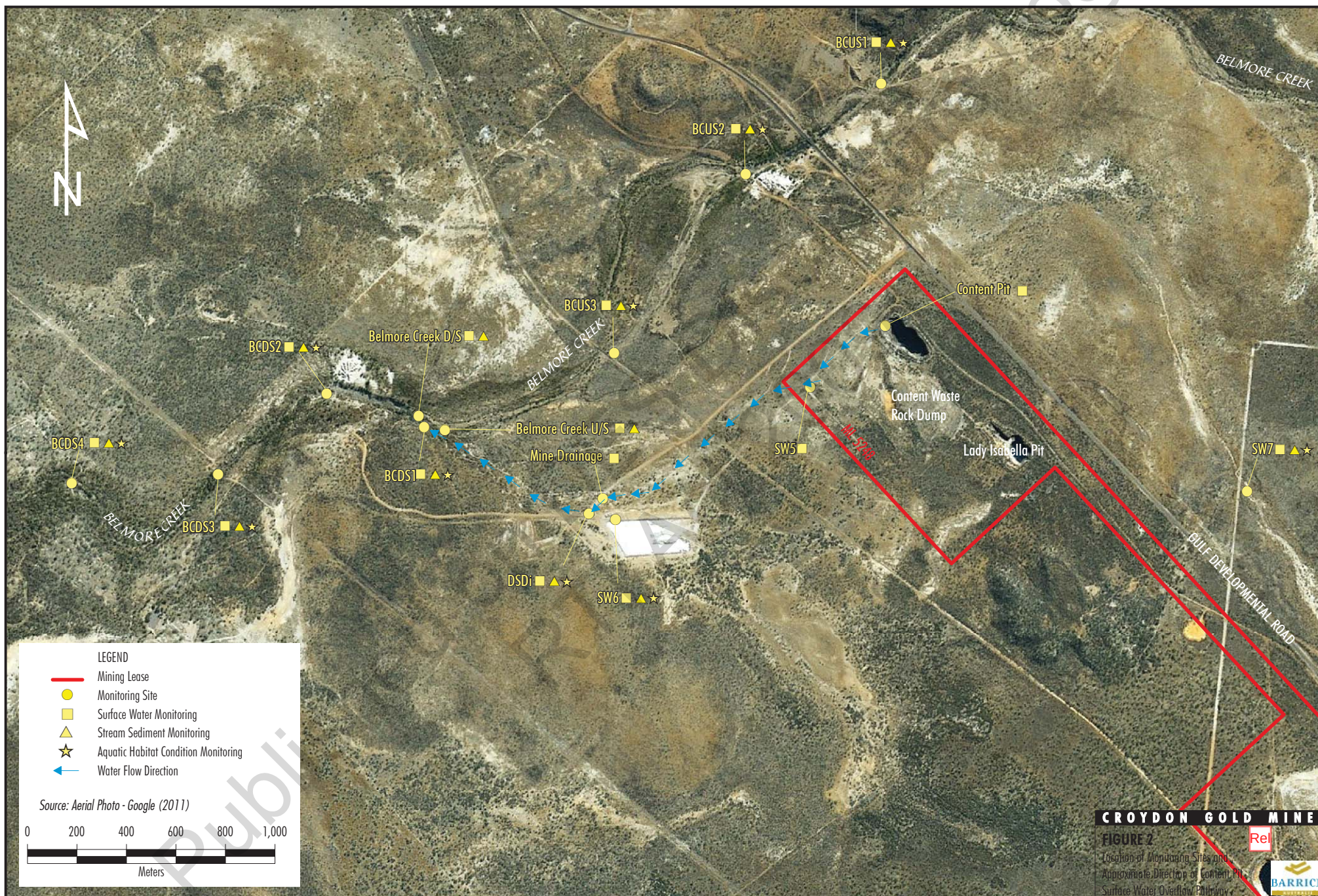
The mining-related landforms on ML 5248 comprise of waste rock dumps, open pits and infrastructure areas (i.e. abandonment bunds, hardstand areas, water management structures and roads/tracks) surrounding the open pits and waste rock dumps. Specifically they include (Figure 2):

- Golden Butterfly Pit;
- Golden Butterfly North Pit;
- Golden Butterfly waste rock dump;
- Content Pit;
- Content waste rock dump;
- Lady Isabella Pit;
- abandonment bunds across the access ramps of the four open pits;
- hardstand areas adjacent to the Content and Golden Butterfly waste rock dumps;
- water diversion bunds and sediment dams adjacent to the Content and Golden Butterfly waste rock dumps; and
- roads and tracks.

Background to Content Pit Surface Water Outflow

The 2008 and 2009 annual rainfall totals (i.e. 978 millimetres [mm] and 1,262 mm, respectively) recorded at the nearest Commonwealth Bureau of Meteorology (BOM) station (Croydon Township - station 029012) were above the average annual rainfall recorded over the past 123 years (i.e. 748.4 mm) (BOM, 2011). The 2010/2011 wet season in the Croydon area was characterised by extraordinary rainfall totals (Section 2.1). In recognition of the diminishing storage capacity within the Content Pit, Barrick was granted approval by the Department of Environment and Resource Management (DERM) on 23 September 2010 to undertake short-term remediation works involving the transfer of water from the Content Pit to the Golden Butterfly Pit to increase the storage capacity of the Content Pit.





As a result of the works, the water level within the Content Pit was decreased by approximately four metres (m) during November and December 2010 (with a subsequent increase of one meter in the Golden Butterfly Pit).

Since completion of the water transfer works in December 2010 and subsequent to the extraordinary wet season rainfall during the 2010/2011 wet season, monitoring of the pit lake water levels on 23 February 2011 indicated that the storage capacity within the Content Pit had again diminished. In recognition of the diminished storage capacity within the Content Pit since the water transfer works, DERM was notified by phone on 24 March 2011 of the following points:

- Barrick had completed the approved short-term remediation works to minimise the potential risk of the Content Pit over-topping during the 2010/2011 wet season. The works included transferring water from the Content Pit to the Golden Butterfly Pit.
- Since completion of the works, Barrick has continued undertaking regular monitoring of the pit lake water levels as a component of the additional hydrogeological investigations required in accordance with the EA.
- Observations of the pit lake water levels on 23 February 2011 following the heavy rainfall conditions in Northern Queensland indicated that the remaining freeboard of the Content and Lady Isabella Pits was approximately 1.5 m and 3 m respectively.
- Given the remaining freeboard of these pits, it was considered that should further heavy rainfall be experienced, there is potential for the Content Pit and Lady Isabella Pit to spill during this wet season.
- Water quality monitoring (conducted on 23 February 2011) of the Content and Lady Isabella Pits indicated pH results of 4.59 and 4.10 respectively and electrical conductivity (EC) results of 810 microSiemens per centimetre ($\mu\text{S}/\text{cm}$) and 530 $\mu\text{S}/\text{cm}$ respectively.
- Access to the site to recommence water transfer works was restricted due to the recent heavy rainfall conditions. As a result, Barrick was unable to access the site to undertake similar short-term works to minimise the potential spill risk from the Content Pit.
- Notwithstanding the above, Barrick:
 - continued to undertake regular monitoring of the pit lake water levels and water quality; and
 - continued hydrogeological investigations in accordance with the EA.

Due to inaccessibility of the site during the 2010/2011 wet season, Barrick retained the services of a local resident to visually monitor the site, in particular the pit lake levels. Barrick was informed by the local resident on the 29th March 2011 that the Content Pit was full and surface water outflows from the pit were observed due to the recent heavy rainfall conditions. A Barrick representative visited the site on the 30th March 2011 and confirmed the surface water outflows from the Content Pit and notified the DERM by telephone as required by EA Conditions A4-1 and A4-2 and began monitoring and sampling as per EA Condition F1-3.

No surface water outflows were recorded from any of the other open pits at the CGM, viz Lady Isabella, Golden Butterfly and Golden Butterfly North open pits during the 2010/2011 wet season. Surface water outflows from the Content Pit ceased on 2 May 2011. Observations also showed that no flow was occurring at the Mine Drainage site or at site DSDi as of 13 April 2011 (Figure 2).

Formal written advice regarding the Content Pit surface water outflow was submitted to the DERM on 14 April 2011. Further follow-up written advice including surface water quality monitoring results undertaken as a result of the Content Pit surface water outflows and results from the April 2011 macroinvertebrate survey report was submitted to the DERM on 1 August 2011.

As described in Barrick's follow-up written advice submitted to the DERM on 1 August 2011, based on the results of the surface water quality monitoring undertaken on-site and at receiving water sites located downstream of the surface water outflows from the Content Pit, Barrick immediately commenced an investigation into the potential for environmental harm as a result of the Content Pit outflow.

This report presents the results of the investigation into the potential for environmental harm as a result of the Content Pit outflow.

1.2 PURPOSE AND SCOPE OF THIS REPORT

This report investigates the potential risk to the ecosystem of Belmore Creek and its relevant tributaries in the vicinity of the CGM as a result of the Content Pit outflow. The investigation included analysing the results of water quality, stream sediment quality and aquatic habitat condition monitoring undertaken and assessing the potential impacts to surface waters, stream sediment and the aquatic habitat of Belmore Creek and its relevant tributaries in the vicinity of the CGM as a result of the Content Pit surface water outflow.

1.3 REPORT STRUCTURE

The remainder of this report is structured as follows:

- Section 2: Describes relevant environmental values.
 - Section 3: Outlines the monitoring programme conducted in response to the surface water outflow.
 - Section 4: Presents the results of monitoring undertaken in response to the surface water outflow and provides an assessment of the potential impacts from the surface water outflow in accordance with the Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000) risk-based decision framework.
 - Section 5: Presents the conclusions of this report.
 - Section 6: Lists the references cited in this report.
- Appendices A and B contain supporting documentation for this report.
- Appendix A: Croydon Gold Mine Macroinvertebrate Survey April 2011
 - Appendix B: Summary Interpretation of Content Pit Water Toxicity Results

2 RELEVANT ENVIRONMENTAL VALUES

The environmental values relevant to this investigation include surface water, stream sediments and the aquatic habitat (including macroinvertebrates) of the Belmore Creek and its tributaries in the vicinity of the CGM.

This section provides a description of the background (i.e. upstream) environment relevant to the environmental values described above.

2.1 SURFACE WATER

Local Hydrology

The CGM experiences highly seasonal rainfall with an annual average of 748.4 mm of rainfall recorded at the nearest Commonwealth Bureau of Meteorology (BOM) station (Croydon Township - station 029012) over the past 123 years (BOM, 2011).

The highly seasonal nature of rainfall means that local creeks/systems in the vicinity of the CGM, including Belmore Creek and its tributaries, are ephemeral, similar to other systems in North Queensland. The north-western section of ML 5248, which includes the Content Pit mining area, lies within the Belmore Creek catchment (Figure 2).

Surface water runoff in local creeks and drainage lines in ML 5248 ceases soon after storm events (Barrick, 2008). Gradients are very low on much of ML 5248 which means that sheet flow is the dominant hydrological process during the wet season (Barrick, 2008).

The Content Pit surface water outflow pathway was confined within a defined channel (which is not a natural watercourse) up to site DSDi (Figure 2). At this point, the surface water outflow pathway enters a tributary of Belmore Creek, approximately 800 m upstream of where the tributary enters Belmore Creek (Figure 2).

2010/2011 Wet Season

The 2010/2011 wet season was characterised by extraordinary rainfall conditions. 2010 was the wettest year on record over the past 123 years with 1,565.8 mm of rainfall recorded at the Croydon Township BOM station (BOM, 2011). The 2010 annual rainfall (1,565.8 mm) was more than double the annual average rainfall over the past 123 years (748.4 mm).

Belmore Creek Upstream Surface Water Quality

Surface water quality monitoring has been conducted at the EA upstream reference monitoring site SW7 (Figure 2) located on a tributary of Belmore Creek north-east of ML 5248 since 2009. Surface water quality monitoring results from this site are considered to be representative of the water quality in Belmore Creek and its tributaries without influence from the CGM.

Surface water quality monitoring has also been undertaken since January 1999 at site SW6 which is located on another tributary of Belmore Creek at a stock water dam south-west of ML 5248 (Figure 2). Considering site SW6 is located upstream of the Content Pit surface water outflow pathway (Figure 2), the water quality at this site was not influenced by the Content Pit surface water outflow and therefore this site is a relevant upstream monitoring site for the purposes of this report.

The remainder of this section provides an overview of the surface water quality monitoring results recorded at Belmore Creek upstream reference monitoring site SW7 since January 2009 and at upstream site SW6 since January 1999.

EA Upstream Reference Monitoring Site SW7 – Summary of Water Quality Monitoring Results

Routine water quality monitoring has been conducted at the Belmore Creek EA upstream reference monitoring site SW7 (Figure 2) since January 2009. Site SW7 is located on a tributary of Belmore Creek north-east of ML 5248 (Figure 2).

The pH for the Belmore Creek upstream reference site SW7 has been generally neutral to slightly acidic (i.e. values ranging from 6.7 to 7.2) since January 2009. EC results have exceeded the EA receiving water trigger level of 250 $\mu\text{S}/\text{cm}$ on two occasions and results have ranged between 25 and 290 $\mu\text{S}/\text{cm}$ since January 2009.

The sulphate trigger level of 56 milligrams per litre (mg/L) was exceeded on one occasion at site SW7. Sulphate results have ranged from 1 mg/L to 57 mg/L since January 2009. Turbidity results exceeded the EA trigger level of 26 NTU on four occasions and results have ranged from 1.5 to 70 NTU since January 2009. Fluoride exceeded the EA trigger level on one occasion and aluminium, cobalt, copper and zinc have each recorded several trigger level exceedances since January 2009.

No parameters have exceeded the receiving water contaminant limits defined in Schedule F – Table 3 of the EA since January 2009.

Table 1 presents a summary the surface water quality results recorded at the Belmore Creek upstream reference site SW7 since January 2009.

Table 1
Summary of Surface Water Quality Results Recorded at Belmore Creek Upstream Site SW7 Since January 2009

Parameter	Trigger Level ¹	Trigger Level Exceedance/ Number of Samples	Range
pH	6-7.5	0/28	6.58 to 7.2
EC	250 $\mu\text{S}/\text{cm}$	2/28	25 to 290 $\mu\text{S}/\text{cm}$
Turbidity	26 NTU	4/24	1.5 to 70 NTU
Sulphate	56 mg/L	1/29	1 to 57 mg/L
Aluminium	1.42 mg/L	4/29	0.01 to 1.53 mg/L
Arsenic	0.013 mg/L	0/29	0.001 to 0.013 mg/L
Cadmium	0.0002 mg/L	0/29	0.0001 to 0.0002 mg/L
Cobalt	0.0014 mg/L	8/29	0.001 to 0.005 mg/L
Copper	0.003 mg/L	8/29	0.001 to 0.012 mg/L
Nickel	0.011 mg/L	0/29	0.001 to 0.004 mg/L
Zinc	0.008 mg/L	5/29	0.005 to 0.025 mg/L
Boron	0.370 mg/L	0/29	0.003 to 0.05 mg/L
Selenium	0.011 mg/L	0/29	0.003 to 0.1 mg/L
Mercury	0.0006 mg/L	0/29	0.0001 to 0.0003 mg/L
Chromium	0.01 mg/L	0/29	0.001 to 0.01 mg/L
Fluoride	0.3 mg/L	1/29	0.1 to 0.34 mg/L

¹ Trigger levels calculated in accordance with Schedule F- Table 2 of the EA.

Belmore Creek Upstream Monitoring Site SW6 – Summary of Water Quality Monitoring Results

Routine water quality monitoring has been conducted at monitoring site SW6 (Figure 2) since January 1999. Site SW6 is located on a stock dam on a separate tributary of Belmore Creek (south-west of ML 5248) compared with EA upstream reference site SW7 (Figure 2).

The pH results at site SW6 have varied between slightly acidic to slightly alkaline (i.e. with values ranging from 5.3 to 9) since January 1999. EC results have exceeded the EA receiving water trigger level of 250 $\mu\text{S}/\text{cm}$ on four occasions. Generally, however, EC has been low relative to the EA receiving water trigger level.

No sulphate concentrations have exceeded the relevant Belmore Creek sulphate trigger level of 56 mg/L since January 2009 with results ranging between 1 mg/L and 43 mg/L. Turbidity results have exceeded the EA trigger level of 26 NTU on each sampling occasion since January 1999. Cadmium, cobalt, copper, nickel, zinc and fluoride results have recorded several exceedances of the relevant EA trigger levels defined in Schedule F – Table 2 of the EA.

Aluminium results have consistently exceeded the EA trigger level of 1.42 mg/L since January 1999 and aluminium was the only parameter to exceed the EA contaminant limit of 5 mg/L on 27 March 2006.

Table 2 provides a summary of the surface water quality results recorded at site SW6 since January 1999. As described earlier in this section, for the purposes of this report, site SW6 is an upstream monitoring site, given it is located upstream of the Content Pit surface water outflow pathway (Figure 2).

Table 2
Summary of Surface Water Quality Results Recorded at Belmore Creek Upstream Site SW6 Since January 1999

Parameter	Trigger Level ¹	Trigger Level Exceedance/ Number of Samples	Range
pH	6-7.5	30/78	5.3 to 9
EC	250 $\mu\text{S}/\text{cm}$	4/78	24 to 480 $\mu\text{S}/\text{cm}$
Turbidity	26 NTU	20/20	72.4 to 310 NTU
Sulphate	56 mg/L	0/78	1 to 43 mg/L
Aluminium	1.42 mg/L	36/55	0.025 to 27 mg/L
Arsenic	0.013 mg/L	0/78	0.001 to 0.011 mg/L
Cadmium	0.0002 mg/L	6/78	0.00001 to 0.0014 mg/L
Cobalt	0.0014 mg/L	32/49	0.001 to 0.025 mg/L
Copper	0.003 mg/L	69/78	0.001 to 0.158 mg/L
Nickel	0.011 mg/L	40/78	0.001 to 0.025 mg/L
Zinc	0.008 mg/L	64/78	0.0025 to 0.073 mg/L
Boron	0.370 mg/L	0/26	0.002 to 55 mg/L
Selenium	0.011 mg/L	0/26	0.003 to 0.1 mg/L
Mercury	0.0006 mg/L	0/26	0.0001 to 0.0002 mg/L
Chromium	0.01 mg/L	0/26	0.001 to 0.01 mg/L
Fluoride	0.3 mg/L	5/28	0.1 to 0.59 mg/L

¹ Trigger levels calculated in accordance with Schedule F- Table 2 of the EA.

Content Pit – Summary of Water Quality Monitoring Results

Routine water quality monitoring has been conducted at the Content Pit (Figure 2) since February 1994.

The pH results recorded at the Content Pit have been acidic with values ranging between 2.81 and 4.3 with pH results gradually improving over time. EC results have been well below the EA contaminant limit of 5,970 $\mu\text{S}/\text{cm}$ defined in Schedule F – Table 8 of the EA. Sulphate levels have not exceeded the EA contaminant limit of 1,000 mg/L since February 1994 and sulphate levels have consistently improved over time. Metal concentrations have been low in comparison with the contaminant limits defined in Schedule F – Table 8 of the EA with the exception of aluminium, cadmium and copper. However, aluminium has not exceeded the contaminant limit of 5 mg/L since October 2008, cadmium has not exceeded the contaminant limit of 0.01 mg/L since January 2001 and copper has not exceeded the contaminant limit of 1 mg/L since January 1995. Fluoride results have only exceeded the contaminant limit of 2 mg/L on two occasions.

Results for all other parameters have remained relatively stable and have not deteriorated since monitoring commenced.

Table 3 provides a summary of the surface water quality results recorded at the Content Pit since February 1994.

Table 3
Summary of Content Pit Surface Water Quality Results (1994 – 2011)

Parameter	EA Contaminant Limit ¹	Number of Contaminant Limit Exceedances/Number of Samples	Range
pH	4-9	48/57	2.81 to 4.3
EC	5,970 $\mu\text{S}/\text{cm}$	0/47	737 to 1,900 $\mu\text{S}/\text{cm}$
Turbidity	4,000 TDS	0/16	0.2 to 97 TDS
Sulphate	1,000 mg/L	0/56	300 to 1,000 mg/L
Aluminium	5 mg/L	6/26	1.31 to 7 mg/L
Arsenic	0.5 mg/L	0/56	0.0025 to 0.23 mg/L
Cadmium	0.01 mg/L	23/57	0.0021 to 0.045 mg/L
Cobalt	1 mg/L	0/24	0.09 to 0.29 mg/L
Copper	1 mg/L	4/57	0.056 to 1.85 mg/L
Nickel	1 mg/L	0/54	0.087 to 0.59 mg/L
Zinc	20 mg/L	0/57	0.229 to 2.52 mg/L
Boron	5 mg/L	0/16	0.044 to 0.06 mg/L
Selenium	0.02 mg/L	0/16	0.003 to 0.01 mg/L
Mercury	0.002 mg/L	0/16	0.0001 to 0.0002 mg/L
Chromium	1 mg/L	0/16	0.001 to 0.01 mg/L
Fluoride	2 mg/L	2/17	1.1 to 2.6 mg/L

¹ Contaminant limits as defined in Schedule F- Table 8 of the EA.

Although the above provides context to the historical water quality results recorded at the Content Pit, this water quality summary is not representative of the Content Pit water quality recorded during the surface water outflow between 30 March and 2 May 2011. The water quality results recorded at the Content Pit during the surface water outflow event are provided in Section 4.

2.2 STREAM SEDIMENT

Belmore Creek Upstream Stream Sediment Quality

Stream sediment monitoring was conducted at the EA upstream reference monitoring site SW7 (Figure 2) located on a tributary of Belmore Creek north-east of ML 5248 during April 2011. Stream sediment monitoring results from this site are considered to be representative of the sediment quality in Belmore Creek and its tributaries without influence from the CGM.

Stream sediment monitoring was also undertaken at site SW6 which is located on a stock water dam on another tributary of Belmore Creek south-west of ML 5248 during April 2011 (Figure 2). Considering site SW6 is located upstream of the Content Pit surface water outflow pathway (Figure 2), the sediment quality at this site was not influenced by the Content Pit surface water outflow and therefore this site is a relevant upstream monitoring site for the purposes of this report.

As described in Section 2.1, the presence of an historic tailings deposit located on the banks of Belmore Creek north-west of the CGM near where the Gulf Development Road crosses Belmore Creek (Figure 2) could potentially have influenced the stream sediments of Belmore Creek over time in the vicinity of the CGM.

The remainder of this section provides an overview of the stream sediment monitoring results recorded at Belmore Creek upstream reference monitoring sites SW7 and SW6 during April 2011.

Belmore Creek EA Upstream Monitoring Sites SW7 and SW6 – Summary of Stream Sediment Monitoring Results

Results from stream sediment monitoring at the Belmore Creek EA upstream reference monitoring sites SW7 and SW6 during April 2011 indicated no exceedances of the ANZECC & ARMCANZ (2000) Interim Sediment Quality Guidelines (ISQG) low values (i.e. the EA stream sediment trigger level values defined in Schedule C – Table 7 of the EA). Elevated aluminium concentrations were recorded at both upstream sites. These naturally elevated aluminium concentrations are considered due to the natural colloidal fraction (i.e. aluminium in an unavailable form).

2.3 AQUATIC HABITAT CONDITION

No baseline macroinvertebrate surveys or aquatic habitat studies have been conducted in Belmore Creek in the vicinity of the CGM prior to 2011. FRC Environmental conducted an investigation into the potential impact of the outflow in April 2011. A detailed description of the results of the macroinvertebrate survey is provided Section 4.3.

Considering the lack of baseline macroinvertebrate or aquatic habitat information for Belmore Creek in the vicinity of the CGM, relevant information of the macroinvertebrates and aquatic habitat recorded at upstream sites in Belmore Creek has been used from FRC Environmental's (2011) *Croydon Gold Mine Macroinvertebrate Survey April 2011* as control sites against which the downstream sites were compared. FRC Environmental's (2011) report included a description of the aquatic habitat and macroinvertebrates at sites located in Belmore Creek upstream of the CGM (i.e. sites BCUS1, BCUS2 and BCUS3) and at the Belmore Creek EA upstream monitoring sites SW7 and SW6. A summary of the aquatic habitat and macroinvertebrates recorded at these upstream sites from FRC Environmental's (2011) report is provided below.

Belmore Creek Upstream Aquatic Habitat

FRC Environmental (2011) identified that the aquatic habitat at the Belmore Creek upstream sites BCUS1, BCUS2 and BCUS3 was in good condition with cobble, pebble and gravel substrates suitable for macroinvertebrates and native vegetation comprising much of the riparian zone. However, sites SW7 and SW6 (located in tributaries of Belmore Creek) recorded the least suitable macroinvertebrate habitat, as the substrates were dominated by fine sand and silt (*ibid.*). Both sites had poor riparian vegetation and had low in-stream habitat diversity (*ibid.*).

FRC Environmental (2011) also observed evidence of cattle access at upstream sites BCUS1, BCUS2, BCUS3 and SW6, which was reported to likely affect macroinvertebrate communities.

Belmore Creek Upstream Aquatic Macroinvertebrates

Total taxonomic richness and PET richness was reported to be generally low at all upstream sites, and was typically higher in the edge and riffle habitats than in bed habitats (FRC Environmental, 2011). No riffle habitat was present at upstream sites SW7, BCUS1 or at site SW6 (FRC Environmental, 2011).

SIGNAL 2 scores are based on the sensitivity of each macroinvertebrate community to pollution or habitat degradation (FRC Environmental, 2011). A low number means the macroinvertebrate is tolerant of a range of environmental conditions including common forms of water pollution (e.g. suspended sediments and nutrient enrichment) (FRC Environmental, 2011). The lowest SIGNAL 2 scores for the edge habitat were recorded at the upstream sites SW7 and BCUS3 (FRC Environmental, 2011). The lowest SIGNAL 2 score for the bed habitat was recorded at the upstream site SW7 (FRC Environmental, 2011). The highest SIGNAL 2 score for each habitat was recorded at upstream site BCUS2 (FRC Environmental, 2011).

A comparison of the macroinvertebrate survey results between the Belmore Creek upstream sites and sites located downstream of the Content Pit surface water outflow pathway is provided in Section 4.3 and Appendix A.

3 ADDITIONAL MONITORING PROGRAMME CONDUCTED IN RESPONSE TO CONTENT PIT SURFACE WATER OUTFLOW

Barrick initiated an additional monitoring programme on 30 March 2011 in response to the surface water outflow from the Content Pit. The approximate direction of the surface water outflow is presented in Figure 2. The additional monitoring programme included surface water and stream sediment monitoring at additional monitoring sites within Belmore Creek upstream and downstream of the CGM (including sites along the surface water outflow pathway). As described in the follow-up written advice provided to the DERM on 1 August 2011, a macroinvertebrate survey was also undertaken by FRC Environmental at relevant sites upstream and downstream of the CGM. A summary of the additional monitoring programme undertaken is provided in Table 4 below.

Table 4
Summary of Additional Monitoring Programme

Monitoring Component	Location	Site ¹	Site Description
Surface Water	On-site Waters	Content Pit	Sample taken from point where surface water flowed from the Content Pit.
		SW5	Sediment dam near the south-west corner of ML 5248 boundary. Sample taken from point where surface water flowed from the dam.
	Surface Water Outflow Pathway	Mine Drainage	The defined channel draining the surface water outflow from the Content Pit. Other surrounding surface water also flowed to this drainage channel.
Surface Water and Stream Sediment	Upstream within a tributary of Belmore Creek	DSDi	Downstream of where the channel draining the Content Pit surface water outflow enters a tributary of Belmore Creek (approximately 800 m upstream of where the tributary enters Belmore Creek).
		SW7	Upstream EA reference monitoring site located on a tributary of Belmore Creek north-east of ML 5248.
		SW6	EA monitoring site located at a stock water dam on a tributary of Belmore Creek south-west of ML 5248. Site located upstream of surface water outflow pathway.
	Belmore Creek Upstream	BCUS1	Located in Belmore Creek approximately 2.4 km upstream of where the Content Pit surface water outflow pathway enters Belmore Creek (i.e. at site BCDS1).
		BCUS2	Located in Belmore Creek approximately 1.85 km upstream of where the Content Pit surface water outflow pathway enters Belmore Creek (i.e. at site BCDS1).
		BCUS3	Located in Belmore Creek approximately 800 m upstream of where the Content Pit surface water outflow pathway enters Belmore Creek (i.e. at site BCDS1).
		Belmore Creek U/S	Located in Belmore Creek immediately upstream of where the Content Pit surface water outflow pathway enters Belmore Creek.
	Belmore Creek Downstream	BCDS1	Located in Belmore Creek immediately downstream of where the Content Pit surface water outflow pathway enters Belmore Creek.
		Belmore Creek D/S	Located in Belmore Creek approximately 50 m downstream of where the Content Pit surface water outflow pathway enters Belmore Creek (i.e. at site BSDS1).
		BCDS2	Located in Belmore Creek approximately 450 m downstream of where the Content Pit surface water outflow pathway enters Belmore Creek (i.e. at site BSDS1).
		BCDS3	Located in Belmore Creek approximately 1 km downstream of where the Content Pit surface water outflow pathway enters Belmore Creek (i.e. at site BSDS1).
		BCDS4	Located in Belmore Creek approximately 1.9 km downstream of where the Content Pit surface water outflow pathway enters Belmore Creek (i.e. at site BSDS1).

¹ Refer to Figure 2.

Table 4 (Continued)
Summary of Additional Monitoring Programme

Monitoring Component	Location	Site ¹	Site Description
Macroinvertebrate Survey	Upstream	SW7, SW6, BCUS1, BCUS2 and BCUS3	As above.
	Downstream	DSDi, BCDS1, BCDS2, BCDS3 and BCDS4	As above.

¹ Refer to Figure 2.

The results from the additional monitoring programme undertaken in response to the Content Pit surface water outflow are provided in Section 4. An analysis of the results and an assessment of the potential impact to the relevant environmental values (Section 2) from the Content Pit surface water outflow is provided in Section 4.

Macroinvertebrate Survey

In response to the Content Pit surface water outflow, Barrick immediately commissioned FRC Environmental to conduct a macroinvertebrate survey in Belmore Creek and its relevant tributaries to characterise the macroinvertebrate communities and aquatic habitat at sites located upstream and downstream of the CGM. A total of ten sites were surveyed in Belmore Creek and its tributaries between 4 and 6 April 2011. Comparative sites (or upstream sites) were chosen to represent the range of aquatic habitats in the area and to match potentially impacted sites, in terms of water body type, stream order and environmental conditions.

The results of the macroinvertebrate survey, including a comparison of the upstream and downstream macroinvertebrate communities and aquatic habitat conditions and an assessment of the impact to macroinvertebrate communities as a result of the Content Pit surface water outflow, are summarised in Section 4.3.

4 RESULTS OF MONITORING PROGRAMME AND ASSESSMENT OF POTENTIAL IMPACTS

This section provides an analysis of the results of the monitoring programme (Section 3) and an assessment of the potential impacts to the relevant environmental values (Section 2) of Belmore Creek and its tributaries in the vicinity of the CGM as a result of the Content Pit surface water outflow. The assessments in this section have been conducted in accordance with the ANZECC and ARMCANZ (2000) risk-based decision framework to investigate the potential risk to the ecosystem of Belmore Creek and its tributaries in the vicinity of the CGM as a result of the Content Pit surface water outflow.

4.1 SURFACE WATER

Surface Water Quality Results

The surface water quality results from the monitoring programme undertaken between 30 March and 2 May 2011 in response to the Content Pit surface water outflows have been compared against the receiving water trigger levels and receiving water or on-site water contaminant limits defined in Schedule F of the EA. A summary of the trigger level and contaminant limit exceedances recorded at the surface water monitoring sites described in Section 3 is provided in Table 5.

Table 5
Comparison of Surface Water Quality Results Against
Relevant EA Trigger Levels and Contaminant Limits

Location	Site ¹	EA Trigger Level Exceedance ²	EA Contaminant Limit Exceedance ³
Belmore Creek Upstream	SW7	Aluminium, Turbidity	No Exceedance
	SW6	Aluminium, Turbidity	No Exceedance
	BCUS1	No Exceedance	No Exceedance
	BCUS2	No Exceedance	No Exceedance
	BCUS3	No Exceedance	No Exceedance
	Belmore Creek U/S	Arsenic, Turbidity	No Exceedance
On-site Waters	Content Pit	Not Applicable	pH
	SW5	Not Applicable	pH, Aluminium, Cadmium and Fluoride
Surface Water Outflow Pathway	Mine Drainage	Aluminium, Cadmium, Cobalt, Copper, EC, Fluoride, Nickel, pH, Sulphate, Turbidity and Zinc	No Exceedance
	DSDi	Aluminium, Cadmium, Cobalt, Copper, Fluoride, Nickel, Sulphate, Turbidity and Zinc	No Exceedance
Belmore Creek Downstream	Belmore Creek D/S	Aluminium, Arsenic, Cadmium, Cobalt, Copper, Turbidity and Zinc	No Exceedance
	BCDS1	Turbidity ⁴	No exceedance
	BCDS2	No exceedance	No exceedance
	BCDS3	No exceedance	No exceedance
	BCDS4	No exceedance	No exceedance

¹ Refer to Figure 2.

² Trigger levels as defined in Schedule F- Table 2 of the EA.

³ Contaminant limits as defined Schedule F- Table 3 of the EA for receiving waters and Schedule F – Table 8 of the EA for on-site waters.

⁴ Turbidity trigger level exceedance only recorded in one of three samples taken at site BCDS1.

A summary of the surface water quality data from the monitoring programme undertaken between 30 March and 2 May 2011 is provided in Attachment 1.

Surface Water Quality Results Analysis

Laboratory analysis of the water quality samples was undertaken for each sample collected at the surface water monitoring sites described in Section 3. The surface water results (Attachment 1) represent the filtered results, except where indicated (i.e. for Selenium). A comparison of the surface water monitoring results against the relevant EA on-site water contaminant limits and EA receiving water trigger level and contaminant limits is provided in Table 5.

The remainder of this section provides an analysis of the surface water quality results downstream of the Content Pit surface water outflow point and in accordance with ANZECC and ARMCANZ (2000) risk-based decision framework, where a trigger level is exceeded, investigates the potential risk to the ecosystem as a result of that exceedance.

On-site Waters

No on-site water EA contaminant limit exceedances were recorded at the Content Pit during the reporting period of 30 March to 2 May 2011 except for pH. One Content Pit water sample recorded a pH result marginally below the contaminant limit range of 4 to 9 (i.e. 3.91 on 30 March 2011) (Attachment 1).

Surface water concentrations at on-site water monitoring site SW5 recorded contaminant limit exceedances of pH, aluminium, cadmium and fluoride during the reporting period (Attachment 1). Historical mine workings are present in the vicinity of site SW5 and it is considered that the material from which the dam at SW5 is constructed could possibly influence the water quality at this site considering the water quality from the Content Pit did not contain elevated metal concentrations.

The exceedances of the parameters above were recorded at either then end of the sampling period or successively increased over time, indicating that evapoconcentration of the water contained in the SW5 sediment dam occurs and increases the concentration of these parameters. In accordance with Condition F3-2 of the EA, both the Content Pit and site SW5 are fenced to minimise access by livestock or native fauna.

Surface Water Outflow Pathway and Downstream Belmore Creek

No receiving water contaminant limits were exceeded at sites downstream of ML 5248 (Table 5).

The monitoring sites Mine Drainage and DSDi each recorded receiving water trigger level exceedances for aluminium, cadmium, cobalt, copper, fluoride, nickel, pH, sulphate, turbidity and zinc, with the Mine Drainage site also recording three exceedances of the receiving water EC trigger level (Table 5).

At the Belmore Creek D/S site, trigger level exceedances were recorded for aluminium, arsenic, cadmium, cobalt, copper, turbidity and zinc (Table 5). All metals concentrations reduce to below receiving water trigger levels by site BCDS1 with this site only recording a trigger level exceedance for turbidity on one occasion (Attachment 1).

Observations during the monitoring programme showed that no flow was occurring at the Mine Drainage site or at site DSDi as of 13 April 2011 (Figure 2). Outflows from the stock dam located upstream of site DSDi were observed to dominate the input to site DSDi at this time. Water was also observed to backflow from site DSDi to the Mine Drainage site once flows from the Content Pit had ceased reporting to the Mine Drainage site. These observations confirm the increase in pH results and decrease in sulphate and EC results at the Mine Drainage and DSDi sites.

4.1.1 Assessment of Potential Impact

The following assessment of the potential impact to surface waters in Belmore Creek and its relevant tributaries in the vicinity of the CGM has been based on the ANZECC and ARMCANZ (2000) *Simplified decision tree for assessing toxicants in ambient waters* (Figure 3). The assessment aims to investigate the potential risk to the ecosystem where a trigger level has been exceeded.

Level of Protection - Target Ecosystem Condition

In accordance with Schedule F – Table 2 of the EA, the ANZECC and ARMCANZ (2000) level of protection or target ecosystem condition relevant to Belmore Creek and its relevant tributaries in the vicinity of the CGM is: *Slightly to moderately disturbed systems*. In accordance with ANZECC and ARMCANZ (2000), an increased level of change of biological indicators might be acceptable for this ecosystem condition compared with an ecosystem of high conservation/ecological value. The key management goal for slightly to moderately disturbed ecosystems should be the maintenance of biological diversity relative to a suitable reference condition (ANZECC and ARMCANZ, 2000).

Comparison of Downstream Surface Water Quality Results with Background Concentrations

Surface water monitoring results from upstream sites SW7 and SW6 each recorded trigger level exceedances for aluminium and turbidity during the reporting period (Table 5). Results from the Belmore Creek U/S site recorded exceedances of the arsenic and turbidity trigger levels defined in the EA (Table 5).

Aluminium concentrations at the upstream sites SW7 and SW6 are also elevated and comparable with aluminium concentrations recorded at sites Mine Drainage, DSDi and Belmore Creek D/S (Attachment 1). Upstream site SW6 recorded a maximum aluminium concentration of 4.82 mg/L (Attachment 1). These naturally elevated aluminium concentrations present upstream and downstream in Belmore Creek are considered a measure of total aluminium and due to the natural colloidal fraction (i.e. aluminium in an unavailable form).

Turbidity results at upstream sites SW7 and SW6 were also elevated, with upstream site SW6 recording a maximum turbidity result of 120 NTU which is comparable to the maximum turbidity results of 110 NTU recorded at sites Mine Drainage and DSDi.

The arsenic trigger level exceedance recorded at the Belmore Creek D/S site (i.e. 0.019 mg/L) is comparable with the arsenic concentration recorded at the Belmore Creek U/S site (0.016 mg/L).

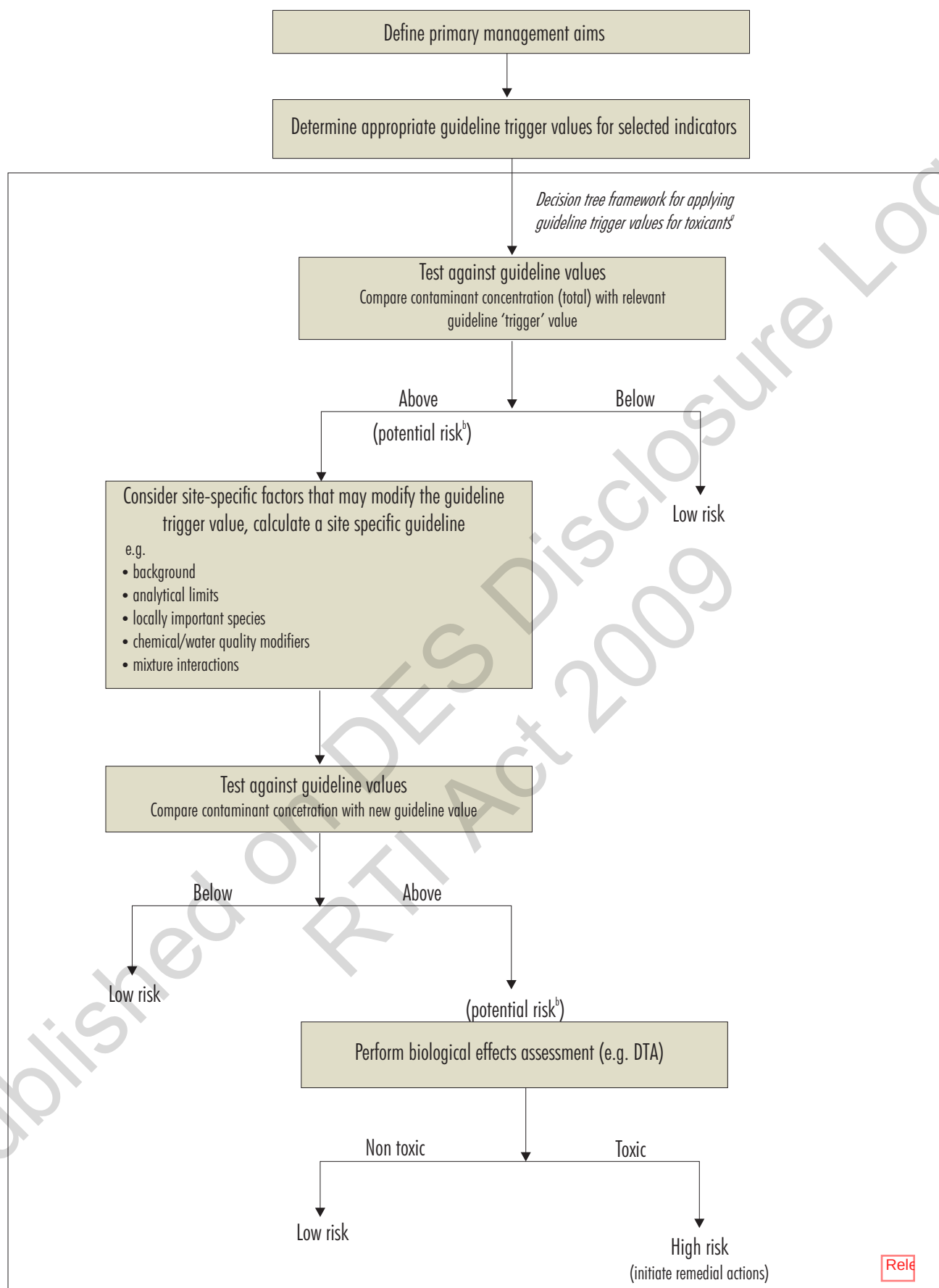
Although the pH results recorded at the Mine Drainage site averaged 5.4 during the reporting period, pH results at site DSDi and sites further downstream increased and remained neutral therefore reducing the potential availability of the parameters that exceeded trigger levels at those sites.

Toxicity Testing of Content Pit Surface Waters

In accordance with the ANZECC and ARMCANZ (2000) *Simplified decision tree for assessing toxicants in ambient waters* (Figure 3), Barrick initiated a biological effects assessment (i.e. toxicity testing) of water samples from the Content Pit to investigate the potential risk to the ecosystem from the pH contaminant limit range exceedance recorded at the Content Pit and the potential risk from the receiving water trigger level exceedances recorded at sites Mine Drainage, DSDi and Belmore Creek D/S

(Section

4.1).



^a Local biological effects data not required in the decision trees

^b Further investigations are not mandatory: users may opt to proceed to management/remedial action

Source: ANZECC and ARMCANZ (2000)

CROYDON GOLD MINE

FIGURE 3

Simplified Decision Tree for
Assessing Toxicants in Ambient Waters



The following five fresh water aquatic toxicity tests were conducted for samples of Content Pit water:

1. 48 hour acute (immobilisation) test using the freshwater cladoceran *Ceriodaphnia dubia*.
2. Partial life-cycle test using the freshwater cladoceran *Ceriodaphnia dubia*.
3. 48 hour acute toxicity test using the freshwater chironomid *Chironomus tepperi*.
4. 96 hour acute toxicity test with the freshwater shrimp *Marcobrachium australiense*.
5. 7 day growth inhibition test using a freshwater aquatic duckweed *Lemna diasperma*.

A summary interpretation of the Content Pit toxicity test results has been undertaken by Associate Professor [CTPI 49-Sch4] of the University of Queensland. [CTPI 49-Sch4] interpretation is provided in full in Appendix B.

The complete test results including a detailed description of the test methods used is presented in Ecotox Services Australasia Pty Ltd's *Toxicity Assessment of Two Pit Water Samples Test Report August 2011* (Attachment 1 of Appendix B).

A summary of Professor Noller's interpretation of the toxicity test results is provided below.

Results of the toxicity testing indicated the sensitivity of the test species ranged from nil or little response to a significant level of effect (Appendix B). Three of the four species showed nil to little response to the pit water (Appendix B). The freshwater cladoceran *Ceriodaphnia dubia* was the most sensitive of the test species to the Content Pit water (Appendix B).

[CTPI 49-Sch4] indicated that in accordance with ANZECC and ARMCANZ (2000) guidelines, the safe dilution of Content Pit water so that there would be no observed effect would be 100 times the NOEC (i.e. no observed effect concentration) value for the most sensitive test species (i.e. 3.1%) (Appendix B). No acute or chronic effects would likely occur at this dilution (Appendix B).

Assessment of Dilution Effect During Content Pit Surface Water Outflow

Significant dilution of the Content Pit water is expected with distance from the Content Pit outflow point. By conducting toxicity testing on direct Content Pit water and not water from site DSDi (the point at which outflows entered the tributary of Belmore Creek), Barrick has undertaken a conservative approach to the toxicity testwork.

Based on the results from the macroinvertebrate survey (Section 4.3), it is considered that dilution of the Content Pit water had occurred so that there was no impact on macroinvertebrate communities by the time flows reached site BCDS1 in Belmore Creek. Only a minor localised impact was observed to macroinvertebrates in the tributary of Belmore Creek approximately 800 m upstream (i.e. at site DSDi) of where the tributary enters Belmore Creek (Section 4.3). Therefore, it is considered the dilution of the Content Pit water required to achieve no observed effects to the most sensitive test species had not yet occurred at this site, although had by the time flows reached site BCDS1. Notwithstanding, the quality of macroinvertebrate habitat at site DSDi was recorded as poor by FRC Environmental and the macroinvertebrate community diversity and value at site DSDi is expected to be limited (Section 4.3 and Appendix B). Accordingly, the localised impact at site DSDi is one which is limited to a site of low aquatic habitat value.

Based on the above, it is considered that no acute or chronic effects to the most sensitive test species (i.e. *Ceriodaphnia dubia*) would occur from the Content Pit surface water outflows in Belmore Creek.

Assessment of Potential Impact Relevant to Target Ecosystem Condition

As shown by the surface water quality results, some impact to surface waters occurred within the tributary of Belmore Creek (downstream of site DSDi) and immediately where tributary flows enter Belmore Creek (i.e. at site BCDS1). However, based on the application of ANZECC and ARMCANZ (2000) risk-based decision framework and the results of the Content Pit water toxicity tests and macroinvertebrate survey, it is considered the Content Pit surface water outflow posed a low risk to Belmore Creek and its relevant tributaries in the vicinity of the CGM, given the following:

- no receiving water contaminant limits were exceeded at any of the monitoring sites downstream of ML 5248;
- three of the four toxicity test species showed nil to little effect from the Content Pit surface water;
- based on the toxicity test results and macroinvertebrate survey results, it is considered that dilution of the Content Pit water had occurred so that there was no impact on macroinvertebrate communities by the time flows reached site BCDS1 in Belmore Creek; and
- only a minor localised impact to macroinvertebrates was observed within the tributary of Belmore Creek approximately 800 m upstream (i.e. at site DSDi) of where tributary flows enter Belmore Creek. Notwithstanding, the quality of macroinvertebrate habitat at site DSDi was recorded as poor by FRC Environmental and the macroinvertebrate community diversity and value at site DSDi is expected to be limited (Section 4.3 and Appendix B). Accordingly, the localised impact at site DSDi is one which is limited to a site of low aquatic habitat value.

Based on the above, the outflow event is not considered to have had a significant effect on the existing slightly to moderately disturbed condition of Belmore Creek and its relevant tributaries in the vicinity of the CGM and the risk posed to the ecosystem of Belmore Creek and its relevant tributaries as a result of the Content Pit water outflow is considered low.

4.2 STREAM SEDIMENT

Stream Sediment Results

The results from the stream sediment monitoring programme undertaken between 5 to 6 April 2011 in response to the Content Pit surface water outflows have been compared against the stream sediment trigger levels and contaminant limits defined in Schedule F - Tables 5 and 6 of the EA respectively. A summary of the trigger level and contaminant limit exceedances recorded at the stream sediment monitoring sites described in Section 3 is provided in Table 6.

Table 6
Comparison of Stream Sediment Results against EA Trigger Levels and Contaminant Limits

Location	Site ¹	EA Trigger Level Exceedance ²	EA Contaminant Limit Exceedance ³
Belmore Creek Upstream	SW7	No Exceedance	No Exceedance
	SW6	Not Applicable ⁴	Aluminium
	BCUS1	Arsenic, Mercury ⁴	Aluminium
	BCUS2	Arsenic, Mercury	Aluminium, Arsenic
	BCUS3	Arsenic, Mercury	Aluminium, Arsenic
Belmore Creek Downstream	DSDi	Arsenic, Mercury	Aluminium, Arsenic
	BCDS1	Arsenic, Mercury ⁴	Aluminium, Arsenic, Cobalt
	BCDS2	Arsenic, Mercury	Aluminium
	BCDS3	Arsenic, Mercury	Arsenic
	BCDS4	Arsenic, Mercury	Aluminium, Arsenic

¹ Refer to Figure 2.

² Trigger levels as defined in Schedule F- Table 5 of the EA.

³ Contaminant limits as defined Schedule F- Table 6 of the EA.

⁴ No trigger levels for aluminium and cobalt are defined in Schedule F- Table 5 of the EA and insufficient data is available to calculate a relevant trigger level in accordance with Schedule F- Table 5 of the EA.

Attachment 2 provides a summary of the stream sediment monitoring data from the monitoring programme undertaken between 5 to 6 April 2011.

Stream Sediment Results Analysis

Laboratory analysis of the stream sediment samples taken on 5 and 6 April 2011 was conducted for each sample collected at the stream sediment monitoring sites described in Section 3. The sediment samples were analysed for the relevant total metals and total mercury at the ALS laboratory. The results provided in Attachment 2 represent the total results. A comparison of the stream sediment monitoring results against the relevant EA stream sediment EA trigger levels and contaminant limits is provided in Table 6.

As identified in Table 6, sites DSDi and sites BCDS1 to BCDS4, downstream of the Content Pit surface water outflow point exceeded the EA stream sediment trigger levels for arsenic and mercury. Exceedances of the arsenic EA contaminant limit (i.e. ISQG high value) were recorded at the downstream sites DSDi, BCDS1, BCDS3 and BCDS4. Exceedances of the aluminium EA contaminant limit were recorded at downstream sites DSDi, BCDS1, BCDS2 and BCDS4. A single cobalt contaminant limit exceedance was also recorded at site BCDS1.

However, in comparison with background/upstream concentrations, EA stream sediment trigger levels (i.e. ISQG low values) for arsenic and mercury were also recorded at upstream sites BCUS1 to BCUS3. Exceedances of the arsenic EA contaminant limit (i.e. ISQG high value) were recorded at upstream sites BCUS2 and BCUS3. Exceedances of the EA aluminium contaminant limit were recorded at upstream sites SW6, BCUS1 to BCUS3. Concentrations of aluminium were typically higher upstream than downstream. These naturally elevated aluminium concentrations present upstream and downstream in Belmore Creek are considered a measure of total aluminium and due to the natural colloidal fraction (i.e. the aluminium in an unavailable form).

In addition to these stream sediment results, it should also be noted that no surface water quality results from the Content Pit or site SW5 or sites within the tributary of the surface water outflow pathway (i.e. Mine Drainage and DSDi) recorded arsenic or mercury trigger level exceedances (Section 4.1). Arsenic surface water trigger level exceedances were only recorded at sites Belmore Creek U/S and Belmore Creek D/S (Section 4.1).

These results suggest that an alternative source of arsenic and mercury is present upstream in Belmore Creek and that the Content Pit surface water outflow has not impacted stream sediments in the tributary of the surface water outflow pathway or in Belmore Creek beyond the existing disturbed condition of stream sediments within these systems.

The remainder of this section provides an assessment of potential impact based on the stream sediment results within the tributary downstream of the Content Pit surface water outflow point (i.e. commencing at site DSDi) and downstream in Belmore Creek (up to the final monitoring site BCDS4) and investigates the potential risk to the ecosystem where a trigger level is exceeded in accordance with ANZECC and ARMCANZ (2000) risk-based decision framework.

4.2.1 Assessment of Potential Impact

The following assessment of the potential impact to stream sediments in Belmore Creek and its relevant tributaries in the vicinity of the CGM has been based on the ANZECC and ARMCANZ (2000) *Decision tree for the assessment of contaminated sediments* (Figure 4). The assessment aims to investigate the potential risk to the ecosystem of Belmore Creek and its relevant tributaries in the vicinity of the CGM where a trigger level has been exceeded.

Level of Protection - Target Ecosystem Condition

The ANZECC and ARMCANZ (2000) level of protection or target ecosystem condition relevant to Belmore Creek and its relevant tributaries in the vicinity of the CGM is: *Slightly to moderately disturbed systems* (Section 4.1.1). The key management goal for slightly to moderately disturbed ecosystems should be the maintenance of biological diversity relative to a suitable reference condition (ANZECC and ARMCANZ, 2000) (Section 4.1.1.).

In accordance with ANZECC and ARMCANZ (2000) methodology, if an ISQG low value (i.e. trigger value) is exceeded, the *Decision tree for the assessment of contaminated sediments* (Figure 4) prompts for further action to be taken to investigate the potential risk to the ecosystem. Although an analysis of the stream sediments indicated comparable upstream and downstream results, based on the trigger level exceedances recorded, in accordance with ANZECC and ARMCANZ (2000) methodology, Barrick conducted sediment speciation tests (i.e. 1M hydrochloric extract tests) on the stream sediment samples from sites Belmore Creek U/S and Belmore Creek D/S (Figure 2) to better estimate the bioavailable fraction of the concentrations.

The results of the sediment speciation tests for the Belmore Creek U/S and Belmore Creek D/S site samples were then compared against ANZECC and ARMCANZ (2000) ISQG low and high values. A summary of the sediment speciation test results for both the <2 mm fraction and <63 µm fraction of the sediments is provided in Table 7 below.

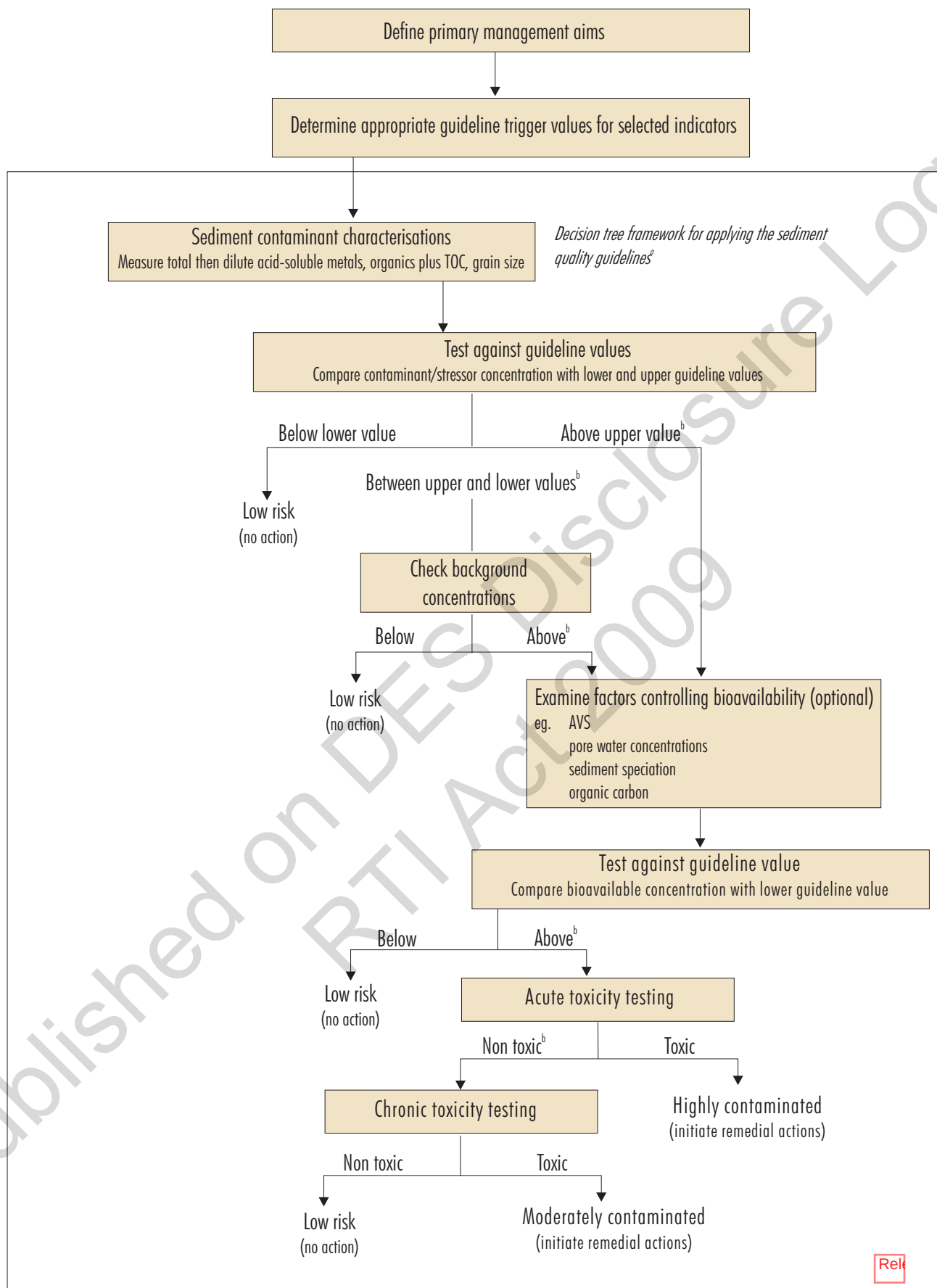


Table 7
Summary of Sediment Speciation (1M Hydrochloric Extract) Test Results

Monitoring Site	Fraction	Parameter	Concentration after 1M HCL Test	ISQG Low Value ¹	ISQG High Value ¹
Belmore Creek U/S	<2mm	Arsenic	23	20	70
	<63 µm	Arsenic	312	20	70
		Zinc	290	200	410
		Mercury	1.3	0.15	1
Belmore Creek D/S	<2mm	Arsenic	25	20	70
	<63 µm	Arsenic	290	20	70
		Zinc	303	200	410
		Mercury	1.14	0.15	1

¹ Table 3.5.1 of ANZECC and ARMCANZ (2000).

Although the sediment speciation test results for the more bioavailable fraction of the sediment samples (i.e. the <63 µm fraction) indicate exceedances of the ISQG low value for arsenic, zinc and mercury and exceedances of the ISQG high value for arsenic and mercury, these exceedances were recorded at both the upstream and downstream sites, with arsenic and mercury concentrations higher at the Belmore Creek U/S site compared with the Belmore Creek D/S site.

Assessment of Potential Impact Relevant to Target Ecosystem Condition

Based on the comparison of downstream stream sediment results with the background concentrations recorded, it is therefore considered:

- that an alternative source of arsenic, mercury and zinc is present upstream in Belmore Creek;
- that the Content Pit surface water outflow posed a low risk to Belmore Creek and its relevant tributaries in the vicinity of the CGM and did not impact stream sediments in Belmore Creek beyond the existing disturbed condition of the stream sediments in this system.

This conclusion is also supported by the results from the macroinvertebrate survey conducted at sites upstream and downstream in Belmore Creek and its relevant tributaries. As discussed in Section 4.3, only a minor localised impact to macroinvertebrates was observed within the tributary of Belmore Creek approximately 800 m upstream (i.e. at site DSDi) of where tributary flows enter Belmore Creek. Notwithstanding, the quality of macroinvertebrate habitat at site DSDi was recorded as poor by FRC Environmental and the macroinvertebrate community diversity and value at site DSDi is expected to be limited (Section 4.3 and Appendix B). Accordingly, the localised impact at site DSDi is one which is limited to a site of low aquatic habitat value.

Based on the conclusions above, no further acute toxicity testing is considered necessary as the outflow event is not considered to have had a significant effect on the existing slightly to moderately disturbed condition of Belmore Creek and its relevant tributaries in the vicinity of the CGM and the risk posed to the ecosystem of Belmore Creek and its relevant tributaries as a result of the Content Pit water outflow is considered low.

4.3 AQUATIC HABITAT CONDITION

Macroinvertebrate Survey Results

As described in Section 3, in response to the surface water outflow from the Content Pit, Barrick immediately conducted a macroinvertebrate survey of Belmore Creek and its relevant tributaries in the vicinity of the CGM. The survey was undertaken by FRC Environmental between 4 and 6 April 2011. FRC Environmental prepared the report *Croydon Gold Mine Macroinvertebrate Survey April 2011* which presents a detailed description of the results of the survey and characterises the impact observed to macroinvertebrates as a result of the outflow.

The macroinvertebrate survey consisted of measuring aquatic habitat, in-situ water quality and macroinvertebrate assemblages at ten sites on Belmore Creek and its relevant tributaries. The monitoring sites included upstream sites SW7, SW6, BCUS1, BCUS2 and BCUS3 and downstream sites DSDi, BCDS1, BCDS2, BCDS3 and BCDS4 (Section 3 and Figure 2). FRC Environmental's full report is provided as Appendix A.

A summary of FRC Environmental's assessment of potential impact to the aquatic habitat and macroinvertebrates is provided in Section 4.3.1 below.

4.3.1 Assessment of Potential Impact

FRC Environmental characterised the potential impact to macroinvertebrates by assessing the in-stream aquatic habitat condition and measuring macroinvertebrate survey data at sites downstream of the Content Pit surface water outflow point compared with relevant upstream sites. Macroinvertebrate survey data collected included macroinvertebrate taxonomic richness, abundance, PET richness, dominant taxa, community composition and SIGNAL 2 scores. The condition of the aquatic habitat was assessed based on the *Queensland AUSRIVAS Sampling and Processing Manual* (Department of Natural Resources and Mines, 2011). Statistical analysis of the survey data was undertaken to determine if changes to components or the entire macroinvertebrate community were present.

A summary of the aquatic habitat and aquatic macroinvertebrate assessments conducted by FRC Environmental is provided below. A description of the aquatic habitat condition and macroinvertebrates at the Belmore Creek upstream monitoring sites is provided in Section 2.3. A detailed description of the results of the survey is provided in FRC Environmental's full report (Appendix A).

Summary of Aquatic Habitat Assessment

Aquatic habitat (including in-stream and surrounding habitat) was assessed based on the *Queensland AUSRIVAS Sampling and Processing Manual* (DNRM, 2001) which includes the assessment of various environmental factors. The assessment of the condition of habitat uses the River Bioassessment Program scoring system. This score places the sites into one of four categories (excellent, good, moderate and poor) based on the quality of the macroinvertebrate habitat.

Habitat scores across all the survey sites ranged from moderate to good (FRC Environmental, 2011). Upstream reference sites SW7 and SW6 had the lowest bioassessment scores (*ibid.*). These scores were due to high embeddedness of the substrate (as it was dominated by fine sediments) and low diversity of in-stream habitat (i.e. there was only shallow pools and runs with no deep pools or riffles present) and poor streamside cover (*ibid.*).

FRC Environmental (2011) reported that these scores indicated that these sites (i.e. SW7 and SW6) are likely to be less suitable for macroinvertebrates. Sites DSDi and BCDS1 also had low bioassessment scores due to high embeddedness and poor in-stream habitat diversity (*ibid.*). Downstream sites BCDS2 and BCDS3 had the highest bioassessment scores which were noted to be greater than upstream sites BCUS2 and BCUS3.

Summary of Aquatic Macroinvertebrate Assessment

Macroinvertebrate survey data collected by FRC Environmental included total taxonomic richness, PET richness, SIGNAL 2 scores and mean taxonomic richness, abundance and community composition across the edge, bed and riffle habitats. A detailed description of these results is provided in Appendix A. The summary or assessment of impact to macroinvertebrates as a result of the Content Pit surface water outflow reported by FRC Environmental (2011) is provided below.

The overtopping of the Content Pit appears to have had a small impact on the macroinvertebrate communities (i.e. on taxonomic richness, abundance and community composition) at site DSDi, which is approximately 30 m downstream of the confluence of the overflow pathway with the tributary of Belmore Creek (approximately 1.5 km from the Content Pit over land) (Figure 2.1). However, the impact appeared to be confined to a small spatial area, and did not extend to the first downstream site on Belmore Creek (i.e. BCDS1), which is approximately 700 m downstream of the confluence of the overflow pathway with the tributary of Belmore Creek (Figure 2.1). As such, the macroinvertebrate taxonomic richness, abundance and community composition at sites downstream of site DSDi do not appear to have been impacted by overflows from the Content Pit.

The in situ water quality results provide no indication of potential impacts from the Content Pit overflow except for electrical conductivity. Increased electrical conductivity was observed at site DSDi immediately downstream of the confluence of the overflow pathway with the tributary of Belmore Creek. Though electrical conductivity levels in the study area did not correlate highly to macroinvertebrate community structure, suggesting that electrical conductivity levels here may not have had a substantial influence on macroinvertebrate community structure.

A number of other factors (e.g. habitat condition, land use [i.e. cattle access] and water quality) also appear to have had an effect on macroinvertebrate communities. As a result, the influence of the overtopping event from the Content Pit on the macroinvertebrate communities in the tributary to Belmore Creek is not able to be clearly defined.

Assessment of Potential Impact Relevant to Target Ecosystem Condition

Based on the above, the Content Pit surface water outflow event is not considered to have had a significant effect on the existing slightly to moderately disturbed condition of Belmore Creek and its relevant tributaries in the vicinity of the CGM and the risk posed to the ecosystem of Belmore Creek and its relevant tributaries as a result of the outflow is considered low.

5 CONCLUSION

This report has presented assessments of surface water quality, stream sediment quality and aquatic habitat condition which have been undertaken in accordance with the ANZECC and ARMCANZ (2000) risk-based decision framework to investigate the potential risk to the ecosystem of Belmore Creek and its relevant tributaries in the vicinity of the CGM as a result of the Content Pit surface water outflow between 30 March and 2 May 2011.

As identified in the CGM EA, the ANZECC and ARMCANZ (2000) level of protection or target ecosystem condition relevant to Belmore Creek and its relevant tributaries in the vicinity of the CGM is: *Slightly to moderately disturbed systems*. ANZECC and ARMCANZ (2000) identifies that the key management goal for slightly to moderately disturbed ecosystems should be the maintenance of biological diversity relative to a suitable reference condition. ANZECC and ARMCANZ (2000) also indicate that an increased level of change of biological indicators might be acceptable for this ecosystem condition compared with an ecosystem of high conservation/ecological value.

A summary of the conclusions of the surface water quality, stream sediment quality and aquatic habitat condition assessments is provided below.

Surface Water

Based on the surface water quality assessment conducted in accordance with the ANZECC and ARMCANZ (2000) risk-based decision framework (Section 4.1), it is considered the Content Pit surface water outflow posed a low risk to the existing slightly to moderately disturbed condition of Belmore Creek and its relevant tributaries in the vicinity of the CGM, given the following:

- no receiving water contaminant limits were exceeded at any of the monitoring sites downstream of ML 5248;
- three of the four toxicity test species showed nil to little effect from the Content Pit surface water;
- based on the toxicity test results and macroinvertebrate survey results, it is considered that dilution of the Content Pit water had occurred so that there was no impact on macroinvertebrate communities by the time flows reached site BCDS1 in Belmore Creek; and
- only a minor localised impact to macroinvertebrates was observed within the tributary of Belmore Creek approximately 800 m upstream (i.e. at site DSDi) of where tributary flows enter Belmore Creek. Notwithstanding, the quality of macroinvertebrate habitat at site DSDi was recorded as poor by FRC Environmental and the macroinvertebrate community diversity and value at site DSDi is expected to be limited. Accordingly, the localised impact at site DSDi is one which is limited to a site of low aquatic habitat value.

Stream Sediment

Based on the stream sediment quality assessment conducted in accordance with the ANZECC and ARMCANZ (2000) risk-based decision framework (Section 4.2), it is considered the Content Pit surface water outflow posed a low risk to the existing slightly to moderately disturbed condition of Belmore Creek and its relevant tributaries in the vicinity of the CGM, given the following:

- a comparison of the stream sediment monitoring results from April 2011 and the sediment speciation test results from August 2011 indicate that the quality of the Belmore Creek downstream sediments, and the sediments at site DSDi, are comparable with the quality of Belmore Creek upstream sediments; and
- that the upstream results were in fact higher than downstream results.

These results indicate that an alternative source of the parameters measured is present upstream in Belmore Creek.

Aquatic Habitat Condition

Based on the aquatic habitat assessment conducted in accordance with the ANZECC and ARMCANZ (2000) risk-based decision framework (Section 4.3), it is considered the Content Pit surface water outflow posed a low risk to the existing slightly to moderately disturbed condition of Belmore Creek and its relevant tributaries in the vicinity of the CGM, given the following:

- no impact was observed to macroinvertebrate communities or aquatic habitat condition in Belmore Creek; and
- although a minor localised impact was observed to macroinvertebrates within the tributary of Belmore Creek approximately 800 m upstream (i.e. at site DSDi) of where tributary flows enter Belmore Creek, the quality of macroinvertebrate habitat at site DSDi was recorded as poor by FRC Environmental and the macroinvertebrate community diversity and value at site DSDi is expected to be limited. Accordingly, the localised impact at site DSDi is one which is limited to a site of low aquatic habitat value.

As a result of the above conclusions and in accordance with the ANZECC and ARMCANZ (2000) risk-based decision framework, no remediation measures are considered necessary.

6 REFERENCES

Australian and New Zealand Environment and Conservation Council and the Agriculture and Resource Management Council of Australia and New Zealand (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Volume 3 Primary Industries – Rationale and Background Information*, October 2000.

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ATTACHMENT 1

SURFACE WATER QUALITY MONITORING RESULTS

Attachment 1
Summary of Surface Water Quality Data from 30 March to 2 May 2011

Site	Category	pH	EC (µS/cm)	F (mg/L)	SO ₄ (mg/L)	Turbidity (NTU)	Al (mg/L)	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Co (mg/L)	Cu (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L)	Zn (mg/L)
Belmore Creek EA Upstream Sites																	
SW7	Maximum	7.19	153	0.2	47	40	1.53	0.013	0.05	0.0001	0.002	0.001	0.002	0.0001	0.003	0.01	0.005
	Minimum	6.63	25	0.1	1	20	0.25	0.002	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	Average	6.92	83.43	0.14	17.29	29.10	0.87	0.01	0.05	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.01
	Median	6.93	102	0.1	20	25.1	0.85	0.004	0.05	0.0001	0.001	0.001	0.002	0.0001	0.002	0.01	0.005
	No. of samples	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
SW6	Maximum	6.99	40	0.1	1	120	4.82	0.002	0.05	0.0001	0.002	0.001	0.002	0.0001	0.002	0.01	0.005
	Minimum	6.8	32	0.1	1	83.2	2.13	0.002	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	Average	6.90	36.00	0.10	1.00	101.6	3.48	0.001	0.05	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.01
	Median	6.895	36	0.1	1	101.6	3.46	0.002	0.05	0.0001	0.0015	0.001	0.0015	0.0001	0.0015	0.01	0.005
	No. of samples	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Additional Belmore Creek Upstream Site																	
Belmore Creek U/S	Maximum	7.21	65	0.2	8	29.7	1.28	0.016	0.05	0.0001	0.003	0.001	0.002	0.0001	0.002	0.01	0.007
	Minimum	6.73	33	0.1	2	9.7	0.04	0.004	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	Average	6.97	41.44	0.11	4.22	22.39	0.62	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
	Median	6.95	39	0.1	4	25	0.56	0.008	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	No. of samples	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Trigger Level ¹		6 - 7.5	250	0.3	56	26	1.42	0.013	0.05	0.0002	0.01	0.0014	0.003	0.0006	0.011	0.011	0.008
Contaminant Limit ²		5 - 9	5,970	2	1,000	NA	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

¹ Receiving Water Trigger Levels – EA Schedule F Table 2.

² Receiving Water Contaminant Limits – EA Schedule F Table 3.

NA – Not Applicable.

Attachment 1 (Continued)
Summary of Surface Water Quality Data from 30 March to 2 May 2011

Location	Site and Sample Number	pH	EC (µS/cm)	F (mg/L)	SO ₄ (mg/L)	Turbidity (NTU)	Al (mg/L)	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Co (mg/L)	Cu (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L) (total)	Zn (mg/L)
Additional Belmore Creek Upstream Sites																	
Belmore Creek Upstream	BCUS1 (Sample 1)	7.16	31	0.1	1	24	0.76	0.002	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	BCUS1 (Sample 2)	7.02	39	0.1	4	26	0.64	0.008	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	BCUS1 (Sample 3)	6.94	39	0.1	4	25	0.56	0.008	0.05	0.0001	0.003	0.001	0.001	0.0001	0.001	0.01	0.005
	BCUS1 (Sample 4)	6.94	39	0.1	3	25	0.52	0.008	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	BCUS2	7.05	34	0.2	1	23	0.54	0.008	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.007
	BCUS3	7.14	37	0.1	3	24	0.25	0.008	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
Trigger Level ¹		6 - 7.5	250	0.3	56	26	1.42	0.013	0.05	0.0002	0.01	0.0014	0.003	0.0006	0.011	0.011	0.008
Contaminant Limit ²		5 - 9	5,970	2	1,000	NA	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

¹ Receiving Water Trigger Levels – EA Schedule F Table 2.

² Receiving Water Contaminant Limits – EA Schedule F Table 3.

NA – Not Applicable.

Attachment 1 (Continued)
Summary of Surface Water Quality Data from 30 March to 2 May 2011

Site	Category	pH	EC (μ S/cm)	F (mg/L)	SO ₄ (mg/L)	Turbidity (NTU)	Al (mg/L)	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Co (mg/L)	Cu (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L)	Zn (mg/L)
On-Site Waters																	
Content Pit	Maximum	4.2	789	1.5	316	90	1.62	0.009	0.05	0.0025	0.002	0.112	0.062	0.0001	0.103	0.01	0.279
	Minimum	3.91	737	1.1	300	0.8	1.31	0.004	0.05	0.0021	0.001	0.09	0.056	0.0001	0.087	0.01	0.229
	Average	4.08	772	1.3	307	12.5	1.45	0.006	0.05	0.0023	0.001	0.100	0.059	0.0001	0.096	0.01	0.254
	Median	4.11	781	1.3	304	3	1.38	0.006	0.05	0.0022	0.001	0.101	0.059	0.0001	0.097	0.01	0.259
	No. of samples	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
SW5	Maximum	4.38	1,130	2.5	491	11	14.9	0.004	0.05	0.0244	0.002	0.234	0.593	0.0001	0.22	0.01	0.959
	Minimum	3.75	428	1	160	0.8	3.9	0.003	0.05	0.0091	0.001	0.089	0.195	0.0001	0.082	0.01	0.385
	Average	3.93	734	1.66	305	3.44	8.45	0.0037	0.05	0.0158	0.0012	0.153	0.387	0.0001	0.147	0.01	0.642
	Median	3.9	757	1.7	311	2	8.89	0.004	0.05	0.0156	0.001	0.16	0.396	0.0001	0.152	0.01	0.662
	No. of samples	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
EA Contaminant Limit ³		4-9	5,970	2	1,000	4,000 (TDS)	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

³ On-site Water Contaminant Limit as defined in Schedule F-Table 8 of the EA.

Attachment 1 (Continued)
Summary of Surface Water Quality Data from 30 March to 2 May 2011

Site	Category	pH	EC (µS/cm)	F (mg/L)	SO ₄ (mg/L)	Turbidity (NTU)	Al (mg/L)	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Co (mg/L)	Cu (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L)	Zn (mg/L)
Surface Water Outflow Pathway Sites																	
Mine Drainage	Maximum	6.88	354	0.8	130	110	1.74	0.003	0.05	0.0032	0.001	0.071	0.035	0.0001	0.047	0.01	0.158
	Minimum	4.9	71	0.3	17	1	0.37	0.002	0.05	0.0001	0.001	0.001	0.008	0.0001	0.003	0.01	0.005
	Average	5.40	237	0.57	84	19.8	0.90	0.0024	0.05	0.0024	0.001	0.0444	0.0263	0.0001	0.033	0.01	0.118
	Median	5.17	236	0.6	80	6	0.71	0.002	0.05	0.0028	0.001	0.041	0.029	0.0001	0.036	0.01	0.142
	No. of samples	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
DSDi	Maximum	6.83	185	0.4	64	110	2.42	0.004	0.05	0.0007	0.002	0.018	0.02	0.0001	0.013	0.01	0.037
	Minimum	6.2	60	0.1	13	44.2	0.28	0.001	0.05	0.0001	0.001	0.001	0.004	0.0001	0.002	0.01	0.005
	Average	6.58	103.6	0.26	30	74.21	1.54	0.00	0.05	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.02
	Median	6.64	86	0.25	21.5	75	1.66	0.002	0.05	0.00055	0.001	0.008	0.008	0.0001	0.008	0.01	0.025
	No. of samples	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Trigger Level ⁴		6 - 7.5	250	0.3	56	26	1.42	0.013	0.05	0.0002	0.01	0.0014	0.003	0.0006	0.011	0.011	0.008
Contaminant Limit ⁵		5 - 9	5,970	2	1,000	NA	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

⁴ Receiving Water Trigger Levels – EA Schedule F Table 2.

⁵ Receiving Water Contaminant Limits – EA Schedule F Table 3.

NA – Not Applicable.

Attachment 1 (Continued)
Summary of Surface Water Quality Data 30 March to 2 May 2011

Site	Category	pH	EC (µS/cm)	F (mg/L)	SO ₄ (mg/L)	Turbidity (NTU)	Al (mg/L)	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Co (mg/L)	Cu (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L)	Zn (mg/L)
Belmore Creek D/S	Maximum	7.27	66	0.2	8	35	2.1	0.019	0.05	0.0003	0.002	0.002	0.004	0.0001	0.003	0.01	0.011
	Minimum	6.58	32	0.1	2	8.9	0.08	0.004	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	Average	6.93	42.44	0.12	4.33	22.36	0.71	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
	Median	6.97	39	0.1	4	22.3	0.45	0.006	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	No. of samples	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Trigger Level ⁶		6 - 7.5	250	0.3	56	26	1.42	0.013	0.05	0.0002	0.01	0.0014	0.003	0.0006	0.011	0.011	0.008
Contaminant Limit ⁷		5 - 9	5,970	2	1,000	NA	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

Location	Site and Sample Number	pH	EC (µS/cm)	F (mg/L)	SO ₄ (mg/L)	Turbidity (NTU)	Al (mg/L)	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Co (mg/L)	Cu (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L)	Zn (mg/L)
Additional Belmore Creek Downstream Sites																	
Belmore Creek Downstream	BCDS1 (Sample 1)	6.97	38	0.1	3	28	0.14	0.006	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	BCDS1 (Sample 2)	6.94	40	0.2	4	23	0.45	0.006	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	BCDS1 (Sample 3)	6.98	39	0.1	3	23	0.19	0.006	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	BCDS2	7.02	38	0.1	3	25	0.44	0.008	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	BCDS3	7.05	39	0.1	3	23	0.41	0.008	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	BCDS4	7.05	39	0.1	3	23	0.19	0.009	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
Trigger Level ⁶		6 - 7.5	250	0.3	56	26	1.42	0.013	0.05	0.0002	0.01	0.0014	0.003	0.0006	0.011	0.011	0.008
Contaminant Limit ⁷		5 - 9	5,970	2	1,000	NA	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

⁶ Receiving Water Trigger Levels – EA Schedule F Table 2.

⁷ Receiving Water Contaminant Limits – EA Schedule F Table 3.

NA – Not Applicable.

ATTACHMENT 2

STREAM SEDIMENT MONITORING RESULTS

Attachment 2
Summary of Stream Sediment Results from April 2011

Location	Site ¹	Al (mg/kg)	As (mg/kg)	B (mg/kg)	Cd (mg/kg)	Cr (mg/kg)	Co (mg/kg)	Cu (mg/kg)	Ni (mg/kg)	Se (mg/kg)	Hg (mg/kg)	Zn (mg/kg)
Belmore Creek Up-stream	SW7	620	5	50	1	3	2	5	2	5	0.1	5
	SW6	3,300	6	50	1	6	4	5	3	5	0.1	13
	BCUS1	3,480	27	50	1	4	2	9	2	5	0.3	56
	BCUS2	2,110	160	50	1	7	2	6	2	5	0.6	30
	BCUS3	1,900	98	50	1	5	2	5	2	5	0.4	22
Belmore Creek Downstream	DSDi	2,580	76	50	1	6	2	8	2	5	0.3	14
	BCDS1	3,190	74	50	1	10	8	24	3	5	0.7	30
	BCDS2	1,860	50	50	1	5	2	5	2	5	0.5	21
	BCDS3	1,240	73	50	1	3	2	5	2	5	0.3	18
	BCDS4	1,630	97	50	1	3	2	5	2	5	0.6	22
Trigger Level ²		NA	20	NA	1.5	80	NA	65	21	NA	0.15	200
Contaminant Limit ³		1,240	70	100	10	370	4	270	52	10	1	410

¹ Refer to Figure 2.

² Trigger levels as defined in Schedule F- Table 5 of the EA.

³ Contaminant limits as defined Schedule F- Table 6 of the EA.

NA – Not Available (insufficient data to calculate relevant trigger level in accordance with Schedule F- Table 5).

APPENDIX A
CROYDON GOLD MINE
MACROINVERTEBRATE SURVEY APRIL 2011

Croydon Gold Mine

Macroinvertebrate Survey

April 2011

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Summary

Background

frc environmental was commissioned by Barrick Australia Pacific Limited, to complete a baseline macroinvertebrate survey in Belmore Creek and its tributaries in the vicinity of the decommissioned Croydon Gold Mine. Due to extensive rainfall in the region in late 2010 and early 2011, an increase in the water level in the Content Pit occurred. Water level monitoring of the Content Pit indicated that further heavy rainfall during the remainder of the wet season could lead to overtopping of the Content Pit. As a result of further heavy rainfall between 29 March 2011, when the survey was commissioned, and 4 April 2011, when the survey commenced, the Content Pit overtopped. This changed the focus of the survey from a baseline assessment to an investigation into the potential impacts due to the overtopping of the Content Pit.

This report presents the findings of the macroinvertebrate survey conducted in Belmore Creek and its tributaries upstream and downstream of the Croydon Gold Mine in April 2011 and assesses the potential impact of the outflows from the Content Pit on the macroinvertebrate communities.

Study Area

Croydon Gold Mine is located in northern Queensland, west of Cairns, approximately 200 km from the Gulf of Carpentaria. Rainfall is highly seasonal and all local waterways are ephemeral. The south-eastern section of the mining lease (i.e. the Golden Butterfly mining area) is located in the upper catchment of Slaughteryard Creek, and the north-western section of the mining lease (i.e. the Content and Lady Isabella mining areas) is located in the Belmore Creek catchment.

As the overtopping event occurred at the Content Pit (located in the Belmore Creek catchment) the survey focused on Belmore Creek. A total of ten sites were surveyed in Belmore Creek and its tributaries including five comparative (upstream) sites and five potentially impacted (downstream) sites.

Aquatic Habitat

In general, aquatic habitat condition was good at most survey sites, with cobble, pebble and gravel substrates suitable for macroinvertebrates and native vegetation was dominant in the riparian zones. The least suitable macroinvertebrate habitat was at comparative (upstream) sites SW7 and SW6. These sites had substrates dominated by fine sand and silt, poor riparian zones and low in-stream habitat diversity.

In Situ Water Quality

In situ water quality was within the ANZECC & ARMCANZ (2000) default trigger values for lowland streams¹ in tropical Australia (and the QWQG trigger value for electrical conductivity) except for turbidity. Turbidity exceeded the upper ANZECC & ARMCANZ (2000) trigger value at all sites except one, but this was likely caused by recent rainfall (and subsequent sediment-laden runoff) in the area.

The *in situ* water quality results provide no indication of potential impacts from the Content Pit overflow except for electrical conductivity. Electrical conductivity was similar at all sites, except comparative site SW7 and potentially impacted site DSDi, immediately downstream of the confluence between the Content Pit overflow and a tributary of Belmore Creek, where levels were higher. However, electrical conductivity levels were below the QWQG trigger value at all sites, including DSDi. The pH at all sites was within recommended guidelines and dissolved oxygen concentrations were only slightly below the trigger value range at two sites.

Macroinvertebrates

The overtopping of the Content Pit appears to have had a small impact on the macroinvertebrate communities at site DSDi, which is located approximately 30 m downstream of the confluence of the overflow pathway with the tributary of Belmore Creek (approximately 1.5 km from the Content Pit over land). The overflow from Content Pit appears to have affected the macroinvertebrate taxonomic richness, abundance and community composition at this site. However, the impact appears to be confined to a small spatial area, not extending to the first downstream site on Belmore Creek (BCDS1). As such sites downstream of site DSDi do not appear to have been impacted by overflows from the Content Pit.

¹ Streams that are at <150 m elevation.

A number of other factors such as habitat condition, land use and water quality also appear to be having an effect on macroinvertebrate communities. As a result the influence of the overtopping event from the Content Pit on the macroinvertebrate communities in the tributary to Belmore Creek is not able to be clearly defined.

Results and Recommendations

Water quality and macroinvertebrate results were spatially variable, and are expected to also vary temporally in response to seasonal and long-term climatic influences. As such, the results of this one-off survey are in-sufficient to fully characterise the impact of the overtopping event from the Content Pit, when compared with the influence of other factors.

Additional survey events or a long-term ecological monitoring program would provide the opportunity to:

- describe the natural variability of the macroinvertebrate communities in the survey area
- determine if the overtopping event from the Content Pit had a short or long term impact, or potentially no impact at all, and
- gather comprehensive background data from comparative sites.

1 Introduction

1.1 Background

frc environmental was commissioned by Barrick Australia Pacific Limited, to complete a baseline macroinvertebrate survey in Belmore Creek and its tributaries in the vicinity of the Croydon Gold Mine. The Croydon Gold Mine was a low-grade gold mine located west of Croydon, 560 kilometres west of Cairns. Operational mining ceased at the Croydon Gold Mine in 1990 and the mine was decommissioned in 1993. Since 1993, activities on the site have included maintenance, monitoring, investigations and reclamation works.

Mining related landforms on the site include waste rock dumps, open pits and infrastructure areas (i.e. abandonment bunds, hardstand areas, water management structures, and roads and tracks). The open pits and waste rock dumps include:

- Golden Butterfly Pit
- Golden Butterfly North Pit
- Golden Butterfly waste rock dump
- Content Pit
- Content waste rock dump, and
- Lady Isabella Pit.

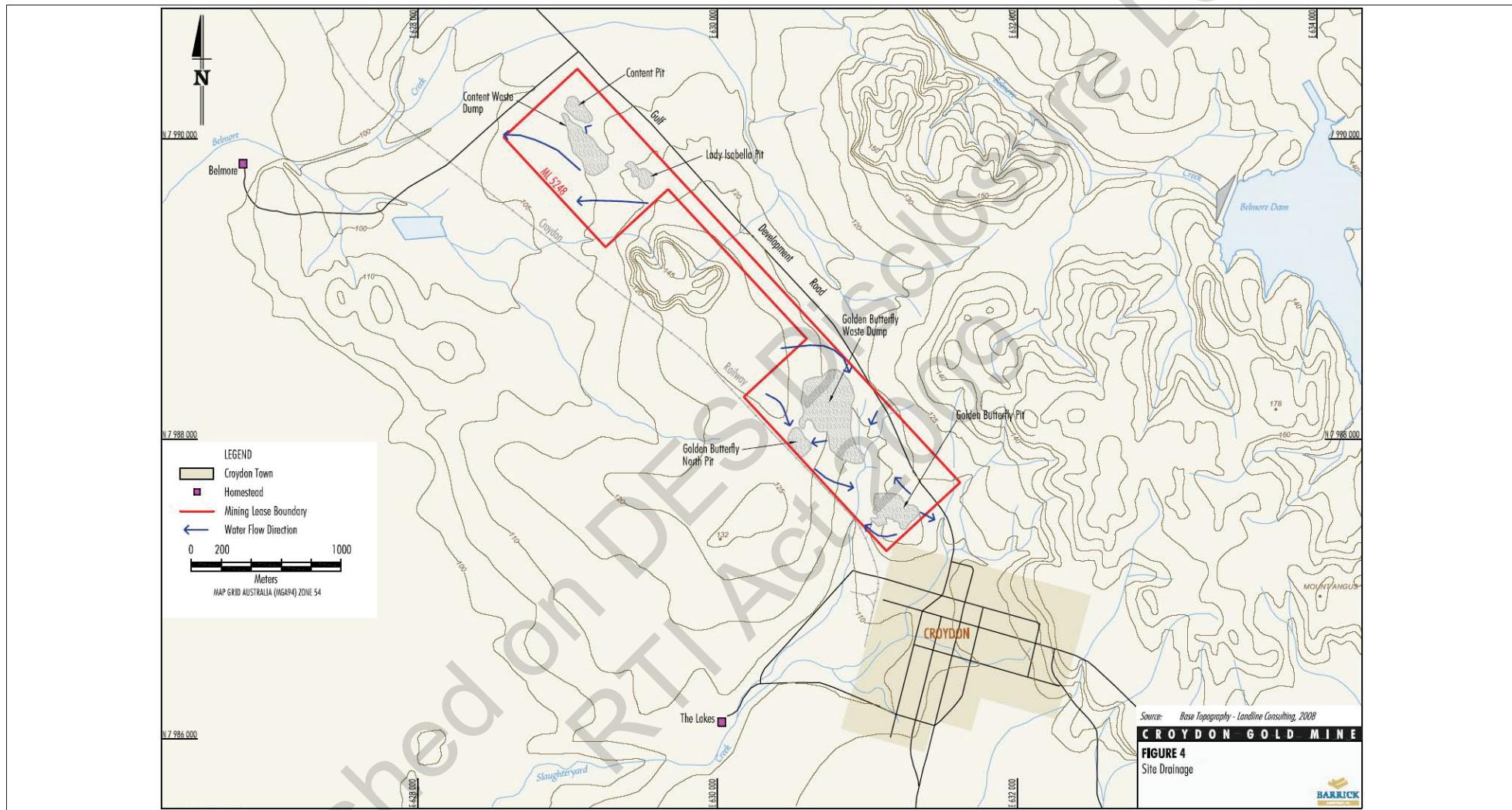
Extensive rainfall in the region in late 2010 and early 2011 led to an increase in the water level in the Content Pit at the Croydon Gold Mine. Water level monitoring indicated that further heavy rainfall during the remainder of the wet season could lead to overtopping of the Content Pit. In late March 2011 a baseline macroinvertebrate survey was commissioned to characterise the existing environment in order to assess the risk to macroinvertebrate communities in the receiving environment if the Content Pit overtopped. However, as a result of further heavy rainfall between 29 March 2011, when the survey was commissioned, and 4 April 2011, when the survey commenced, the Content Pit overtopped. This changed the focus of the survey from a baseline assessment to an investigation into the potential impacts due to the overtopping of the Content Pit.

This report presents the findings of the macroinvertebrate survey conducted in Belmore Creek and its tributaries upstream and downstream of the Croydon Gold Mine in April 2011 and assesses the potential impact of the outflows from the Content Pit on the macroinvertebrate communities.

1.2 Study Area

The Croydon Gold Mine is located in northern Queensland, west of Cairns, approximately 200 km from the Gulf of Carpentaria. Rainfall in the area is highly seasonal and all local waterways are ephemeral. The south-eastern section of the mining lease (i.e. the Golden Butterfly mining area) is located in the upper catchment of Slaughteryard Creek, and the north-western section of the mining lease (i.e. the Content and Lady Isabella mining areas) is located in the Belmore Creek catchment. There are no hydrological flow records for the mining lease, but it is believed that surface water runoff in local creeks ceases shortly after rainfall events and that sheet flow is dominant in the wet season.

As the overtopping event occurred at the Content Pit (located in the Belmore Creek catchment), the survey focused on Belmore Creek and its tributaries. A total of ten sites were surveyed on Belmore Creek and its tributaries, including five comparative (upstream) sites and five potentially impacted (downstream) sites (Figure 1.1).



Croydon Gold Mine Macroinvertebrate Survey

Figure 1.1 Croydon Gold Mine Location and Site Drainage.

Image supplied by Barrick Australia Pacific Ltd.

June 2011

2 Methods

2.1 Survey Design

Survey Timing

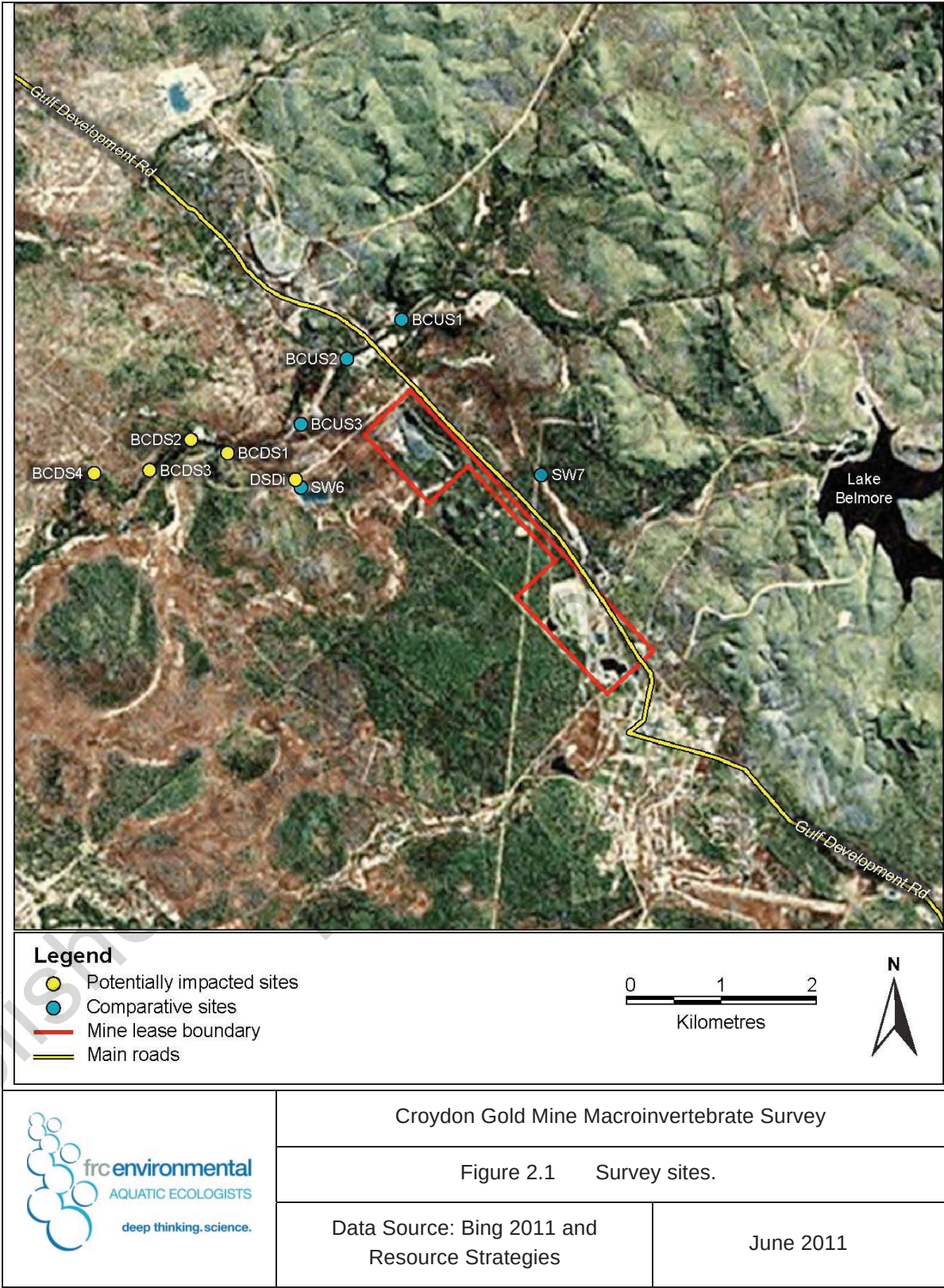
Aquatic habitat, water quality and macroinvertebrates were surveyed between 4 and 6 April 2011.

Weather was fine for the duration of the survey; there was dry track access and flowing water present in all creeks. The survey area experienced substantial rainfall in the months before the survey.

Site Details

A total of ten sites were surveyed in Belmore Creek and its tributaries by frc environmental (Figure 2.1):

- site SW7 – a comparative site, upstream of the mine, on a tributary of Belmore Creek, at a pre-existing water quality monitoring site
- sites BCUS1, BCUS2 and BCUS3 – three comparative sites on Belmore Creek, upstream of the mining lease
- site SW6 – a comparative site, upstream of the confluence between the Content Pit overflow and a tributary of Belmore Creek, at a pre-existing water quality monitoring site
- site DSDi – a potentially impacted site immediately downstream of the confluence between the Content Pit overflow and a tributary of Belmore Creek, and
- sites BCDS1, BCDS2, BCDS3 and BCDS4 – four potentially impacted sites on Belmore Creek, downstream of the confluence of the Content Pit overflow and a tributary of Belmore Creek.



With the exception of sites SW7 and SW6, comparative sites were chosen to represent the range of aquatic habitats in the area and to match potentially impacted sites, in terms of water body type (e.g. natural channel), stream order, and environmental conditions (e.g. erosion, vegetation and available habitat). Comparative site SW7 was selected because it was a pre-existing water quality monitoring site and because of its location upstream of the mine. Site SW6 was selected because it was a pre-existing water quality monitoring site and because of its location upstream of the Content Pit overflow. Site SW6 was located on the edge of a stock dam situated on a tributary of Belmore Creek. Sampling was conducted where the Belmore Creek tributary flowed out of the stock dam. The stock dam also receives flow from natural runoff.

Limitations

The waterways in the survey area are ephemeral, and of the sites surveyed, many are likely to be dry for part of the year. Aquatic faunal communities within ephemeral waterways are highly variable over time, with community structure strongly linked to flow conditions (Smith et al. 2004). The results of this study are based on a single field survey, completed during a very wet summer period. Additional surveys would be required to assess the natural variation of the macroinvertebrate communities.

2.2 Aquatic Habitat

Aquatic Habitat for Fauna

At each site, the condition of the surrounding and in-stream habitat was described based on the *Queensland AUSRIVAS Sampling and Processing Manual* (DNRM 2001), including an assessment of:

- reach environs (i.e. land directly adjacent to the riparian zone)
- type and condition of riparian vegetation
- availability of habitats (e.g. pools, riffles and runs)
- water depth, mean and maximum
- water velocity, mean and maximum
- bank erosion
- substrate composition
- channel diversity
- the presence of in-stream habitat (e.g. large woody debris), overhangs, undercuts, bars, and other forms of shelter, and
- physical barriers to water flow and fish passage.

Habitat Bioassessment Scores

The aquatic habitat descriptions were used to provide an assessment of the condition of habitat following the River Bioassessment Program scoring system. Based on these descriptions, each site was given a habitat assessment score following the River Bioassessment Program scoring system (DNRM 2001).

The habitat bioassessment score datasheets (DNRM 2001) were used to numerically score nine criteria, which were then allocated to one of four categories (excellent, good, moderate and poor). The sum of the numerical rating from each category produced an overall habitat assessment score (Table 2.1):

- Excellent >110
- Good 75 – 110,
- Moderate 39 – 74, and
- Poor ≤38.

Table 2.1 Habitat bioassessment scores used to derive overall condition of habitats.

Habitat Category	Category Score Range			
	Excellent	Good	Moderate	Poor
Bottom substrate / available cover	16 – 20	11 – 15	6 – 10	0 – 5
Embeddedness	16 – 20	11 – 15	6 – 10	0 – 5
Velocity / depth category	16 – 20	11 – 15	6 – 10	0 – 5
Channel alteration	12 – 15	8 – 11	4 – 7	0 – 3
Bottom scouring & deposition	12 – 15	8 – 11	4 – 7	0 – 3
Pool / riffle, run / bend ratio	12 – 15	8 – 11	4 – 7	0 – 3
Bank stability	9 – 10	6 – 8	3 – 5	0 – 2
Bank vegetative stability	9 – 10	6 – 8	3 – 5	0 – 2
Streamside cover	9 – 10	6 – 8	3 – 5	0 – 2
Total (Habitat Bioassessment Score for the Site)	111 – 135	75 – 110	39 – 74	0 – 38

Water Quality

Physical water quality measurements were collected *in situ* using a Hydrolab QUANTA water quality meter. The following variables were recorded:

- water temperature (°C)
- turbidity (NTU)
- dissolved oxygen (DO, % saturation)
- pH, and
- electrical conductivity (EC, $\mu\text{S}/\text{cm}$).

The water quality meter electrical conductivity probe failed to take readings during the survey; however, water quality samples collected by Barrick Australia Pacific Ltd at the same time as the survey were analysed for electrical conductivity and those results are presented in this report.

Data Analysis

There are no relevant guidelines for intermittent and ephemeral streams of this region in the Queensland Water Quality Guidelines (QWQG) (with the exception of a preliminary guideline value for conductivity), and the QWQG advises that the default ANZECC & ARMCANZ (2000) guidelines may not be appropriate (DERM 2009). Nevertheless, in the absence of any other guidelines, the results were compared with the ANZECC & ARMCANZ (2000) default trigger values for lowland streams² in tropical Australia and the preliminary QWQG trigger value for electrical conductivity (Table 2.2), to provide an overall indication of water quality. Results at the potentially impacted sites were also compared with the results at the comparative sites during the survey.

² Streams that are at <150 m elevation.

Table 2.2 ANZECC & ARMCANZ (2000) trigger values for physico-chemical water quality parameters in lowland freshwater systems in the survey area.

Parameter	Units	ANZECC & ARMCANZ (2000)
		Trigger Values
Dissolved oxygen ³	% saturation	90 – 120
pH	pH units	6.0 – 8.0
Electrical conductivity	µS/cm	500 ⁴
Turbidity ⁵	NTU	2 – 15.0

2.3 Aquatic Macroinvertebrates

Sample Collection

AUSRIVAS Samples

At each site, single samples from each of the edge, bed and riffle habitats (where present) were also collected. This sampling followed the methods in the Queensland AUSRIVAS sampling manual, and is designed to provide a broad description of macroinvertebrate communities, rather than a quantitative assessment (DNRM 2001). A standard triangular-framed, macroinvertebrate sampling net with 250 µm mesh was used to collect the samples. A 10 m section of stream bed or edge habitat was disturbed, and a sample collected by passing the net through the disturbed area.

Quantitative Samples

At each site, five macroinvertebrate samples were collected from edge habitat and five samples were collected from the bed habitat. At sites where a riffle habitat was present, five macroinvertebrate samples were also collected from the riffle habitat. The substrate and edge habitat for edge samples was disturbed within a 30 x 30 cm area for five seconds, and each sample was then collected by sweeping a standard triangular-framed, macroinvertebrate sampling net, with 250 µm mesh, through the disturbed area five times.

³ Dissolved oxygen values derived from daytime measurements, and may vary overnight and with depth.

⁴ Preliminary QWQG value for freshwaters in the Gulf region (75th percentile).

⁵ Low values for base flow conditions in Northern Territory rivers; Queensland turbidity values highly variable and dependent on catchment modification and seasonal rainfall runoff.

This quantitative sampling enabled a more rigorous analysis of the variability within and between sites to determine whether the overtopping from Content Pit impacted macroinvertebrate communities downstream.

Sample Processing

All samples were preserved in methylated spirits and returned to frc environmental's Brisbane laboratory, where they were sorted, counted and identified to the lowest practical taxonomic level (in most instances family), to comply with AUSRIVAS standards and those described by Chessman (2003).

Data Analysis

Data from the potentially impacted sites was compared to background data from the comparative sites for:

- taxonomic richness
- abundance
- PET richness
- dominant taxa
- community composition, and
- SIGNAL 2 / family bi-plots.

Calculation of Indices

Taxonomic richness, PET richness and SIGNAL 2 scores were calculated for each sample. These indices were used to indicate the current ecological health of surveyed waterways.

Taxonomic Richness

Taxonomic richness is the number of taxa (in this assessment, families) present in a sample. Taxonomic richness is a basic, unambiguous and effective diversity measure. It is however, affected by arbitrary choice of sample size. Where all samples are of equal size, taxonomic richness is a useful tool when used in conjunction with other indices. Richness does not take into account the relative abundance of each taxa, so rare and common taxa are considered equally.

Abundance

Abundance is the total number of macroinvertebrates present in a sample.

PET Richness

While some groups of macroinvertebrates are tolerant of pollution and environmental degradation, others are sensitive to these stressors (Chessman 2003). Plecoptera (stoneflies), Ephemeroptera (mayflies), and Trichoptera (caddisflies) are referred to as PET taxa, and are particularly sensitive to disturbance. There are typically more PET families within sites of good habitat and water quality than in degraded sites. PET taxa are often the first to disappear when water quality or environmental degradation occurs (EHMP 2007). The lower the PET score the greater the inferred degradation.

SIGNAL 2 Scores

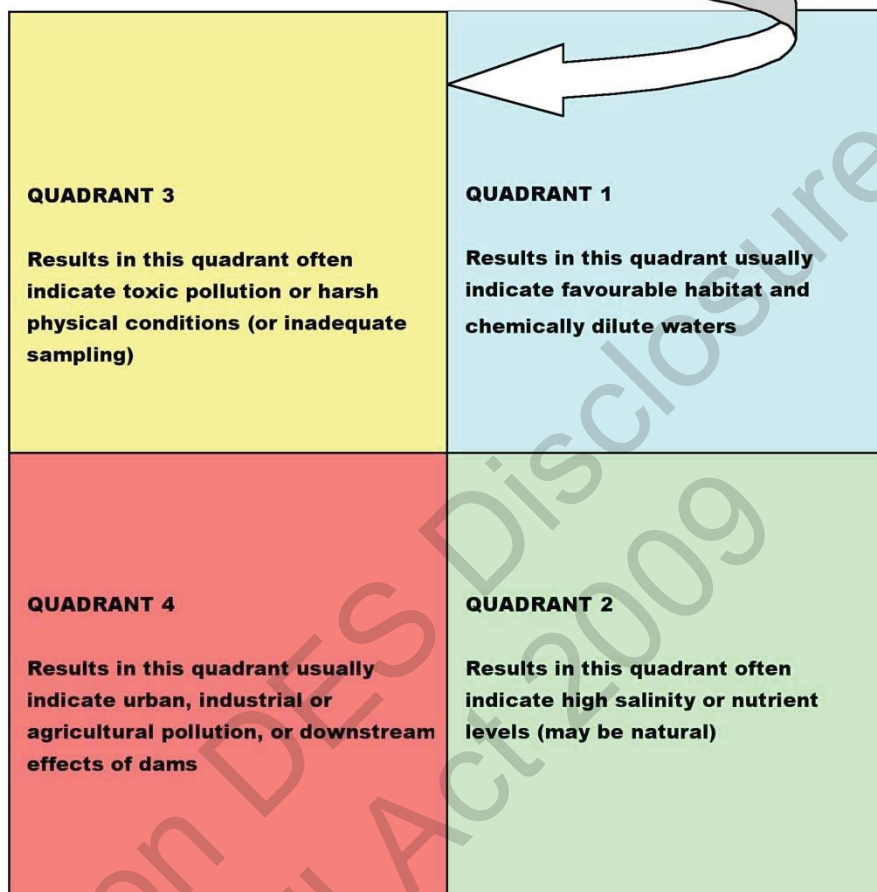
SIGNAL (**S**tream **I**nvertebrate **G**rade **N**umber — **A**verage **L**evel) scores are also based on the sensitivity of each macroinvertebrate family to pollution or habitat degradation. The SIGNAL system has been under continual development for over 10 years, with the current version known as SIGNAL 2. Each macroinvertebrate family has been assigned a grade number between 1 and 10 based on their sensitivity to various pollutants. A low number means that the macroinvertebrate is tolerant of a range of environmental conditions, including common forms of water pollution (e.g. suspended sediments and nutrient enrichment).

SIGNAL 2 scores are weighted for abundance. The scores take the relative abundance of tolerant or sensitive taxa into account (instead of only the presence / absence of these taxa). The overall SIGNAL 2 score for a site is based on:

- the total of the SIGNAL grade
- multiplied by the weight factor for each taxa, and
- divided by the total of the weight factors for each taxa.

SIGNAL 2 scores are interpreted in conjunction with the number of families found in the sample. This is achieved using a SIGNAL 2 / Family bi-plot (Chessman 2003). The plots are divided into quadrants, with each quadrant indicative of particular conditions (Figure 2.2). The quadrants used in this report are based on the default quadrant boundaries provided in Chessman (2001).

Borders between quadrants vary with geographic area,
sampling method and habitat type



Number of macro-invertebrate families

Figure 2.2 Quadrant diagram for SIGNAL 2 / Family Bi-plot.

Analyses of Quantitative Samples

Univariate

ANOVA (analysis of variance) is a statistical hypothesis testing procedure that compares the mean and variance around the mean within each test group (e.g. among replicates within a site) with that among each test group (e.g. sites). The null hypothesis is that this mean is the same for all groups. Generally, if the significance level of the F-test (p value) is below 0.05, the null hypothesis can be rejected.

A one-way ANOVA (analysis of variance) test was used for differences among sites. A significant difference ($p < 0.05$) at a potentially impacted site, relative to comparative sites,

may indicate an impact associated with the Content Pit overtopping. As macroinvertebrate richness is strongly linked to habitat type, differences in richness were therefore analysed separately for each habitat. Where an ANOVA test indicated significant differences among sites, a Student Newman-Keuls (SNK) test was used to determine which pairs of sites differed.

Multivariate

Multivariate analyses consider changes to the macroinvertebrate community structure as a whole, rather than to a single component of the community (e.g. indicator species) or single indices derived to represent the community (i.e. univariate analyses such as richness). Multivariate analyses provide a powerful tool to determine similarities or dissimilarities in community composition (i.e. type and abundance of each taxon) between pre-determined factors (e.g. sites and impacts).

To determine the extent of impact, differences in community composition within potentially impacted sites and comparative sites were examined using a one-way analysis of similarity (ANOSIM). Prior to analysis, community data were $\log_{x+1}$ transformed and converted to a Bray-Curtis similarity matrix. Community differences between sites were displayed visually, for each habitat at each site, using non-metric multi-dimensional scaling (MDS) ordinations. These were overlaid by lines indicating 40% or 50% similarity between sites, as determined using CLUSTER analysis (Clarke 1993). Individual taxa, that contributed to the differences between sites, were identified using the similarity percentages (SIMPER) species contributions routine (Clarke 1993).

To examine the relationships between macroinvertebrate communities and environmental variables (e.g. substrate composition, metal concentrations in sediments and water, pH levels and electrical conductivity), these were compared at the same sites using BIOENV.

The combination of environmental variable/s that best described the biological community pattern were ranked and analysed using a rank correlation coefficient test (Spearman's coefficient – Rho (ρ)). The combinations of environmental variables that best describe the macroinvertebrate communities typically have values of ρ closer to 1 than 0. Environmental variables were normalised and converted to a Euclidean Distance matrix for the analyses, and the most strongly correlated groups were visualised using MDS ordinations.

3 Results and Discussion

3.1 Aquatic Habitat

Aquatic Habitat for Fauna

Site Descriptions

In general, aquatic habitat was good at most survey sites, with cobble, pebble and gravel substrates suitable for macroinvertebrates and native vegetation dominant in the riparian zones. The least suitable macroinvertebrate habitat was at comparative (upstream) sites SW7 and SW6. These sites had substrates dominated by fine sand and silt, and poor riparian zones.

Figure 3.1

View downstream at site SW7 (comparative site).

The substrate was dominated by sand, with some gravel and silt. The riparian zone comprised mainly native vegetation, dominated by grass, with some small trees. Sand deposits were evident along the creek. There were no aquatic macrophytes. There was no evidence of cattle access.



Figure 3.2

View upstream at site BCUS1 (comparative site).

The substrate was dominated by cobbles, with some pebbles, gravel and sand. The riparian zone comprised mainly native vegetation, dominated by small trees and shrubs, with some grass. There were no sand deposits or aquatic macrophytes at this site. There was evidence of cattle access.



Figure 3.3

View downstream at site BCUS2 (comparative site).

The substrate was dominated by sand, with some pebbles, gravel and silt. The riparian zone comprised mainly native vegetation, dominated by small trees and shrubs. Sand deposits were evident on the creek bed. There were no aquatic macrophytes, but there was some filamentous algae. There was evidence of cattle access.



Figure 3.4

View upstream of right channel at site BCUS3 (comparative site).

The substrate was dominated by sand, gravel and pebbles, with some cobbles and silt. The riparian zone comprised mainly native vegetation, dominated by shrubs, with some grass and small trees. Sand deposits were evident on the creek bed. The submerged aquatic macrophyte water milfoil (*Myriophyllum* sp.) formed large beds. There was evidence of cattle access.

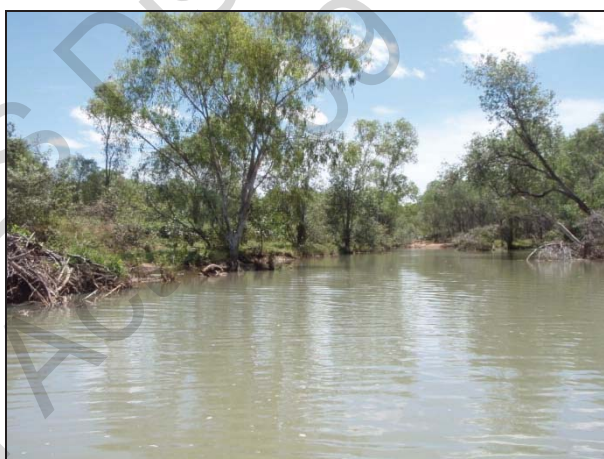


Figure 3.5

View of tributary outflow at site SW6 (comparative site).

This site was on the edge of a stock dam. The substrate was dominated by silt, with some sand and gravel. The riparian zone comprised sparse, mainly native vegetation and was dominated by grasses. There were no sand deposits or aquatic macrophytes. There were some filamentous algae along the edge. There was evidence of cattle access.



Figure 3.6

View upstream at site DSDi (potentially impacted site).

The substrate was dominated by sand, with some cobble, pebble, gravel and silt present. Sand deposits were evident on the creek bed. The riparian zone comprised mainly native vegetation dominated by grass. There were no aquatic macrophytes. There was evidence of cattle access.



Figure 3.7

View across stream at site BCDS1 (potentially impacted site).

The substrate was dominated by sand, with some bedrock, boulders, cobbles, pebbles, gravel and silt present. Sand deposits were evident on the creek bed. The riparian zone comprised dominated by small trees and shrubs. There was low coverage of the substrate by the aquatic macrophyte water milfoil (*Myriophyllum* sp.). There was evidence of cattle access.

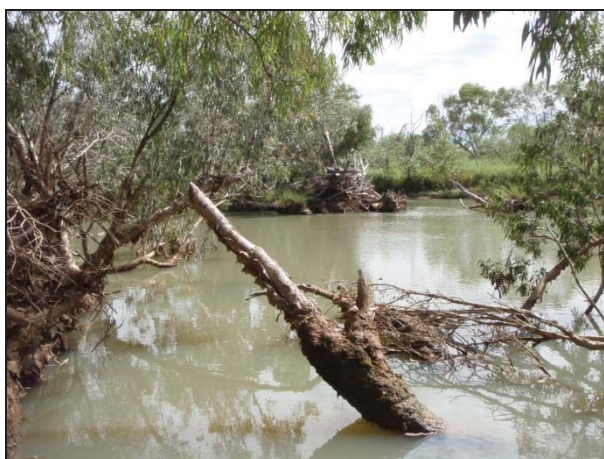


Figure 3.8

View upstream at site BCDS2 (potentially impacted site).

The substrate was dominated by sand, with cobbles, pebbles, gravel and silt also present. There were no sand deposits. The riparian zone comprised mainly native vegetation dominated by small trees and shrubs. There were no aquatic macrophytes. There was evidence of cattle access.



Figure 3.9

View upstream at site BCDS3 (potentially impacted site).

The substrate was dominated by sand and gravel, with some cobbles, pebbles and silt. Some sand deposits were evident on the creek bed. The riparian zone comprised mainly native vegetation dominated by grass, shrubs and small trees. There were no aquatic macrophytes. There was evidence of cattle access.



Figure 3.10

View upstream at site BCDS4 (potentially impacted site).

The substrate was dominated by sand, with some cobbles, pebbles, gravel and silt. The riparian zone comprised mainly native vegetation dominated by shrubs, with some grass and trees. There were no sand deposits or aquatic macrophytes. There was evidence of cattle access.



Bioassessment Scores

Habitat bioassessment scores ranged from moderate to good at all sites (Figure 3.11).

Comparative sites SW7 and SW6 had the lowest bioassessment scores. These scores were due to high embeddedness of the substrate (as it was dominated by fine sediments), as well as low diversity of in-stream habitat (i.e. there was only shallow pools and runs, with no deep pools or riffles present), and poor streamside cover. This indicates that these sites are likely to be less suitable for macroinvertebrates. Potentially impacted sites DSDi and BCDS1 also had relatively low bioassessment scores due to high embeddedness and poor in-stream habitat diversity.

There was a noticeable improvement in habitat condition between potentially impacted sites BCDS1 and BCDS2 (Figure 3.11). Along with comparative sites BCUS2 and BCUS3, potentially impacted sites BCDS2 and BCDS3 had the highest bioassessment scores, with each site classified as good. These sites had good in-stream habitat diversity, low embeddedness and high streamside cover.

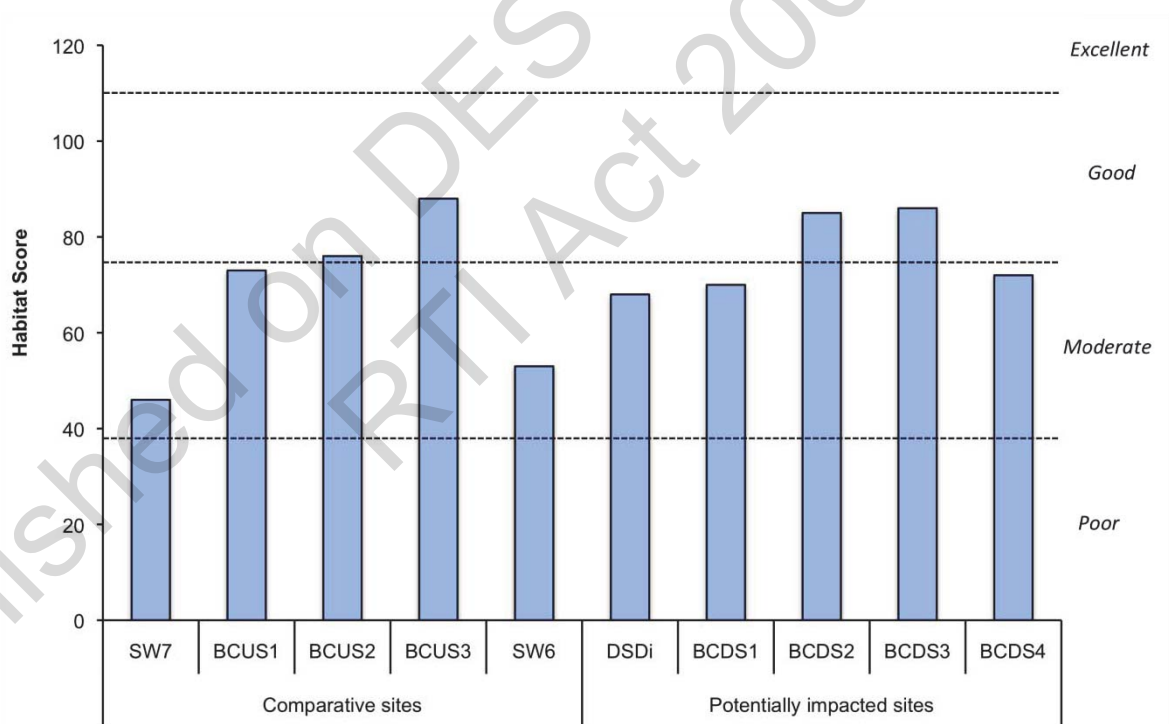


Figure 3.11 Habitat bioassessment scores at each site.

Water Quality

Water Temperature

Water temperature ranged from 24.1 °C – 31.4 °C. There are no ANZECC & ARMCANZ (2000) trigger values for water temperature. Temperature was similar across all sites however it was slightly lower at site DSDi, downstream of confluence of the Content Pit overflow and the Belmore Creek tributary. This is likely due to diurnal variation in temperature and the time of day it was measured.

Turbidity

Turbidity exceeded the upper and lower ANZECC & ARMCANZ (2000) trigger values at all sites, except site SW6 where it only exceeded the lower trigger value (Figure 3.12). Turbidity ranged from 14.2 – 52.6 NTU.

In general, turbidity was similar at all sites except comparative sites SW7 and BCUS3 (Figure 3.12). Turbidity at these sites was approximately double the turbidity at all other sites. The high turbidity recorded at all sites was likely due to the recent rainfall in the region and runoff carrying suspended sediments entering the creeks. Turbidity can have a negative impact on aquatic flora and fauna through a reduction in light penetration of the water and the siltation of interstitial spaces between cobbles and pebbles that provide habitat.

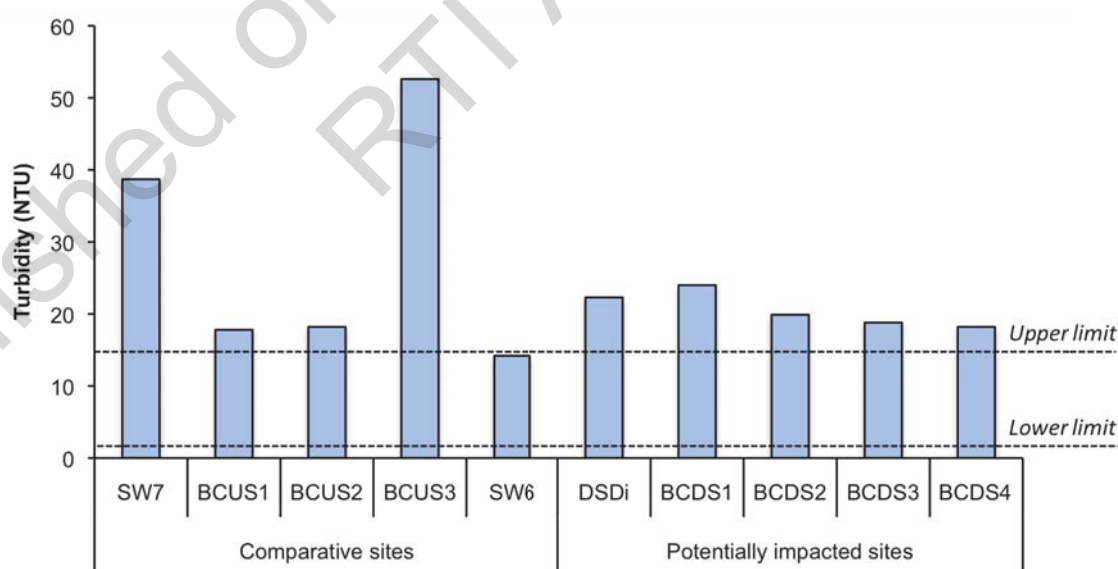


Figure 3.12 Turbidity at each site.

pH

The pH was within the ANZECC & ARMCANZ (2000) trigger value range at all sites, ranging from 6.6 to 7.59 (Figure 3.13). The pH was more alkaline downstream of the Content Pit overflow at DSDi, but the pH here was not substantially higher than at the other sites.

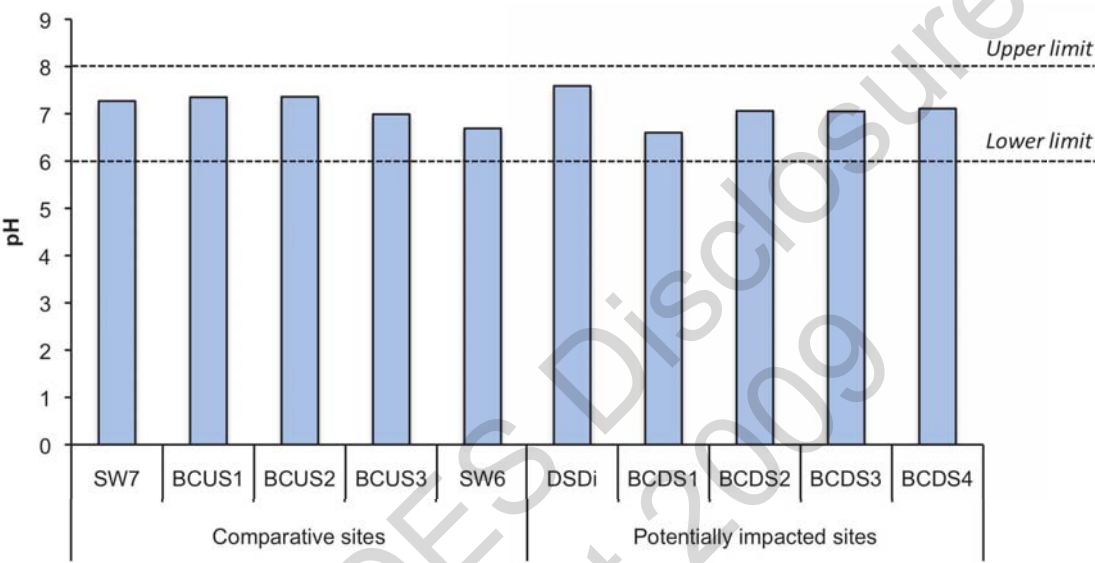


Figure 3.13 The pH at each site.

Electrical Conductivity

Electrical conductivity was below the QWQG trigger value at all sites (Figure 3.14). Conductivity was similar at all sites except comparative site SW7 and potentially impacted site DSDi. It is possible that the Content Pit overflow had an impact on conductivity at site DSDi, but the substantial decrease in conductivity between sites DSDi and BCDS1 (which are approximately 700 m apart) and the high value at comparative site SW7 suggest local variation may also be a factor. High conductivity can be directly toxic to macroinvertebrates and lead to reduced abundance and taxonomic richness; however the conductivity recorded at sites SW7 and DSDi is not considered to be 'high' in the context of the available water quality guidelines.

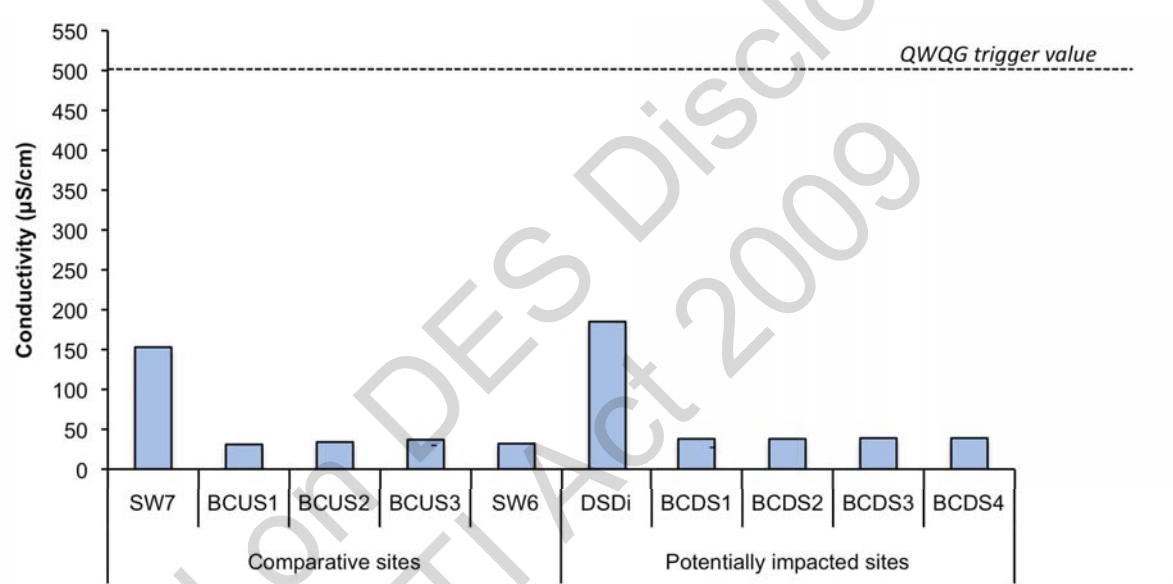


Figure 3.14 Electrical conductivity at each site.

Dissolved Oxygen

The percent saturation of dissolved oxygen (DO) was within the ANZECC & ARMCANZ (2000) trigger value range at all sites except comparative sites SW7 and SW6 (Figure 3.15). These sites had less flow than other survey sites, which may be a contributing factor to the lower dissolved oxygen. Dissolved oxygen was also slightly lower in potentially impacted sites than at comparative sites on Belmore Creek (although DO was within the trigger value range at all potentially impacted sites). This may indicate an impact from the Content Pit overflow; however, dissolved oxygen is highly variable throughout the day and should be measured over 24 hours to determine if any differences are real. Dissolved oxygen is essential to aquatic fauna survival and low dissolved oxygen can lead to a reduction in abundance and taxonomic richness.

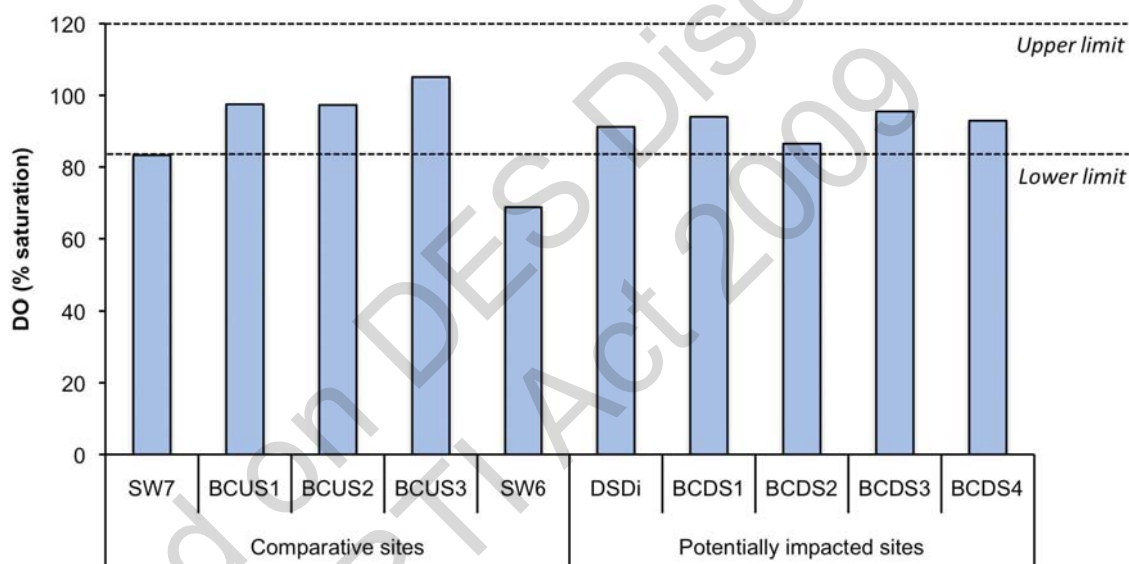


Figure 3.15 Dissolved oxygen at each site, and the ANZECC & ARMCANZ (2000) trigger level range.

3.2 Aquatic Macroinvertebrates

AUSRIVAS Assessment

Total Taxonomic Richness

Total taxonomic richness was generally low and variable across sites. It was typically higher in the edge and riffle habitats than in the bed habitat (Figure 3.16).

Macroinvertebrate taxonomic richness in the edge habitat was lowest at potentially impacted site BCDS1 and highest at potentially impacted site BCDS3 (Figure 3.16). Taxonomic richness was higher at site DSDi, downstream of the Content Pit overflow, than at comparative sites BCUS2 and SW6. This suggests that the overflow has not had a substantial impact on macroinvertebrates in edge habitat.

Total taxonomic richness in the bed habitat was variable, with similar results in the comparative and potentially impacted sites (Figure 3.16). No taxa were recorded for the site immediately downstream of the Content Pit overflow which suggests a potential impact on macroinvertebrates; however, only three taxa were found at sites BCUS2 and BCDS1 which indicates other factors (e.g. habitat or natural variability) may be influencing macroinvertebrates in the bed at site DSDi.

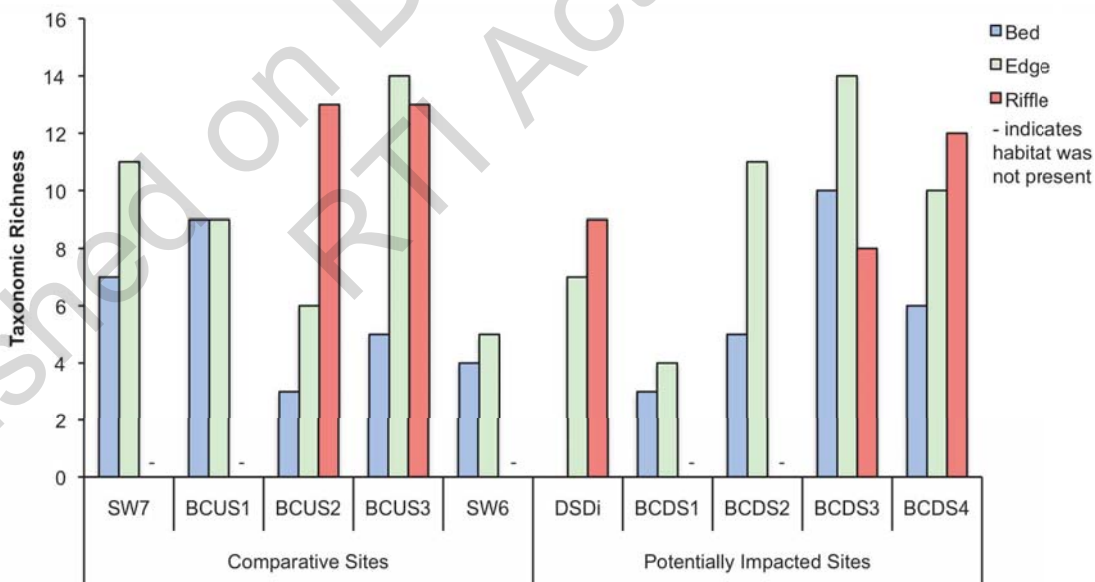


Figure 3.16 Total taxonomic richness for bed, edge and riffle habitats.

Total taxonomic richness in the riffle was generally lower at potentially impacted sites than at comparative sites. This is similar to the results for the quantitative samples and is likely to be the result of better riffle habitat (i.e. a greater percentage of cobble and pebble in the substrate; and shallow, fast flow) at these sites.

Variation in the results for the edge, bed and riffle habitats suggest that the Content Pit overflow did not have a substantial, or possibly any, effect on macroinvertebrate taxonomic richness.

PET Richness

PET richness was typically low across all habitats, but was higher in the edge and riffle habitats than in the bed habitat (Figure 3.17).

Potentially impacted site DSDi, immediately downstream of the Content Pit overflow, had the lowest PET richness for all habitats (with no taxa at all recorded in the bed) (Figure 3.17). This may indicate a potential impact from the Content Pit overflow; however, PET richness was low for the bed habitat at all comparative sites except site BCUS1, which suggests other factors (e.g. habitat) may also have been affecting PET taxa.

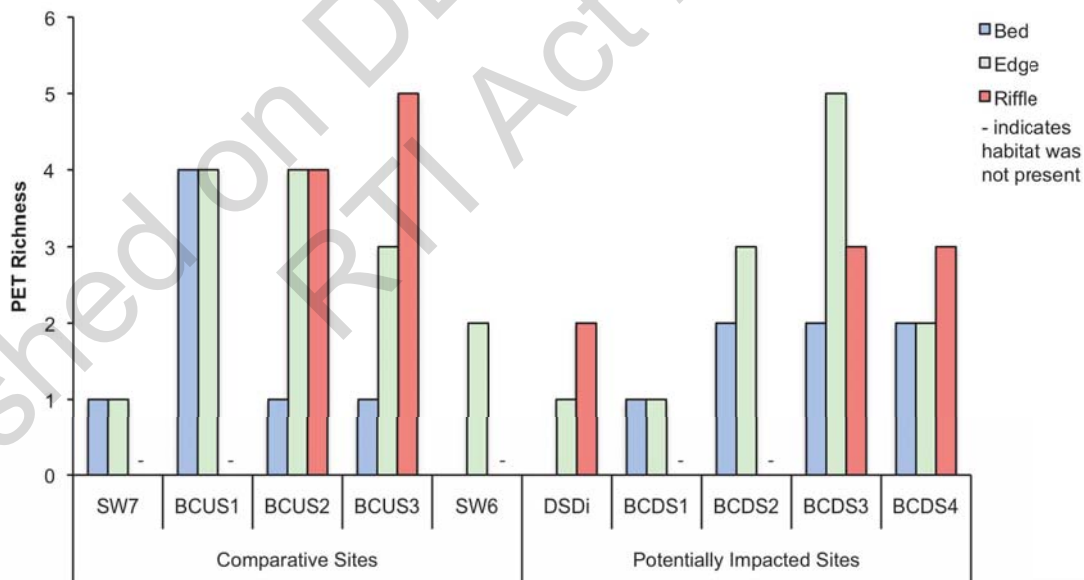


Figure 3.17 PET richness for edge, bed and riffle habitats.

SIGNAL 2

The lowest SIGNAL 2 scores for the edge habitat were recorded at comparative sites SW7 and BCUS3 (Figure 3.18). The lowest SIGNAL 2 score for the bed habitat was recorded at site SW7. The highest SIGNAL 2 scores for each habitat were recorded at comparative site BCUS2. SIGNAL 2 scores for all other sites were similar.

These results suggest there was no clear impact on pollution sensitive taxa from the Content Pit overflow. This is supported by the SIGNAL 2 / Family Bi-plot, which shows no distinction between comparative and potentially impacted sites, with all sites located in quadrants three and four (Figure 3.18). Quadrant three indicates toxic pollution or harsh physical conditions, while quadrant four indicates urban, agricultural or industrial pollution, or the downstream effects of dams. As the creeks in this region are ephemeral they are subject to naturally harsh conditions; and all sites are in an agricultural area, with most sites showing signs of cattle access. These conditions were likely to be affecting the macroinvertebrate communities.

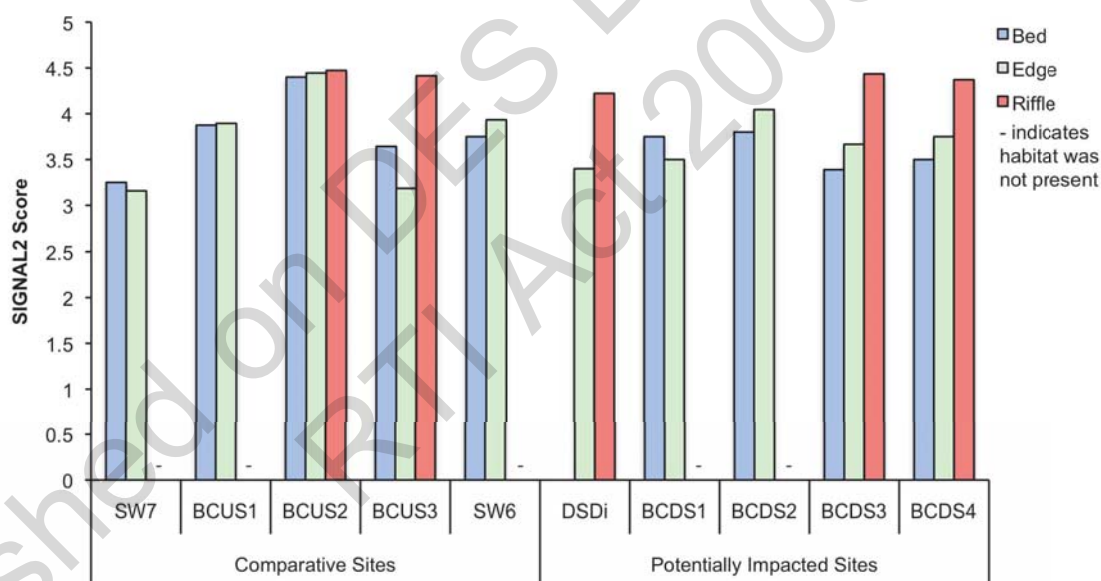


Figure 3.18 SIGNAL 2 scores for the edge, bed and riffle habitats.

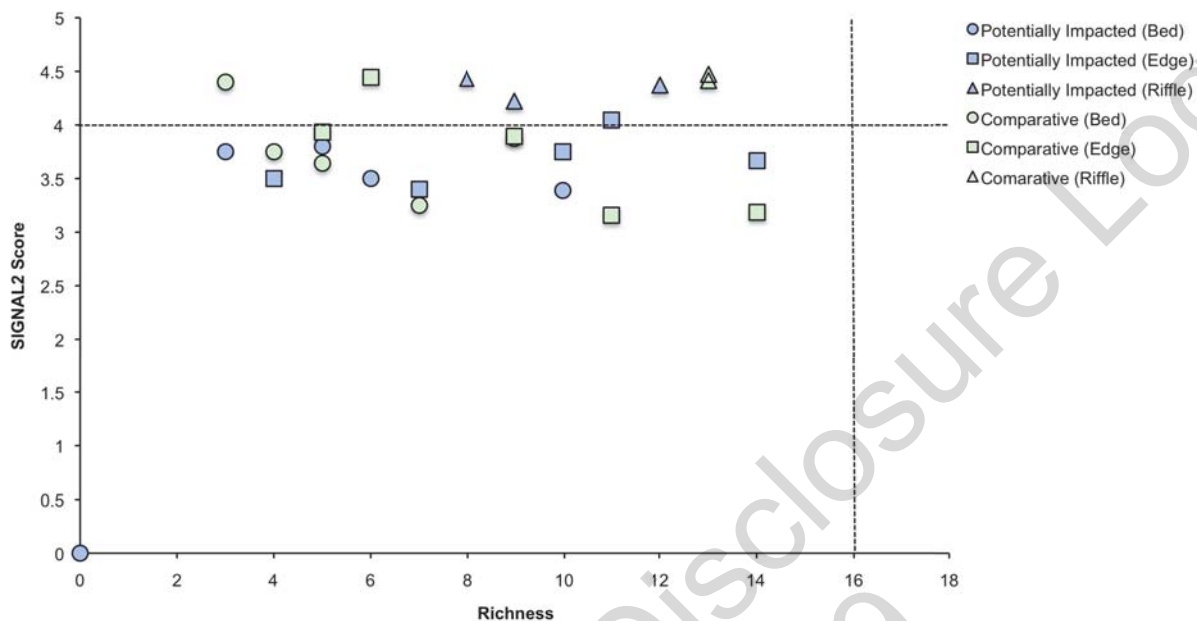


Figure 3.19 SIGNAL 2 / Family Bi-plot for edge, bed and riffle habitats.

Quantitative Impact Assessment

Mean Taxonomic Richness

Edge Habitat

Mean taxonomic richness in the edge habitat was highest at comparative site SW7 and lowest at comparative site SW6, where richness was significantly lower than all other sites (ANOVA SNK tests, $p < 0.05$) (Figure 3.20). This is likely due to the good and poor quality of the edge habitat present at these sites, respectively. Although the habitat bioassessment score at site SW7 was low, the presence of overhanging grasses at this site provided good edge habitat that was not affected by the embeddedness and low in-stream diversity.

In general, macroinvertebrate taxonomic richness was higher at the potentially impacted sites than at the comparative sites, except site DSDi (although richness here was only significantly lower than at site SW7; ANOVA SNK tests, $p < 0.05$) (Figure 3.20). This suggests that the Content Pit overflow did have an impact at site DSDi, but did not have an impact on the macroinvertebrate communities of the edge habitat further downstream in Belmore Creek.

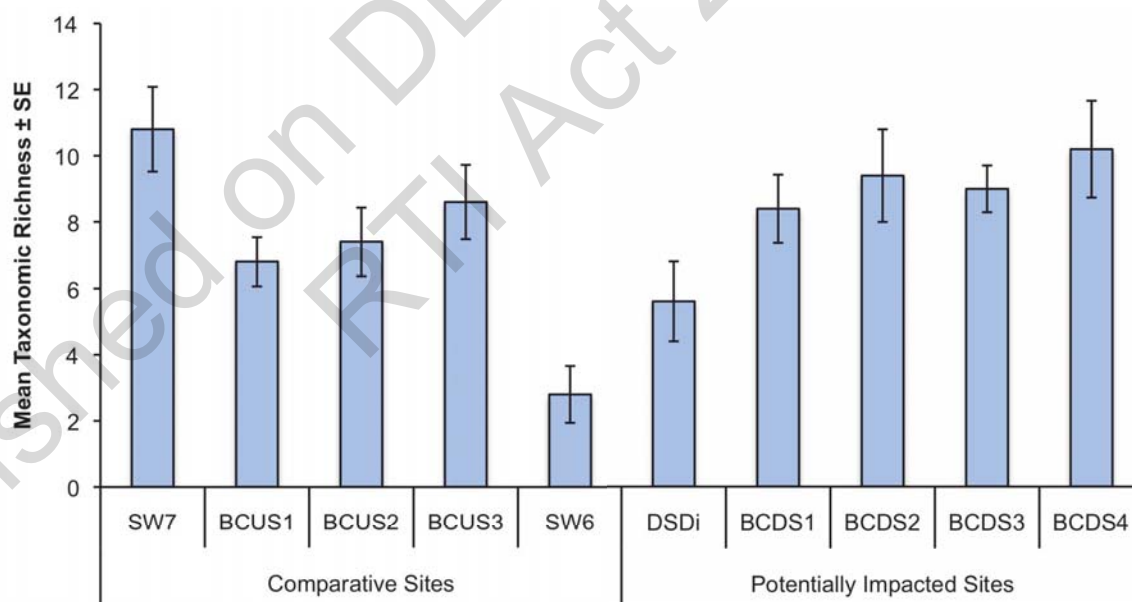


Figure 3.20 Mean taxonomic richness in edge habitat.

Bed Habitat

Mean taxonomic richness in the bed habitat was lowest at comparative site BCUS2 and potentially impacted sites DSDi and BCDS4 (Figure 3.21). It was highest at potentially impacted sites BCDS2 and BCDS3.

A decrease in taxonomic richness on the tributary of Belmore Creek from comparative site SW6 to potentially impacted site DSDi indicates a likely impact from the Content Pit overflow (Figure 3.21). However taxonomic richness increased from site DSDi to site BCDS1 and sites further downstream (with the difference in richness between site DSDi and BCDS2 being statistically significant; ANOVA SNK tests, $p < 0.05$), suggesting that any potential impact was limited in spatial extent. In addition, taxonomic richness in the bed was variable across sites, which may indicate that natural variability was also a factor in the low richness at site DSDi.

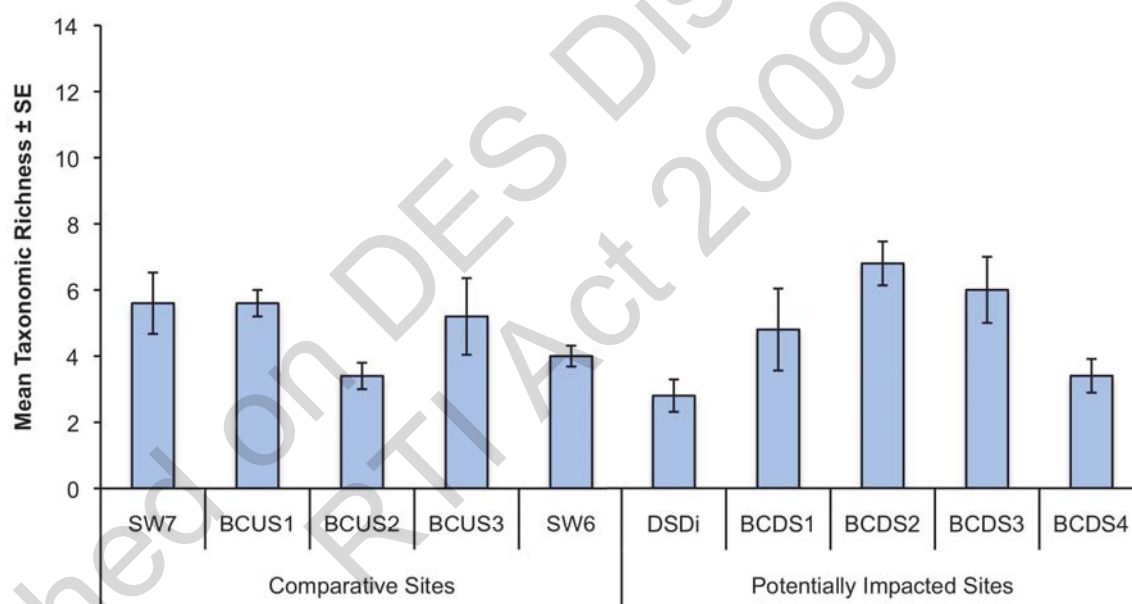


Figure 3.21 Mean taxonomic richness in bed habitat.

Riffle Habitat

Mean taxonomic richness in the riffle habitat was lower at the potentially impacted sites than at the comparative sites (Figure 3.22), although there were no significant differences in richness between sites (ANOVA SNK tests, $p > 0.05$). The taxonomic richness in the edge and bed habitats was relatively high at potentially impacted site BCDS3 and relatively high for the edge habitat at BCDS4; this difference may have been due to the Content Pit overflow, but is more likely to be related to habitat conditions or other factors.

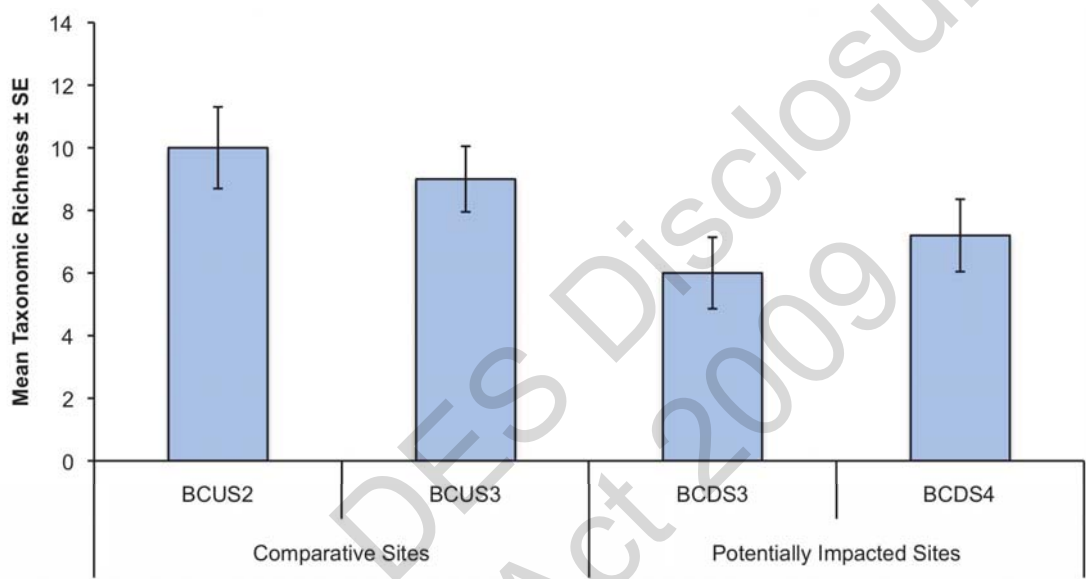


Figure 3.22 Mean taxonomic richness in riffle habitat.

Mean Abundance

Edge Habitat

Mean abundance in the edge habitat was lowest at potentially impacted site DSDi but was also low at comparative sites SW7 and SW6 (Figure 3.23); abundance at sites DSDi and SW6 was significantly lower than at most other sites (ANOVA SNK tests, $p < 0.05$). In general, mean abundance was higher at potentially impacted sites on Belmore Creek than at comparative sites, except for BCUS3.

Limited habitat availability at sites SW7 and SW6 is likely to have contributed to the low abundance at these sites, despite the presence of some good habitat at site SW7. It is possible that the Content Pit overflow had an impact in the tributary to Belmore Creek at site DSDi. Site DSDi had good edge habitat, therefore it is possible that the Content Pit overflow impacted macroinvertebrates communities at this site. Mean abundance increased between sites DSDi and BCDS1, suggesting that any potential impact was spatially limited.

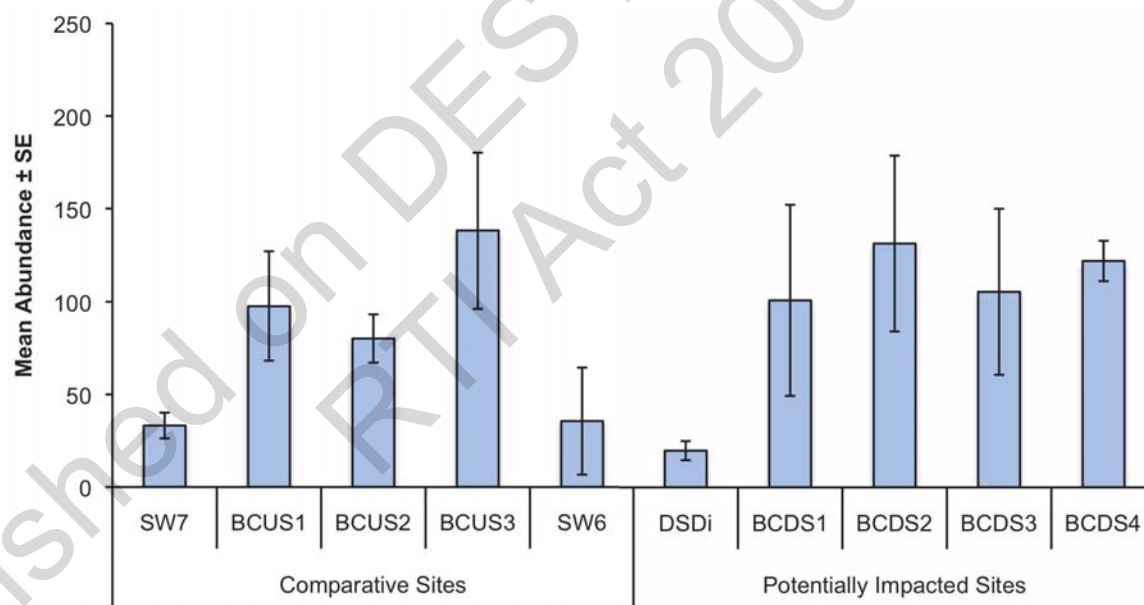


Figure 3.23 Mean abundance in the edge habitat.

Bed Habitat

Mean abundance in the bed habitat was low at all sites except sites BCUS3 and BCDS2, where abundance was significantly higher than at all other sites (ANOVA SNK tests, $p < 0.05$; Figure 3.24). The lowest abundances were at potentially impacted sites DSDi and BCDS4. A decrease in abundance between sites SW6 and DSDi indicates a possible impact on macroinvertebrates from the Content Pit overflow. However, the increase in abundance between sites DSDi and BCDS1, and the variability in abundance across sites, suggests any impact is limited or may be the result of natural variation.

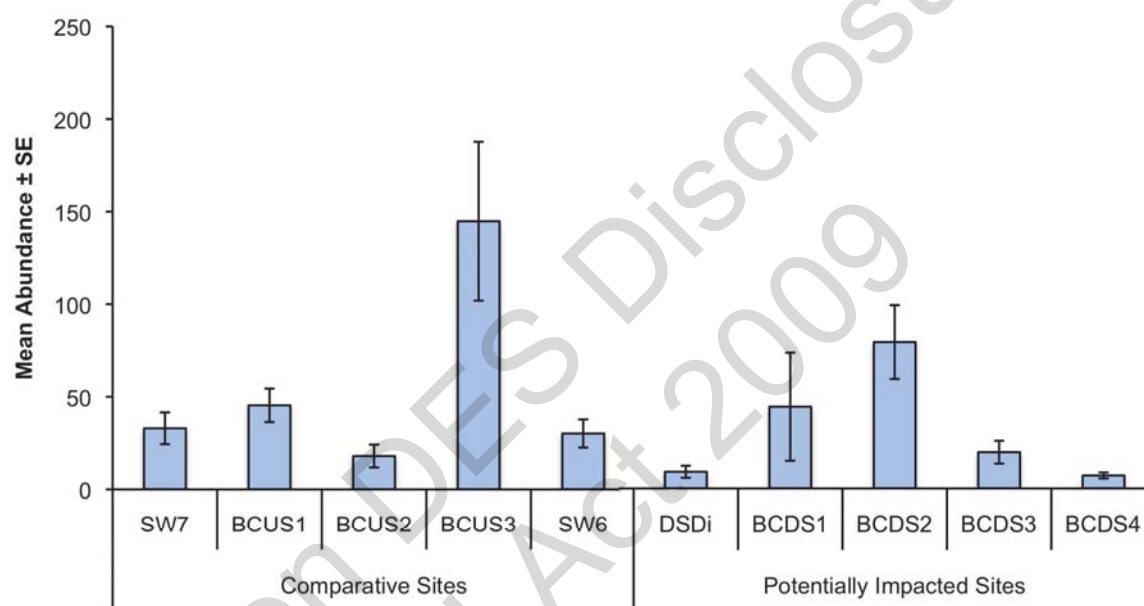


Figure 3.24 Mean abundance in the bed habitat.

Riffle Habitat

Mean abundance in the riffle habitat was higher at comparative sites than at potentially impacted sites (Figure 3.25), although there were no significant differences in richness between sites (ANOVA SNK tests, $p > 0.05$).

The abundance in the edge habitat at these potentially impacted sites was relatively high compared to the comparative sites, but was low for the bed habitat. This suggests that the difference in abundance between comparative and potentially impacted sites for the riffle habitat may not have been due to the Content Pit overflow, but was likely due to habitat conditions.

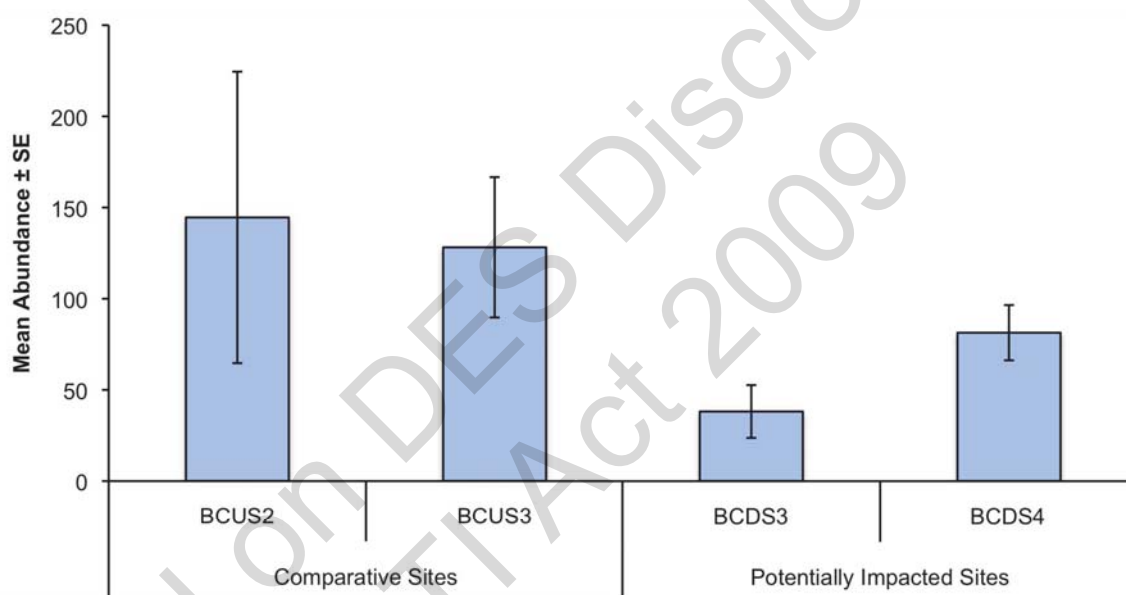


Figure 3.25 Mean abundance in the riffle habitat.

Community Composition

Edge Habitat

Macroinvertebrate community composition in the edge habitat was significantly different between sites; however, the differences were small (ANOSIM Global $R = 0.37$, $p = 0.001$). While communities between some sites were different from each other, there were no distinct groupings between communities at comparative and potentially impacted sites (Figure 3.26).

Communities at comparative site SW6 and potentially impacted site DSDi were the most distinct from communities at other sites (Figure 3.26). At potentially impacted site DSDi, this was mostly due to a decreased abundance or an absence of some taxa at this site compared with other sites, including both tolerant taxa such as non-biting midge larvae (sub-families Chironominae and Tanypodinae), and sensitive taxa such as caenid mayflies and leptocerid and ecnomid caddisflies (SIMPER). This may be indicative of an impact from the overtopping of the Content Pit, though it is important to note that abundances of other relatively sensitive taxa such as baetid mayflies and mites were similar to or higher than at other sites.

Communities at comparative site SW6 had low abundances of fairly tolerant taxa such as biting (family Ceratopogonidae) and non-biting midge larvae, and lacked a range of taxa that were relatively widespread across the study area, such as baetid and caenid mayflies, waterboatmen (family Corixidae), dragonfly larvae (family Libellulidae) and caddisflies (families Leptoceridae and Ecnomidae).

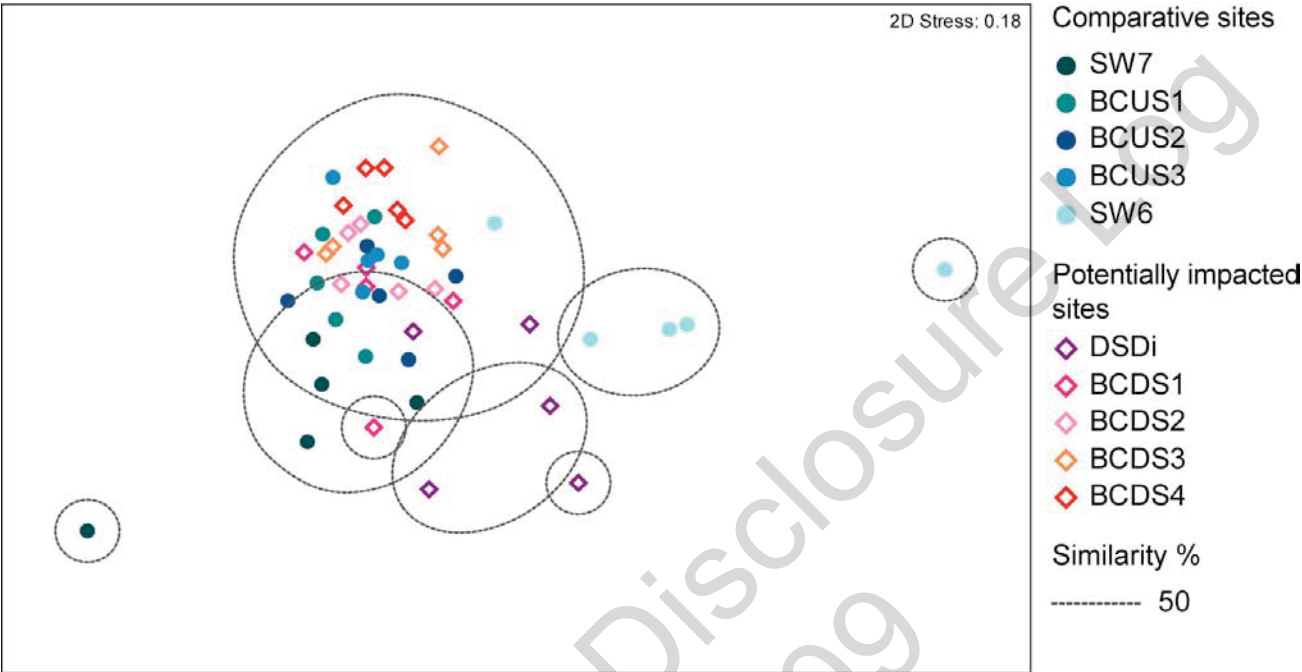


Figure 3.26 MDS ordination showing the differences between sites in macroinvertebrate community composition in edge habitat, and 50% similarity groupings based on CLUSTER analysis.

A comparison of environmental variables and macroinvertebrate community composition in the edge showed a significant correlation between community composition and a combination of turbidity, magnesium, arsenic, copper and total phosphorus concentrations (BIOENV Rho = 0.895, $p=0.04$). Comparative sites SW7 and SW6 and potentially impacted site DSDi were distinctly different from all other sites (Figure 3.27 and Figure 3.28), which suggest these water quality variables influenced macroinvertebrate communities at these sites.

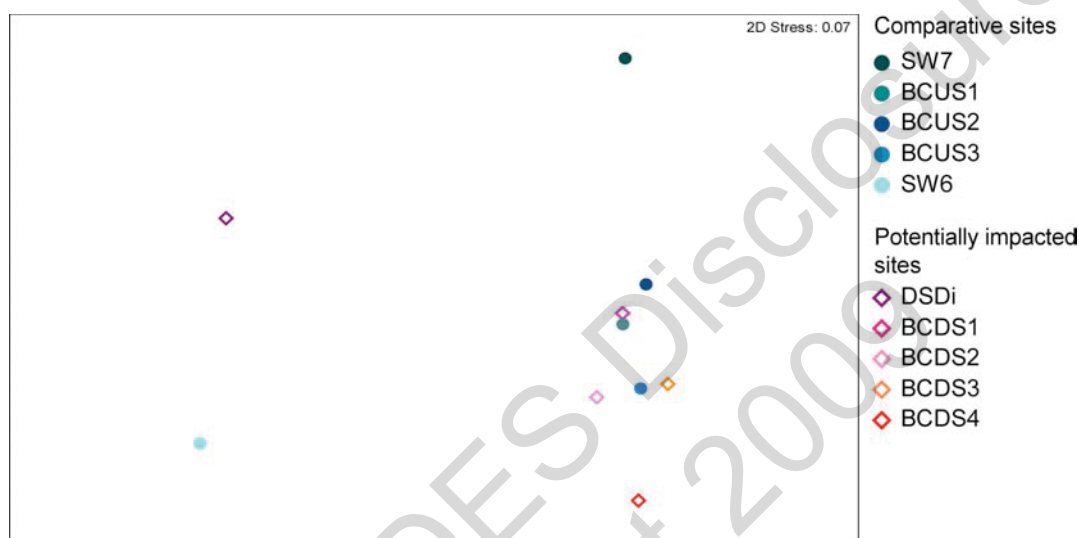


Figure 3.27 MDS ordination showing the differences between sites in macroinvertebrate community composition (averaged across replicates) in edge habitat.

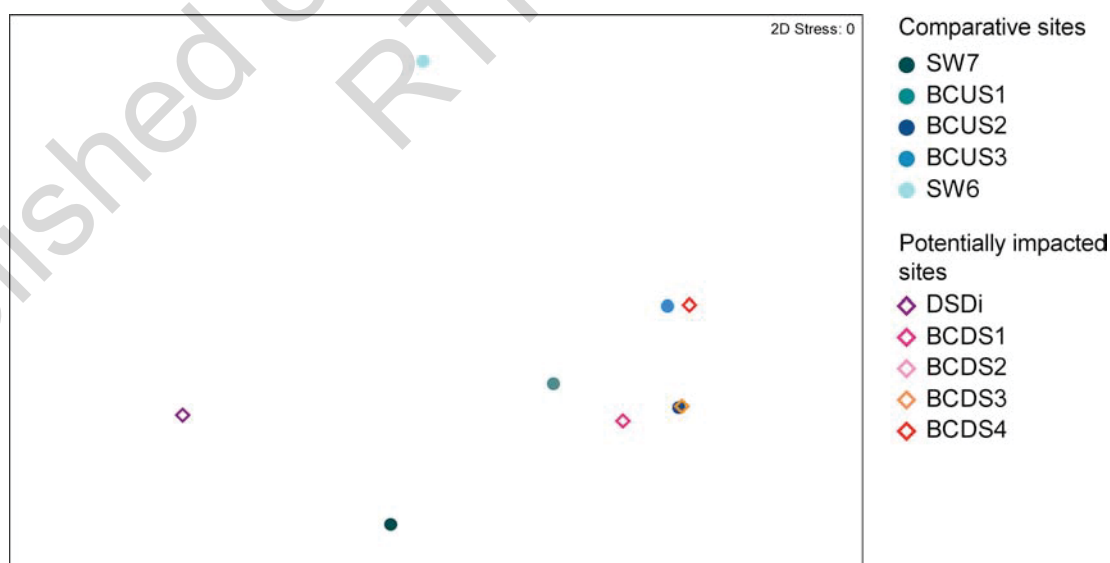


Figure 3.28 MDS ordination showing the differences between sites in water quality (turbidity, magnesium, arsenic, copper and total phosphorus).

Of these water quality variables, turbidity was higher at sites SW7, SW6 and DSDi than at the other sites surveyed; it is possible that elevated turbidity at site DSDi was related to overland flow from the overtopping Content Pit carrying suspended sediments to the tributary of Belmore Creek (though note that turbidity at site DSDi was similar to that at other sites during *in situ* sampling of turbidity). Magnesium concentrations were elevated at sites DSDi and SW7, and total phosphorus concentrations were elevated at sites DSDi and SW6; it is unclear whether this is related to the overtopping of Content Pit.

Arsenic concentrations were lower at sites SW7, SW6 and DSDi than at the other sites surveyed, which indicates that the overtopping of Content Pit did not have an adverse effect on macroinvertebrate communities due to toxicity of arsenic. Conversely, copper concentrations were elevated at these sites compared with the others surveyed: particularly at site DSDi, which may be a result of the overtopping of the Content Pit.

Bed Habitat

Macroinvertebrate community composition in the bed habitat was significantly different between sites, however the magnitude of this difference was small, and mostly indistinct at a 40% similarity level (ANOSIM global $R = 0.452$, $p = 0.01$; Figure 3.29).

Nevertheless, communities at site DSDi were different from those at other sites (Figure 3.29). This was mostly attributable to a low abundance of most taxa, including some sensitive taxa such as caddisflies (Ecnomidae and Leptoceridae), and an absence of taxa commonly found in the study area (caenid mayflies, mites and waterboatmen) (SIMPER). This may be indicative of an impact from the overtopping of the Content Pit.

A comparison of environmental variables, including water quality and sediment quality, and macroinvertebrate community composition in the bed showed no significant correlations.

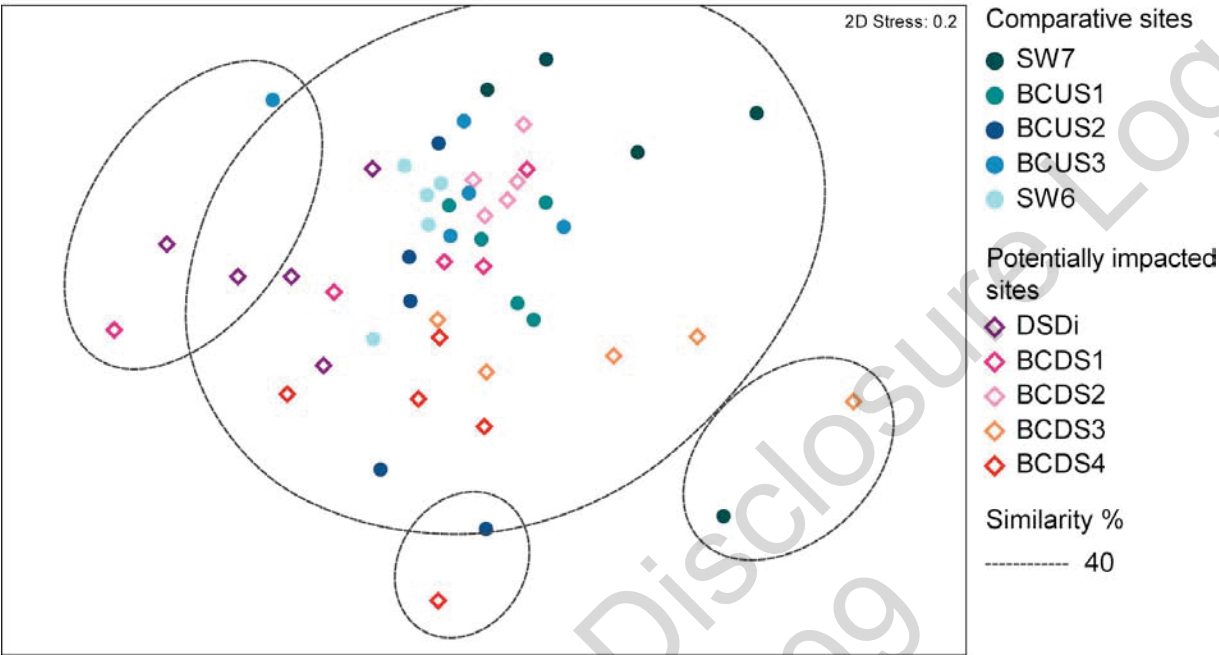


Figure 3.29 MDS ordination showing the differences between sites in macroinvertebrate community composition in bed habitat.

Riffle Habitat

There were distinct differences in macroinvertebrate community composition in the riffle habitat at comparative sites and the riffle habitat at potentially impacted sites (ANOSIM Global $R = 0.336$, $p = 0.01$); however communities at both the two comparative sites and the two potentially impacted sites were not significantly different from each other (ANOSIM pairwise tests $p > 0.05$, Figure 3.30). As discussed above, based on the results for other habitats, it is likely that these differences are related to riffle habitat quality upstream and downstream of the Content Pit, rather than the overtopping of the pit. A comparison of environmental variables, including water quality and sediment quality, and macroinvertebrate community composition in the riffle showed no significant correlations.

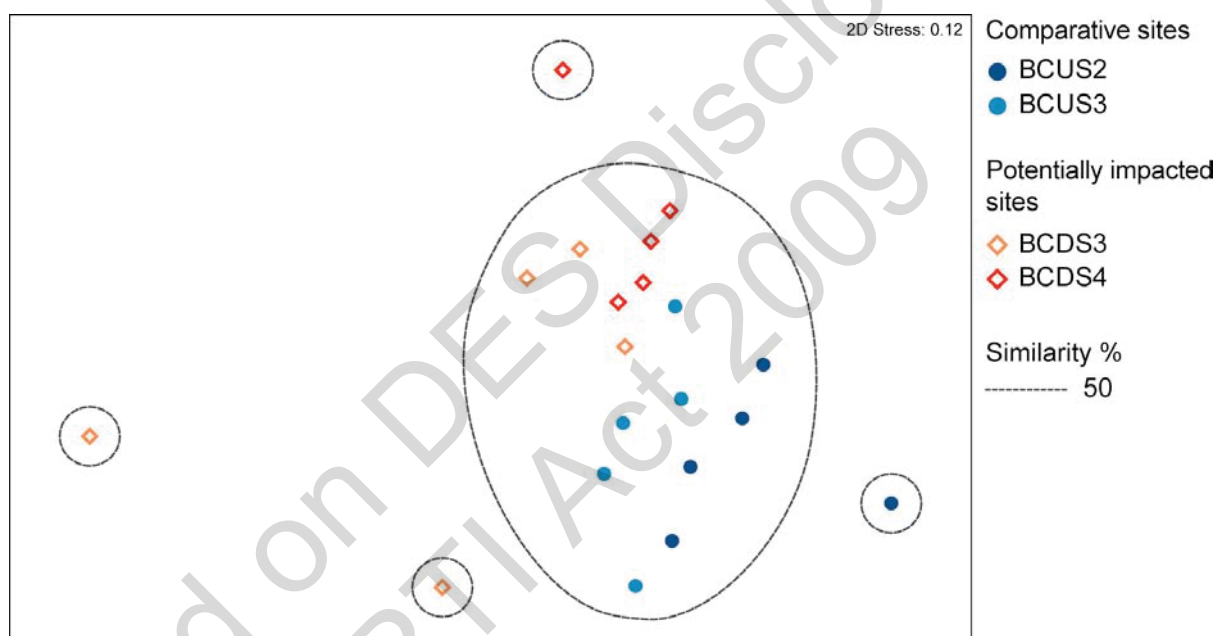


Figure 3.30 MDS ordination showing the differences between sites in macroinvertebrate community composition in riffle habitat.

4 Summary and Recommendations

4.1 Summary

The overtopping of the Content Pit appears to have had a small impact on the macroinvertebrate communities (i.e. on taxonomic richness, abundance and community composition) at site DSDi, which is approximately 30 m downstream of the confluence of the overflow pathway with the tributary of Belmore Creek (approximately 1.5 km from the Content Pit over land) (Figure 2.1). However, the impact appeared to be confined to a small spatial area, and did not extend to the first downstream site on Belmore Creek (i.e. BCDS1), which is approximately 700 m downstream of the confluence of the overflow pathway with the tributary of Belmore Creek (Figure 2.1). As such, the macroinvertebrate taxonomic richness, abundance and community composition at sites downstream of site DSDi do not appear to have been impacted by overflows from the Content Pit.

The *in situ* water quality results provide no indication of potential impacts from the Content Pit overflow except for electrical conductivity. Increased electrical conductivity was observed at site DSDi immediately downstream of the confluence of the overflow pathway with the tributary of Belmore Creek. Though electrical conductivity levels in the study area did not correlate highly to macroinvertebrate community structure, suggesting that electrical conductivity levels here may not have had a substantial influence on macroinvertebrate community structure.

A number of other factors (e.g. habitat condition, land use [i.e. cattle access] and water quality) also appear to have had an effect on macroinvertebrate communities. As a result, the influence of the overtopping event from the Content Pit on the macroinvertebrate communities in the tributary to Belmore Creek is not able to be clearly defined.

4.2 Recommendations

Water quality and macroinvertebrate results were spatially variable, and are expected to also vary temporally in response to seasonal and long-term climatic influences. As such, the results of this one-off survey are insufficient to fully characterise the impact from overtopping of the Content Pit, when compared with the influence of other factors. Additional surveys or a long-term ecological monitoring program would provide the opportunity to:

- describe the natural variability of the macroinvertebrate communities in the survey area

- determine if the overtopping event from the Content Pit had a short or long-term impact, or potentially no impact at all, and
- gather comprehensive background data from comparative sites.

4.3 Limitations

This macroinvertebrate survey was initially intended to provide baseline data for a survey in Belmore Creek and its tributaries in the vicinity of the Croydon Gold Mine, however due to heavy rainfall before sampling began, the Content Pit overtopped. Consequently, there is no baseline data from the area to which the survey results can be compared. The lack of baseline data limits the interpretation of the survey data, as it is not possible to assess whether the patterns in macroinvertebrate community structure existed before the overtopping occurred.

5 References

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APPENDIX B

SUMMARY INTERPRETATION OF CONTENT PIT WATER TOXICITY RESULTS

CROYDON GOLD MINE

Summary Interpretation of Content Pit Water Toxicity Results - Croydon Gold Mine

Report by:

CTPI 49-Sch4

Centre for Mined Land Rehabilitation

THE UNIVERSITY OF QUEENSLAND

Prepared for:
Barrick Gold of Australia Limited

October 2011



**Summary Interpretation of Content Pit Water Toxicity Results
Croydon Gold Mine
October 2011**

The following is a preliminary summary interpretation of the Content Pit water toxicity test results from Ecotox Services Australasia Pty. Ltd.

Summary of Freshwater Aquatic Toxicity Tests Undertaken for Content Pit Water Elutriate

The following fresh water aquatic toxicity tests were conducted for samples of Content Pit water from the Croydon Gold Mine during August and September 2011:

1. 48 hour acute (immobilisation) test using the freshwater cladoceran *Ceriodaphnia dubia*.
2. 8 day partial life-cycle test using the freshwater cladoceran *Ceriodaphnia dubia*.
3. 48 hour acute toxicity test using the freshwater chironomid *Chironomus tepperi*.
4. 96 hour acute toxicity test with the freshwater shrimp *Marcobrachium australiense*.
5. 7 day growth inhibition test using a freshwater aquatic duckweed *Lemna dierasperma*.

Pit water samples were diluted with Dilute Mineral Water to achieve the required test concentrations. The complete test results providing a detailed description of the test methods used is presented in Ecotox Services Australasia Pty. Ltd. *Toxicity Assessment of a Two Pit Water Samples Test Report August 2011* (Appendix 1).

Summary of Results

The following tables present the results of the five freshwater toxicity tests described above.

**Table 1
48 hour acute (immobilisation) toxicity test using the freshwater cladoceran
*Ceriodaphnia dubia***

Date	Concentration (%)	% Non-Immobilised at 48 hr
26 August 2011	48 hr EC10	<6.3%
	48 hr EC50	6.7%
	NOEC	<6.3%
	LOEC	6.3%
2 September 2011	48 hr IC10	4.9 (3.7 – 6.5)%
	48 hr IC50	7.6 (6.1 – 9.2)%
	NOEC	3.1%
	LOEC	6.3%

Table 2
Partial life-cycle test using the freshwater cladoceran *Ceriodaphnia dubia*

Date	Concentration (%)	% Survival at 8 days
26 August 2011	8 day IC10 (survival)	13.3 (12.5 – 16.3)%
	8 day IC50 (survival)	17.7 (12.5 – 25.0)%
	NOEC	12.5%
	LOEC	25%
	Concentration (%)	% Number of Young
	8 day IC10 (reproduction)	<6.3%
	8 day IC50 (reproduction)	7.8%
	NOEC	<6.3%
	LOEC	6.3%
2 September 2011	Concentration (%)	% Survival at 7 days
	7 day EC10 (survival)	>12.5%
	7 day EC50 (survival)	>12.5%
	NOEC	12.5%
	LOEC	>12.5%
	Concentration (%)	% Number of Young
	8 day IC10 (reproduction)	2.5 (1.3 – 3.8)%
	8 day IC50 (reproduction)	10.4%
	NOEC	3.1%
	LOEC	6.3%

Table 3
48 hour acute toxicity test using the freshwater chironomid *Chironomus tepperi*

Date	Concentration (%)	% Survival at 48 hr
26 August 2011	48 hr EC10	>100%
	48 hr EC50	>100%
	NOEC	100%
	LOEC	>100%

Table 4
96 hour acute survival test using the freshwater shrimp *Macrobrachium australiense*

Date	Concentration (%)	% Un-affected
8 September 2011	96 hr IC10	50.5%
	96 hr EC50	64.7 (57.2 – 73.2)%
	NOEC	50%
	LOEC	100%

Table 5
7 day growth inhibition of the freshwater aquatic duckweed *Lemna disperma*

Date	Concentration (%)	% Specific Growth Rate
26 August 2011	7 day IC10	>96.8%
	7 day IC50	>96.8%
	NOEC	96.8%
	LOEC	>96.8%

Interpretation of Results

The results for both acute and chronic testing showed that the five taxa of four species have a range of sensitivities ranging from nil or little response to a significant level of effect and that *Ceriodaphnia dubia* was the most sensitive for both kinds of tests. The following are the highest sensitivity results for the freshwater cladoceran *Ceriodaphnia dubia*:

- (i) For acute toxicity the 48 hour acute (immobilisation) test gave IC50 of 7.6 % (6.1% - 9.2%) and NOEC of 3.1%; and
- (ii) For chronic toxicity the 8 day partial life-cycle test gave IC50s of 17.7% for survival and 10.4% for reproduction, respectively and NOECs of 12.5% (survival) and 3.1% (reproduction).

For estimate of safe dilution of such water it is appropriate use safety factors on the NOEC value in accordance with ANZECC and ARMCANZ (2000) guidelines. These are as follows:

- (i) For acute effects a safety factor of 100; and
- (ii) For chronic effects a safety factor of 10.

Based on the above, there should be no observable chronic effect at the edge of the point of discharge and no observable acute effect at the end of the mixing zone.

Thus a proposed safe release of Content Pit water would require a minimum dilution of 100 times the NOEC value for the acute toxicity test for *Ceriodaphnia dubia* (i.e. 3.1%) which would also avoid a chronic effect.

Appendix 1

Ecotox Services Australasia Pty. Ltd.

Toxicity Assessment of a Two Pit Water Samples - Croydon Gold Mine
Test Report August 2011

Toxicity Assessment of a Two Pit Water Samples

Barrick Australia Pacific Ltd

Test Report

August 2011

Released

Toxicity Assessment of a Two Pit Water Samples

Barrick Australia Pacific Ltd

Test Report

August 2011

Released

Toxicity Test Report: TR0787/1

(page 1 of 2)

This document is issued in accordance with NATA's accreditation requirements

Client:	Barrick Australia Pacific Ltd Locked Bag 12, Cloisters Square Perth WA 6850	ESA Job #:	PR0787
Attention:	CTPI 49-Sch4	Date Sampled:	Not supplied
Client Ref:	Not supplied	Date Received:	26 August 2011
		Sampled By:	Client
		ESA Quote #:	PL0787_q02

Lab ID No.:	Sample Name:	Sample Description:
4927	Lady Isabella Pit	Aqueous sample, pH 4.5, conductivity 518µS/cm, total ammonia <2.0mg/L*. Sample received at room temperature in apparent good condition
4928	Content Pit	Aqueous sample, pH 4.3, conductivity 709µS/cm, total ammonia <2.0mg/L*. Sample received at room temperature in apparent good condition

*Ammonia analysis is not covered by Ecotox Services Australasia's scope of accreditation

Test Performed:	48-hr acute toxicity test using the freshwater cladoceran <i>Ceriodaphnia cf dubia</i>
Test Protocol:	ESA SOP 101 (ESA 2011), based on USEPA (2002) and Bailey <i>et al.</i> (2000)
Test Temperature:	The test was performed at 25±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The samples were serially diluted with Dilute Mineral Water (DMW) to achieve the test concentrations. A DMW control was tested concurrently with the samples.
Source of Test Organisms:	ESA Laboratory culture
Test Initiated:	26 August 2011 at 1230h

Sample 4927: Lady Isabella Pit	Sample 4928: Content Pit	Vacant
Concentration (%)	Concentration (%)	
% non-immobilised (Mean ± SD)	% non-immobilised (Mean ± SD)	
DMW Control 100 ± 0.0	DMW Control 100 ± 0.0	
6.3 25.0 ± 30.0 *	6.3 55.0 ± 41.2	
12.5 0.0 ± 0.0	12.5 0.0 ± 0.0	
25 0.0 ± 0.0	25 0.0 ± 0.0	
50 0.0 ± 0.0	50 0.0 ± 0.0	
100 0.0 ± 0.0	100 0.0 ± 0.0	
48-hr EC10 = <6.3%	48-hr EC10 = <6.3%	
48-hr EC50 = <6.3%	48-hr EC50 = 6.7%**	
NOEC = <6.3%	NOEC = <6.3%	
LOEC = 6.3%	LOEC = 6.3%	

*Significantly lower percent immobilisation compared with the DMW Control (Heteroscedastic t Test, 1-tailed, P=0.05)

** 95% confidence limits are not reliable

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % non-immobilised	≥90.0%	100%	Yes
Reference Toxicant within cusum chart limits	159.2-374.7mg KCl/L	219.6mg KCl/L	Yes

Toxicity Test Report: TR0787/1

(page 2 of 2)

Test Report Authorised by: CTPI 49-Sch4 CTPI 49-Sch4 Director on 20 September 2011

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

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Citations:

Bailey, H.C., Krassoi, R., Elphick, J.R., Mulhall, A., Hunt, P., Tedmanson, L. and Lovell, A. (2000) Application of *Ceriodaphnia cf. dubia* for whole effluent toxicity tests in the Hawkesbury-Nepean watershed, New South Wales, Australia: method development and validation. *Environmental Toxicology and Chemistry* 19:88-93.

ESA (2011) SOP 101 – Acute toxicity test using *Ceriodaphnia dubia*. Issue No. 9. Ecotox Services Australasia, Sydney, New South Wales.

USEPA (2002) *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms*. 4th Ed. United States Environmental Protection Agency, Office of Water, Washington DC.

Toxicity Test Report: TR0787/2

(page 1 of 2)

This document is issued in accordance with NATA's accreditation requirements

Client:	Barrick Australia Pacific Ltd Locked Bag 12, Cloisters Square Perth WA 6850	ESA Job #:	PR0787
Attention:	CTPI 49-Sch4	Date Sampled:	Not supplied
Client Ref:	Not supplied	Date Received:	26 August 2011
		Sampled By:	Client
		ESA Quote #:	PL0787_q02

Lab ID No.:	Sample Name:	Sample Description:
4927	Lady Isabella Pit	Aqueous sample, pH 4.5, conductivity 518µS/cm, total ammonia <2.0mg/L*. Sample received at room temperature in apparent good condition

*Ammonia analysis is not covered by Ecotox Services Australasia's scope of accreditation

Test Performed:	48-hr acute toxicity test using the freshwater cladoceran <i>Ceriodaphnia cf dubia</i>
Test Protocol:	ESA SOP 101 (ESA 2011), based on USEPA (2002) and Bailey <i>et al.</i> (2000)
Test Temperature:	The test was performed at 25±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The samples were serially diluted with Dilute Mineral Water (DMW) to achieve the test concentrations. A DMW control was tested concurrently with the samples.
Source of Test Organisms:	ESA Laboratory culture
Tests Initiated:	1 September 2011 at 1430h

Sample 4927: Lady Isabella Pit Concentration (%)	% non-immobilised (Mean ± SD)	Vacant	Vacant
DMW Control	100 ± 0.0		
0.01	100 ± 0.0		
1.6	100 ± 0.0		
3.1	100 ± 0.0		
6.3	85.0 ± 19.2		
12.5	0.0 ± 0.0		
48-hr IC10 = 6.0 (5.4-9.5)% 48-hr EC50 = 8.0 (7.2-8.9)% NOEC = 6.3% LOEC = 12.5%			

*Significantly lower percent immobilisation compared with the DMW Control (Steel's Many-One Rank Test, 1-tailed, P=0.05)

Toxicity Test Report: TR0787/2

(page 2 of 2)

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % non-immobilised	≥90.0%	100%	Yes
Reference Toxicant within cusum chart limits	165.2-366.4mg KCl/L	289.8mg KCl/L	Yes

CTPI 49-Sch4

Test Report Authorised by:

CTPI 49-Sch4

Director on 20 September 2011

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

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Citations:

Bailey, H.C., Krasso, R., Elphick, J.R., Mulhall, A., Hunt, P., Tedmanson, L. and Lovell, A. (2000) Application of *Ceriodaphnia cf. dubia* for whole effluent toxicity tests in the Hawkesbury-Nepean watershed, New South Wales, Australia: method development and validation. *Environmental Toxicology and Chemistry* 19:88-93.

ESA (2011) *SOP 101 – Acute toxicity test using Ceriodaphnia dubia*. Issue No. 9. Ecotox Services Australasia, Sydney, New South Wales.

USEPA (2002) *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms*. 4th Ed. United States Environmental Protection Agency, Office of Water, Washington DC.

Toxicity Test Report: TR0787/3

(page 1 of 2)

This document is issued in accordance with NATA's accreditation requirements

Client:	Barrick Australia Pacific Ltd Locked Bag 12, Cloisters Square Perth WA 6850	ESA Job #:	PR0787
Attention:	CTPI 49-Sch4	Date Sampled:	Not supplied
Client Ref:	Not supplied	Date Received:	26 August 2011
		Sampled By:	Client
		ESA Quote #:	PL0787_q02

Lab ID No.:	Sample Name:	Sample Description:
4928	Content Pit	Aqueous sample, pH 4.3, conductivity 709µS/cm, total ammonia <2.0mg/L*. Sample received at room temperature in apparent good condition

*Ammonia analysis is not covered by Ecotox Services Australasia's scope of accreditation

Test Performed:	48-hr acute toxicity test using the freshwater cladoceran <i>Ceriodaphnia cf dubia</i>
Test Protocol:	ESA SOP 101 (ESA 2011), based on USEPA (2002) and Bailey <i>et al.</i> (2000)
Test Temperature:	The test was performed at 25±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The sample was serially diluted with Dilute Mineral Water (DMW) to achieve the test concentrations. A DMW control was tested concurrently with the sample.
Source of Test Organisms:	ESA Laboratory culture
Tests Initiated:	2 September 2011 at 1130h

Sample 4928: Content Pit Concentration (%)	% non-immobilised (Mean ± SD)	Vacant	Vacant
DMW Control	100 ± 0.0		
0.01	95.0 ± 10.0		
1.6	100 ± 0.0		
3.1	100 ± 0.0		
6.3	75.0 ± 10.0 *		
12.5	5.0 ± 10.0 *		
48-hr IC10 = 4.9 (3.7-6.5)%			
48-hr IC50 = 7.6 (6.1-9.2)%			
NOEC = 3.1%			
LOEC = 6.3%			

*Significantly lower percent immobilisation compared with the DMW Control (Steel's Many-One Rank Test, 1-tailed, P=0.05)

Toxicity Test Report: TR0787/3

(page 2 of 2)

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % non-immobilised	≥90.0%	100%	Yes
Reference Toxicant within cusum chart limits	167.7-372.1mg KCl/L	300.0mg KCl/L	Yes

CTPI 49-Sch4

Test Report Authorised by:

CTPI 49-Sch4

Director on 20 September 2011

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

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Citations:

Bailey, H.C., Krassoi, R., Elphick, J.R., Mulhall, A., Hunt, P., Tedmanson, L. and Lovell, A. (2000) Application of *Ceriodaphnia cf. dubia* for whole effluent toxicity tests in the Hawkesbury-Nepean watershed, New South Wales, Australia: method development and validation. *Environmental Toxicology and Chemistry* 19:88-93.

ESA (2011) *SOP 101 – Acute toxicity test using Ceriodaphnia dubia*. Issue No. 9. Ecotox Services Australasia, Sydney, New South Wales.

USEPA (2002) *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms*. 4th Ed. United States Environmental Protection Agency, Office of Water, Washington DC.

Toxicity Test Report: TR0787/4

(page 1 of 2)

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Client:	Barrick Australia Pacific Ltd Locked Bag 12, Cloisters Square Perth WA 6850	ESA Job #:	PR0787
Attention:	CTPI 49-Sch4	Date Sampled:	Not supplied
Client Ref:	Not supplied	Date Received:	26 August 2011
		Sampled By:	Client
		ESA Quote #:	PL0787_q02

Lab ID No.:	Sample Name:	Sample Description:
4927	Lady Isabella Pit	Aqueous sample, pH 4.5, conductivity 518µS/cm, total ammonia <2.0mg/L*. Sample received at room temperature in apparent good condition
4928	Content Pit	Aqueous sample, pH 4.3, conductivity 709µS/cm, total ammonia <2.0mg/L*. Sample received at room temperature in apparent good condition

*Ammonia analysis is not covered by Ecotox Services Australasia's scope of accreditation

Test Performed:	Partial life-cycle toxicity test using the freshwater cladoceran <i>Ceriodaphnia cf dubia</i>
Test Protocol:	ESA SOP 102 (ESA 2011), based on USEPA (2002) and Bailey <i>et al.</i> (2000)
Test Temperature:	The test was performed at 25±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The samples were serially diluted with Dilute Mineral Water (DMW) to achieve the test concentrations. A DMW control was tested concurrently with the samples.
Source of Test Organisms:	ESA Laboratory culture
Test Initiated:	26 August 2011 at 1230h

Sample 4927: Lady Isabella Pit			Sample 4927: Lady Isabella Pit		
Concentration (%)	% Survival at 8 days (Mean ± SD)		Concentration (%)	Number of Young (Mean ± SD)	
DMW Control	90.0	± 31.6	DMW Control	17.1	± 5.9
6.3	100	± 0.0	6.3	11.0	± 2.8 *
12.5	60.0	± 51.6	12.5	1.9	± 2.3 *
25	0.0	± 0.0	25	0.0	± 0.0
50	0.0	± 0.0	50	0.0	± 0.0
100	0.0	± 0.0	100	0.0	± 0.0
8 day EC10 (survival) = 8.7 (7.6-12.5)%			8 day IC10 (reproduction) = <6.3%		
8 day EC50 (survival) = 13.7 (11.1-16.9)%			8 day IC50 (reproduction) = 8.0%**		
NOEC = 12.5%			NOEC = <6.3%		
LOEC = 25%			LOEC = 6.3%		

* Significantly lower number of young compared with DMW Control (Wilcoxon Rank Sum Test, 1-tailed, P=0.05)

** 95% confidence limits are not reliable

Toxicity Test Report: TR0787/4

(page 2 of 2)

Sample 4928: Content Pit		Sample 4928: Content Pit	
Concentration (%)	% Survival at 8 days (Mean ± SD)	Concentration (%)	Number of Young (Mean ± SD)
DMW Control	90.0 ± 31.6	DMW Control	17.1 ± 5.9
6.3	90.0 ± 31.6	6.3	10.5 ± 2.5 *
12.5	100 ± 0.0	12.5	2.4 ± 2.5 *
25	0.0 ± 0.0	25	0.0 ± 0.0
50	0.0 ± 0.0	50	0.0 ± 0.0
100	0.0 ± 0.0	100	0.0 ± 0.0
8 day IC10 (survival) = 13.3 (12.5-16.3)% 8 day EC50 (survival) = 17.7 (12.5-25.0)% NOEC = 12.5% LOEC = 25%		8 day IC10 (reproduction) = <6.3% 8 day IC50 (reproduction) = 7.8%** NOEC = <6.3% LOEC = 6.3%	

* Significantly lower number of young compared with DMW Control (Wilcoxon Rank Sum Test, 1-tailed, P=0.05)

** 95% confidence limits are not reliable

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % survival	≥80.0%	90.0%	Yes
Control mean number of young	≥15.0	19	Yes
Reference Toxicant within cusum chart limits	184.3-257.6mg KCl/L	211.8mg KCl/L	Yes

CTPI 49-Sch4

Test Report Authorised by:

CTPI 49-Sch4

Director on 20 September 2011

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

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Citations:

Bailey, H.C., Krasso, R., Elphick, J.R., Mulhall, A., Hunt, P., Tedmanson, L. and Lovell, A. (2000) Application of *Ceriodaphnia cf. dubia* for whole effluent toxicity tests in the Hawkesbury-Nepean watershed, New South Wales, Australia: method development and validation. *Environmental Toxicology and Chemistry* 19:88-93.

ESA (2011) ESA SOP 102 – *Acute Toxicity Test Using Ceriodaphnia dubia*. Issue No 8. Ecotox Services Australasia, Sydney, NSW.

USEPA (2002) *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms*. 4th Ed. United States Environmental Protection Agency, Office of Water, Washington DC.

Toxicity Test Report: TR0787/5

(page 1 of 2)

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Client:	Barrick Australia Pacific Ltd Locked Bag 12, Cloisters Square Perth WA 6850	ESA Job #:	PR0787
Attention:	CTPI 49-Sch4	Date Sampled:	Not supplied
Client Ref:	Not supplied	Date Received:	26 August 2011
		Sampled By:	Client
		ESA Quote #:	PL0787_q02

Lab ID No.:	Sample Name:	Sample Description:
4927	Lady Isabella Pit	Aqueous sample, pH 4.5, conductivity 518µS/cm, total ammonia <2.0mg/L*. Sample received at room temperature in apparent good condition
4928	Content Pit	Aqueous sample, pH 4.3, conductivity 709µS/cm, total ammonia <2.0mg/L*. Sample received at room temperature in apparent good condition

*Ammonia analysis is not covered by Ecotox Services Australasia's scope of accreditation

Test Performed:	Partial life-cycle toxicity test using the freshwater cladoceran <i>Ceriodaphnia cf dubia</i>
Test Protocol:	ESA SOP 102 (ESA 2011), based on USEPA (2002) and Bailey <i>et al.</i> (2000)
Test Temperature:	The test was performed at 25±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The samples were serially diluted with Dilute Mineral Water (DMW) to achieve the test concentrations. A DMW control was tested concurrently with the samples.
Source of Test Organisms:	ESA Laboratory culture
Test Initiated:	9 September 2011 at 1330h

Sample 4927: Lady Isabella Pit		Sample 4927: Lady Isabella Pit	
Concentration (%)	% Survival at 7 days (Mean ± SD)	Concentration (%)	Number of Young (Mean ± SD)
DMW Control	100 ± 0.0	DMW Control	15.3 ± 1.7
0.01	100 ± 0.0	0.01	12.5 ± 3.0
1.6	100 ± 0.0	1.6	12.9 ± 3.2
3.1	80.0 ± 42.2	3.1	12.8 ± 5.3
6.3	100 ± 0.0	6.3	13.2 ± 2.9
12.5	50.0 ± 52.7 *	12.5	2.2 ± 2.3 **
7 day EC10 (survival) = 3.7 (0.1-6.7)%		7 day IC10 (reproduction) = <0.01%	
7 day EC50 (survival) = >12.5%		7 day IC50 (reproduction) = 9.3 (8.4-9.9)%	
NOEC = 6.3%		NOEC = 6.3%	
LOEC = 12.5%		LOEC = 12.5%	

*Significantly lower percent survival compared with the DMW Control (Fisher's Exact Test, 1-tailed, P=0.05)

** Significantly lower number of young compared with DMW Control (Wilcoxon Rank Sum Test Test, 1-tailed, P=0.05)

Toxicity Test Report: TR0787/5

(page 2 of 2)

Sample 4928: Content Pit		Sample 4928: Content Pit	
Concentration (%)	% Survival at 7 days (Mean ± SD)	Concentration (%)	Number of Young (Mean ± SD)
DMW Control	100 ± 0.0	DMW Control	15.3 ± 1.7
0.01	100 ± 0.0	0.01	15.6 ± 2.4
1.6	100 ± 0.0	1.6	14.8 ± 1.4
3.1	90.0 ± 31.6	3.1	13.3 ± 4.4
6.3	100 ± 0.0	6.3	7.8 ± 0.9 *
12.5	100 ± 0.0	12.5	7.7 ± 1.4 *
7 day EC10 (survival) = >12.5%		7 day IC10 (reproduction) = 2.5 (1.3-3.8)%	
7 day EC50 (survival) = >12.5%		7 day IC50 (reproduction) = 10.4%**	
NOEC = 12.5%		NOEC = 3.1%	
LOEC = >12.5%		LOEC = 6.3%	

*Significantly lower number of young compared with DMW Control (Wilcoxon Rank Sum Test Test, 1-tailed, P=0.05)

**95% confidence limits are not available

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % survival	≥80.0%	100%	Yes
Control mean number of young	≥15.0	15.3	Yes
Reference Toxicant within cusum chart limits	169.6-282.4mg KCl/L	215.7mg KCl/L	Yes

CTPI 49-Sch4

Test Report Authorised by:

CTPI 49-Sch4

Director on 20 September 2011

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

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Citations:

Bailey, H.C., Krassoi, R., Elphick, J.R., Mulhall, A., Hunt, P., Tedmanson, L. and Lovell, A. (2000) Application of *Ceriodaphnia cf. dubia* for whole effluent toxicity tests in the Hawkesbury-Nepean watershed, New South Wales, Australia: method development and validation. *Environmental Toxicology and Chemistry* 19:88-93.

ESA (2011) ESA SOP 102 – *Acute Toxicity Test Using Ceriodaphnia dubia*. Issue No 8. Ecotox Services Australasia, Sydney, NSW.

USEPA (2002) *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms*. 4th Ed. United States Environmental Protection Agency, Office of Water, Washington DC.

Toxicity Test Report: TR0787/6

(page 1 of 2)

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Client:	Barrick Australia Pacific Ltd Locked Bag 12, Cloisters Square Perth WA 6850	ESA Job #:	PR0787
Attention:	CTPI 49-Sch4	Date Sampled:	Not supplied
Client Ref:	Not supplied	Date Received:	26 August 2011
		Sampled By:	Client
		ESA Quote #:	PL0787_q02

Lab ID No.:	Sample Name:	Sample Description:
4927	Lady Isabella Pit	Aqueous sample, pH 4.5, conductivity 518µS/cm, total ammonia <2.0mg/L*. Sample received at room temperature in apparent good condition
4928	Content Pit	Aqueous sample, pH 4.3, conductivity 709µS/cm, total ammonia <2.0mg/L*. Sample received at room temperature in apparent good condition

*Ammonia analysis is not covered by Ecotox Services Australasia's scope of accreditation

Test Performed:	7-day Growth inhibition of the freshwater aquatic duckweed <i>Lemna disperma</i>
Test Protocol:	ESA SOP 112 (ESA 2011), based on OECD method 221 (2006)
Test Temperature:	The test was performed at 25±2°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The samples were serially diluted with Swedish standard medium (SIS) to achieve the test concentrations. A SIS control was tested concurrently with the samples.
Source of Test Organisms:	ESA Laboratory culture
Test Initiated:	26 August 2011 at 1600h

Sample 4927: Lady Isabella Pit		Sample 4928: Content Pit		Vacant
Concentration (%)	Specific Growth Rate (Mean ± SD)	Concentration (%)	Specific Growth Rate (Mean ± SD)	
SIS Control	0.35 ± 0.1	SIS Control	0.35 ± 0.1	
6.1	0.38 ± 0.1	6.1	0.34 ± 0.1	
12.1	0.28 ± 0.0	12.1	0.31 ± 0.1	
24.2	0.37 ± 0.1	24.2	0.35 ± 0.1	
48.4	0.33 ± 0.1	48.4	0.36 ± 0.1	
96.8	0.27 ± 0.1	96.8	0.32 ± 0.0	
7 day IC10 = 49.3%*		7 day IC10 = >96.8%		
7 day IC50 = >96.8%		7 day IC50 = >96.8%		
NOEC = 96.8%		NOEC = 96.8%		
LOEC = >96.8%		LOEC = >96.8%		

*95% confidence limits are not available

Toxicity Test Report: TR0787/6

(page 2 of 2)

QA/QC Parameter	Criterion	This Test	Criterion met?
Control frond doubling time	<2.5 days	2.0 days	Yes
Reference Toxicant within cusum chart limits	2.5-7.2g KCl/L	4.0g KCl/L	Yes

CTPI 49-Sch4

Test Report Authorised by:

CTPI 49-Sch4

Director on 20 September 2011

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

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Citations:

ESA (2011) *SOP 112 – Duckweed Growth Inhibition Test*. Issue No. 3. Ecotox Services Australasia, Sydney NSW

OECD (2006) *Lemna sp. Growth Inhibition Test*. Method 221. OECD Guideline for the Testing of Chemicals. Organisation for Economic Cooperation and Development, Paris

Toxicity Test Report: TR0787/7

(page 1 of 2)

Client:	Barrick Australia Pacific Ltd Locked Bag 12, Cloisters Square Perth WA 6850	ESA Job #:	PR0787
Attention:	CTPI 49-Sch4	Date Sampled:	Not supplied
Client Ref:	Not supplied	Date Received:	26 August 2011
		Sampled By:	Client
		ESA Quote #:	PL0787_q02

Lab ID No.:	Sample Name:	Sample Description:
4927	Lady Isabella Pit	Aqueous sample, pH 4.5, conductivity 518µS/cm, total ammonia <2.0mg/L. Sample received at room temperature in apparent good condition
4928	Content Pit	Aqueous sample, pH 4.3, conductivity 709µS/cm, total ammonia <2.0mg/L. Sample received at room temperature in apparent good condition

Test Performed:	48-hr acute toxicity test using the freshwater chironomid <i>Chironomus tepperi</i>
Test Protocol:	None available
Test Temperature:	The test was performed at 25±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The samples were serially diluted with Dilute Mineral Water (DMW) to achieve the test concentrations. A DMW control was tested concurrently with the samples.
Source of Test Organisms:	ESA Laboratory culture
Test Initiated:	26 August 2011 at 1300h

Sample 4927: Lady Isabella Pit		Sample 4928: Content Pit		Vacant
Concentration (%)	% Survival (Mean ± SD)	Concentration (%)	% Survival (Mean ± SD)	
DMW Control	95.0 ± 10.0	DMW Control	95.0 ± 10.0	
6.3	100 ± 0.0	6.3	100 ± 0.0	
12.5	100 ± 0.0	12.5	100 ± 0.0	
25	100 ± 0.0	25	100 ± 0.0	
50	80.0 ± 16.3	50	100 ± 0.0	
100	75.0 ± 30.0	100	90.0 ± 11.6	
48-hr IC10 = 42.6%*		48-hr EC10 = >100%		
48-hr EC50 = >100%		48-hr EC50 = >100%		
NOEC = 100%		NOEC = 100%		
LOEC = >100%		LOEC = >100%		

*95% confidence limits are not available

Toxicity Test Report: TR0787/7

(page 2 of 2)

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % survival	≥90.0%	95.0%	Yes
Reference Toxicant within cusum chart limits	Not available*	88.0µg Cu/L	n/a

* Cusum chart limits are not available due to limited testing with *C. tepperi*

CTPI 49-Sch4

Test Report Authorised by:

CTPI 49-Sch4

Director on 20 September 2011

Results are based on the samples in the condition as received by ESA. This document shall not be reproduced except in full.

Toxicity Test Report: TR0787/8

(page 1 of 2)

Client:	Barrick Australia Pacific Ltd Locked Bag 12, Cloisters Square Perth WA 6850	ESA Job #:	PR0787
Attention:	CTPI 49-Sch4	Date Sampled:	Not supplied
Client Ref:	Not supplied	Date Received:	26 August 2011
		Sampled By:	Client
		ESA Quote #:	PL0787_q02

Lab ID No.:	Sample Name:	Sample Description:
4927	Lady Isabella Pit	Aqueous sample, pH 4.5, conductivity 518µS/cm, total ammonia <2.0mg/L. Sample received at room temperature in apparent good condition
4928	Content Pit	Aqueous sample, pH 4.3, conductivity 709µS/cm, total ammonia <2.0mg/L. Sample received at room temperature in apparent good condition

Test Performed:	96-hr acute survival test using the freshwater shrimp <i>Macrobrachium australiense</i>
Test Protocol:	ESA SOP 107 (ESA 2011), based on methods described by the USEPA (1996) and the Department of Transport and Communications (1990)
Test Temperature:	The test was performed at 25±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The samples were serially diluted with dilute mineral water (DMW) to achieve the test concentrations. A DMW control was tested concurrently with the samples.
Source of Test Organisms:	Hatchery reared, QLD
Test Initiated:	8 September 2011 at 1500h

Sample 4927: Lady Isabella Pit		Sample 4928: Content Pit		Vacant
Concentration (%)	% Un-affected (Mean ± SD)	Concentration (%)	% Un-affected (Mean ± SD)	
DMW Control	75.0 ± 19.2	DMW Control	75.0 ± 19.2	
6.3	86.7 ± 11.6	6.3	80.0 ± 0.0	
12.5	73.3 ± 11.6	12.5	80.0 ± 28.3	
25	80.0 ± 0.0	25	73.3 ± 11.6	
50	80.0 ± 20.0	50	73.3 ± 11.6	
100	0.0 ± 0.0	100	0.0 ± 0.0	
96-hr IC10 = 50.9 %*		96-hr IC10 = 50.5 %*		
96-hr EC50 = 65.4 (58.1-73.6)%		96-hr EC50 = 64.7 (57.2-73.2)%		
NOEC = 50%		NOEC = 50%		
LOEC = 100%		LOEC = 100%		

*95% confidence limits are not available

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % un-affected	≥70.0%	75.0%	Yes
Reference toxicant cusum chart limits	Not available*	167.3µg Cu/L	n/a

*Reference toxicant cusum chart limits are not available due to limited testing with *macrobrachium australiense*

Toxicity Test Report: TR0787/8

(page 2 of 2)

Test Report Authorised by:

CTPI 49-Sch4

CTPI 49-Sch4

Director on 20 September 2011

Results are based on the samples in the condition as received by ESA. This document shall not be reproduced except in full.

Citations:

ESA (2011) SOP 107 –*Juvenile Tiger Prawn Toxicity Test*. Issue No 7. Ecotox Services Australasia, Sydney, NSW

Department of Transport and Communications (1990) Guidelines for Acceptance of Oil Spill Dispersants in Australian Waters. Pollution Prevention Section, Department of Transport and Communications, Canberra ACT.

USEPA (1996) Ecological Effects Test Guidelines, OPPTS 850.1045, *Penaeid Acute Toxicity Test*. Public Draft. United States Environmental Protection Agency, Washington DC.

**Statistical Printouts for the Acute
Test with *Ceriodaphnia dubia***

Ceriodaphnia Acute Toxicity Test-48 Hr Immobilisation

Start Date: 26/08/2011 12:30 Test ID: PR0787/02 Sample ID: Lady Isabella Pit
 End Date: 28/08/2011 12:30 Lab ID: 4927 Sample Type: AQ-Aqueous
 Sample Date: Protocol: ESA 101 Test Species: CD-Ceriodaphnia dubia
 Comments:

Conc-%	1	2	3	4
DMW Control	1.0000	1.0000	1.0000	1.0000
6.3	0.0000	0.0000	0.6000	0.4000
12.5	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

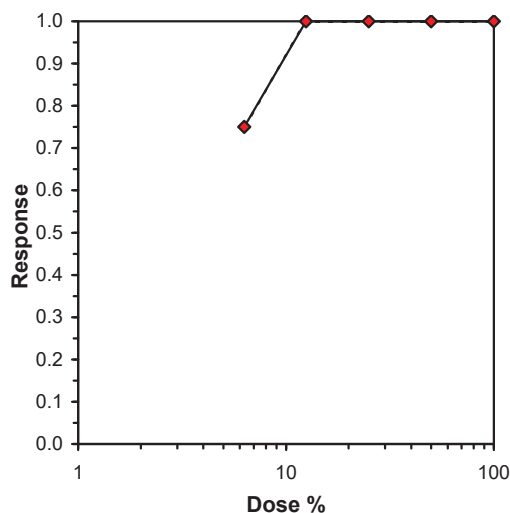
Conc-%	Transform: Arcsin Square Root							t-Stat	1-Tailed Critical	MSD	Isotonic	
	Mean	N-Mean	Mean	Min	Max	CV%	N				Mean	N-Mean
DMW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4				1.0000	1.0000
*6.3	0.2500	0.2500	0.5055	0.2255	0.8861	65.988	4	5.036	2.353	0.3925	0.2500	0.2500
12.5	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4				0.0000	0.0000
25	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4				0.0000	0.0000
50	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4				0.0000	0.0000
100	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4				0.0000	0.0000

Auxiliary Tests	Statistic		Critical	Skew	Kurt	
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.890195		0.818	0.311506	0.273989	
Equality of variance cannot be confirmed						
Hypothesis Test (1-tail, 0.05)	MSDu	MSDp	MSB	MSE	F-Prob	df
Heteroscedastic t Test indicates significant differences	0.285694	0.300731	1.410619	0.055624	0.002367	1, 6
Treatments vs DMW Control						

Log-Logit Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05*	2.3476	0.3984	0.1376	3.1779
IC10*	2.8664	0.5062	0.0905	3.9493
IC15*	3.2272	0.5839	0.0486	4.4962
IC20*	3.5209	0.6486	0.0098	4.9471
IC25*	3.7788	0.7064	0.0000	5.3471
IC40*	4.4621	0.8638	0.0000	6.4240
IC50*	4.9063	0.9649	0.0000	7.1362

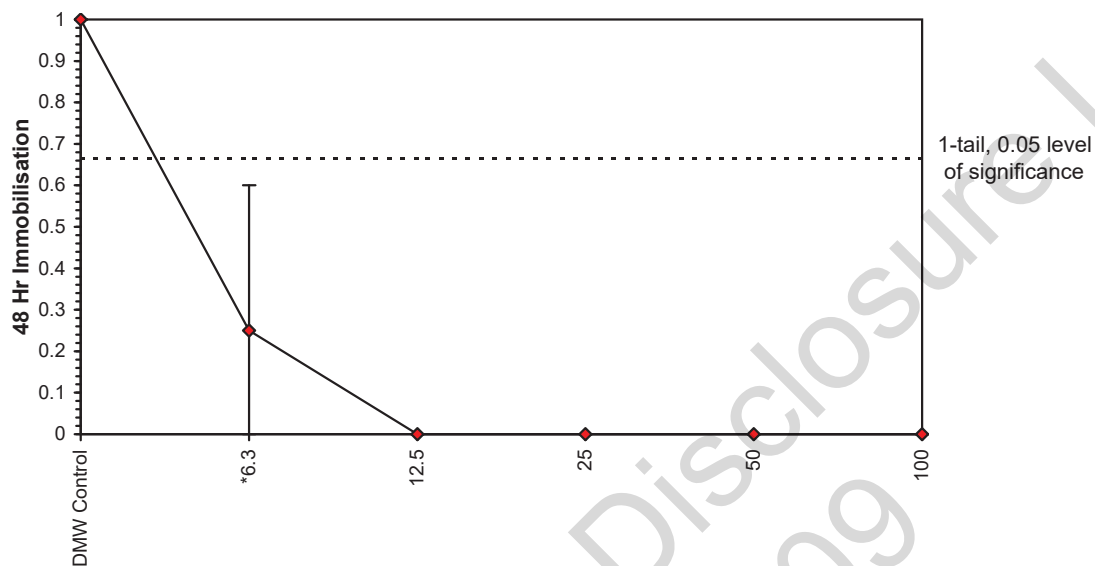
* indicates IC estimate less than the lowest concentration



Ceriodaphnia Acute Toxicity Test-48 Hr Immobilisation

Start Date:	26/08/2011 12:30	Test ID:	PR0787/02	Sample ID:	Lady Isabella Pit
End Date:	28/08/2011 12:30	Lab ID:	4927	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 101	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



Ceriodaphnia Acute Toxicity Test-48 Hr Immobilisation

Start Date:	26/08/2011 12:30	Test ID:	PR0787/02	Sample ID:	Lady Isabella Pit
End Date:	28/08/2011 12:30	Lab ID:	4927	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 101	Test Species:	CD-Ceriodaphnia dubia
Comments:					

		Auxiliary Data Summary					
Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	% Survival	100.00	100.00	100.00	0.00	0.00	4
6.3		25.00	0.00	60.00	30.00	21.91	4
12.5		0.00	0.00	0.00	0.00		4
25		0.00	0.00	0.00	0.00		4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
DMW Control	pH	8.00	8.00	8.00	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.00	8.00	8.00	0.00	0.00	1
25		7.80	7.80	7.80	0.00	0.00	1
50		7.40	7.40	7.40	0.00	0.00	1
100		4.50	4.50	4.50	0.00	0.00	1
DMW Control	DO %	100.50	100.50	100.50	0.00	0.00	1
6.3		99.80	99.80	99.80	0.00	0.00	1
12.5		98.70	98.70	98.70	0.00	0.00	1
25		99.10	99.10	99.10	0.00	0.00	1
50		100.30	100.30	100.30	0.00	0.00	1
100		99.90	99.90	99.90	0.00	0.00	1
DMW Control	Cond uS/cm	172.40	172.40	172.40	0.00	0.00	1
6.3		195.20	195.20	195.20	0.00	0.00	1
12.5		213.00	213.00	213.00	0.00	0.00	1
25		254.00	254.00	254.00	0.00	0.00	1
50		334.00	334.00	334.00	0.00	0.00	1
100		518.00	518.00	518.00	0.00	0.00	1

Ceriodaphnia Acute Toxicity Test-48 Hr Immobilisation

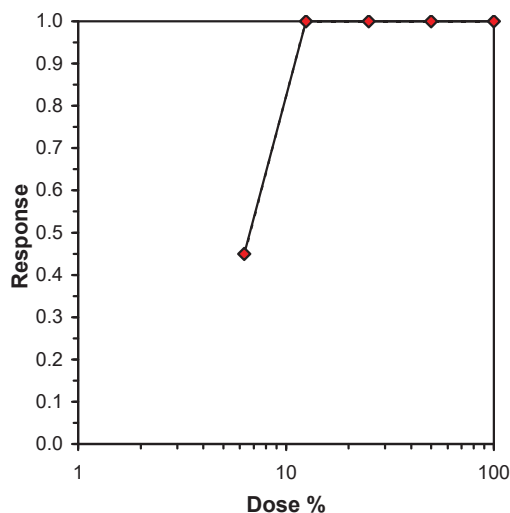
Start Date: 26/08/2011 12:30 Test ID: PR0787/03 Sample ID: Content Pit
 End Date: 28/08/2011 12:30 Lab ID: 4928 Sample Type: AQ-Aqueous
 Sample Date: Protocol: ESA 101 Test Species: CD-Ceriodaphnia dubia
 Comments:

Conc-%	1	2	3	4
DMW Control	1.0000	1.0000	1.0000	1.0000
6.3	1.0000	0.8000	0.2000	0.2000
12.5	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

Conc-%	Transform: Arcsin Square Root							t-Stat	1-Tailed Critical	MSD	Number Resp	Total Number
	Mean	N-Mean	Mean	Min	Max	CV%	N					
DMW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4				0	20
6.3	0.5500	0.5500	0.8449	0.4636	1.3453	53.362	4	2.219	2.353	0.5305	9	20
12.5	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4				20	20
25	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4				20	20
50	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4				20	20
100	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4				20	20

Auxiliary Tests	Statistic		Critical	Skew	Kurt	
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.891049		0.818	0.240227	0.053834	
Equality of variance cannot be confirmed						
Hypothesis Test (1-tail, 0.05)	MSDu	MSDp	MSB	MSE	F-Prob	df
Heteroscedastic t Test indicates no significant differences	0.420668	0.442809	0.500703	0.101644	0.068248	1, 6
Treatments vs DMW Control						

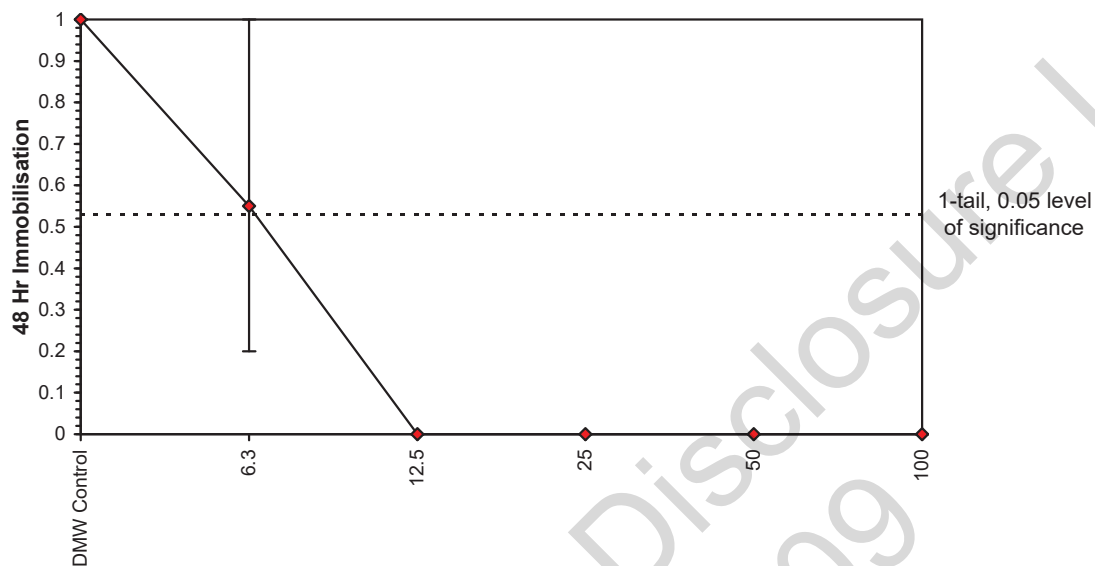
Trimmed Spearman-Kärber			
Trim Level	EC50	95% CL	
0.0%			
5.0%			
10.0%			
20.0%			
Auto-45.0%	6.7049	5.2115	8.6263



Ceriodaphnia Acute Toxicity Test-48 Hr Immobilisation

Start Date:	26/08/2011 12:30	Test ID:	PR0787/03	Sample ID:	Content Pit
End Date:	28/08/2011 12:30	Lab ID:	4928	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 101	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



Ceriodaphnia Acute Toxicity Test-48 Hr Immobilisation

Start Date:	26/08/2011 12:30	Test ID:	PR0787/03	Sample ID:	Content Pit
End Date:	28/08/2011 12:30	Lab ID:	4928	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 101	Test Species:	CD-Ceriodaphnia dubia
Comments:					

		Auxiliary Data Summary					
Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	% Survival	100.00	100.00	100.00	0.00	0.00	4
6.3		55.00	20.00	100.00	41.23	11.67	4
12.5		0.00	0.00	0.00	0.00		4
25		0.00	0.00	0.00	0.00		4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
DMW Control	pH	8.00	8.00	8.00	0.00	0.00	1
6.3		7.90	7.90	7.90	0.00	0.00	1
12.5		7.80	7.80	7.80	0.00	0.00	1
25		7.70	7.70	7.70	0.00	0.00	1
50		7.40	7.40	7.40	0.00	0.00	1
100		4.30	4.30	4.30	0.00	0.00	1
DMW Control	DO %	100.50	100.50	100.50	0.00	0.00	1
6.3		100.20	100.20	100.20	0.00	0.00	1
12.5		98.60	98.60	98.60	0.00	0.00	1
25		99.60	99.60	99.60	0.00	0.00	1
50		99.90	99.90	99.90	0.00	0.00	1
100		98.60	98.60	98.60	0.00	0.00	1
DMW Control	Cond uS/cm	172.40	172.40	172.40	0.00	0.00	1
6.3		206.00	206.00	206.00	0.00	0.00	1
12.5		236.00	236.00	236.00	0.00	0.00	1
25		300.00	300.00	300.00	0.00	0.00	1
50		428.00	428.00	428.00	0.00	0.00	1
100		709.00	709.00	709.00	0.00	0.00	1

Ceriodaphnia Acute Toxicity Test-48 Hr Immobilisation

Start Date: 26/08/2011 12:30 Test ID: PR0787/03 Sample ID: CONTENT PIT
 End Date: 28/08/2011 12:30 Lab ID: 4928 Sample Type: AQ-Aqueous
 Sample Date: Protocol: ESA 101 Test Species: CD-Ceriodaphnia dubia
 Comments:

Conc-%	1	2	3	4
DMW Control	1.0000	1.0000	1.0000	1.0000
6.3	1.0000	0.8000	0.2000	0.2000
12.5	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000

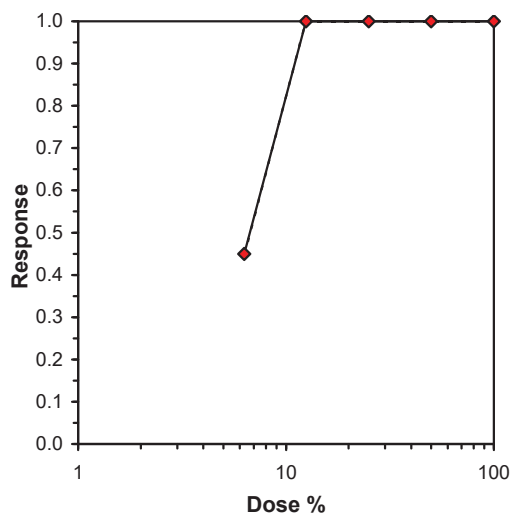
Conc-%	Transform: Arcsin Square Root							t-Stat	1-Tailed Critical	MSD	Isotonic	
	Mean	N-Mean	Mean	Min	Max	CV%	N				Mean	N-Mean
DMW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4				1.0000	1.0000
6.3	0.5500	0.5500	0.8449	0.4636	1.3453	53.362	4	2.219	2.353	0.5305	0.5500	0.5500
12.5	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4				0.0000	0.0000
25	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4				0.0000	0.0000
50	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4				0.0000	0.0000
100	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4				0.0000	0.0000

Auxiliary Tests	Statistic		Critical	Skew	Kurt	
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.891049		0.818	0.240227	0.053834	
Equality of variance cannot be confirmed						
Hypothesis Test (1-tail, 0.05)	MSDu	MSDp	MSB	MSE	F-Prob	df
Heteroscedastic t Test indicates no significant differences	0.420668	0.442809	0.500703	0.101644	0.068248	1, 6
Treatments vs DMW Control						

Log-Logit Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05*	2.9848	0.6724	1.7924 6.0597	2.2203
IC10*	3.6990	0.8011	2.1439 7.8606	1.5455
IC15*	4.2040	0.8253	2.3815 7.8525	0.9691
IC20*	4.6197	0.8525	2.5713 7.8300	0.6045
IC25*	4.9880	0.8715	2.7353 7.7997	0.3468
IC40*	5.9775	0.7522	3.1592 7.6777	-0.4009
IC50	6.3963	0.6449	3.5675 7.7106	-0.8119

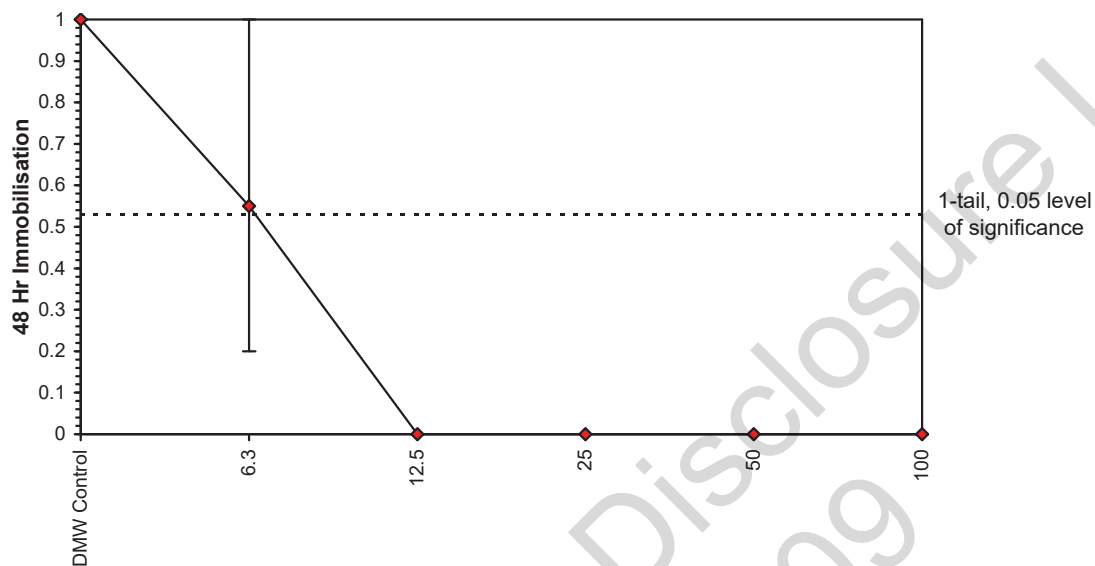
* indicates IC estimate less than the lowest concentration



Ceriodaphnia Acute Toxicity Test-48 Hr Immobilisation

Start Date:	26/08/2011 12:30	Test ID:	PR0787/03	Sample ID:	CONTENT PIT
End Date:	28/08/2011 12:30	Lab ID:	4928	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 101	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



Ceriodaphnia Acute Toxicity Test-48 Hr Immobilisation

Start Date:	26/08/2011 12:30	Test ID:	PR0787/03	Sample ID:	CONTENT PIT
End Date:	28/08/2011 12:30	Lab ID:	4928	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 101	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	% Survival	100.00	100.00	100.00	0.00	0.00	4
6.3		55.00	20.00	100.00	41.23	11.67	4
12.5		0.00	0.00	0.00	0.00		4
25		0.00	0.00	0.00	0.00		4
50		0.00	0.00	0.00	0.00		4
100		0.00	0.00	0.00	0.00		4
DMW Control	pH	8.00	8.00	8.00	0.00	0.00	1
6.3		7.90	7.90	7.90	0.00	0.00	1
12.5		7.80	7.80	7.80	0.00	0.00	1
25		7.70	7.70	7.70	0.00	0.00	1
50		7.40	7.40	7.40	0.00	0.00	1
100		4.30	4.30	4.30	0.00	0.00	1
DMW Control	DO %	100.50	100.50	100.50	0.00	0.00	1
6.3		100.20	100.20	100.20	0.00	0.00	1
12.5		98.60	98.60	98.60	0.00	0.00	1
25		99.60	99.60	99.60	0.00	0.00	1
50		99.90	99.90	99.90	0.00	0.00	1
100		98.60	98.60	98.60	0.00	0.00	1
DMW Control	Cond uS/cm	172.40	172.40	172.40	0.00	0.00	1
6.3		206.00	206.00	206.00	0.00	0.00	1
12.5		236.00	236.00	236.00	0.00	0.00	1
25		300.00	300.00	300.00	0.00	0.00	1
50		428.00	428.00	428.00	0.00	0.00	1
100		709.00	709.00	709.00	0.00	0.00	1

Ceriodaphnia Acute Toxicity Test-48 Hr Immobilisation

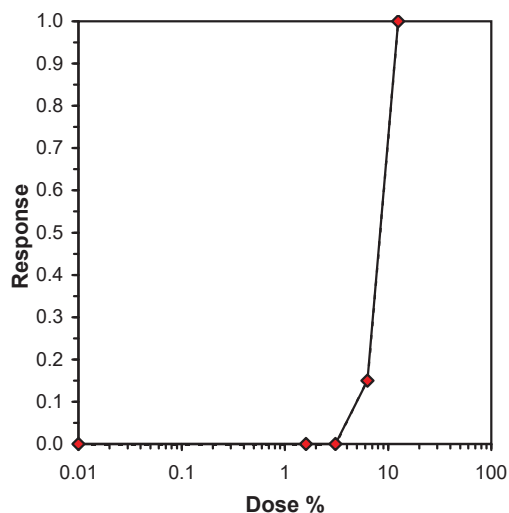
Start Date: 1/09/2011 14:30 Test ID: PR0787/02 Sample ID: Lady Isabella Pit
End Date: 3/09/2011 14:30 Lab ID: 4927 Sample Type: AQ-Aqueous
Sample Date: Protocol: ESA 101 Test Species: CD-Ceriodaphnia dubia
Comments:

Conc-%	1	2	3	4
DMW Control	1.0000	1.0000	1.0000	1.0000
0.01	1.0000	1.0000	1.0000	1.0000
1.6	1.0000	1.0000	1.0000	1.0000
3.1	1.0000	1.0000	1.0000	1.0000
6.3	1.0000	1.0000	0.6000	0.8000
12.5	0.0000	0.0000	0.0000	0.0000

Conc-%	Transform: Arcsin Square Root							Rank Sum	1-Tailed Critical	Number Resp	Total Number
	Mean	N-Mean	Mean	Min	Max	CV%	N				
DMW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4			0	20
0.01	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	0	20
1.6	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	0	20
3.1	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	0	20
6.3	0.8500	0.8500	1.1709	0.8861	1.3453	18.840	4	14.00	10.00	3	20
12.5	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			20	20

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.591406	0.905	-1.10947	6.797125
Equality of variance cannot be confirmed				
Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	6.3	12.5	8.87412	15.87302
Treatments vs DMW Control				

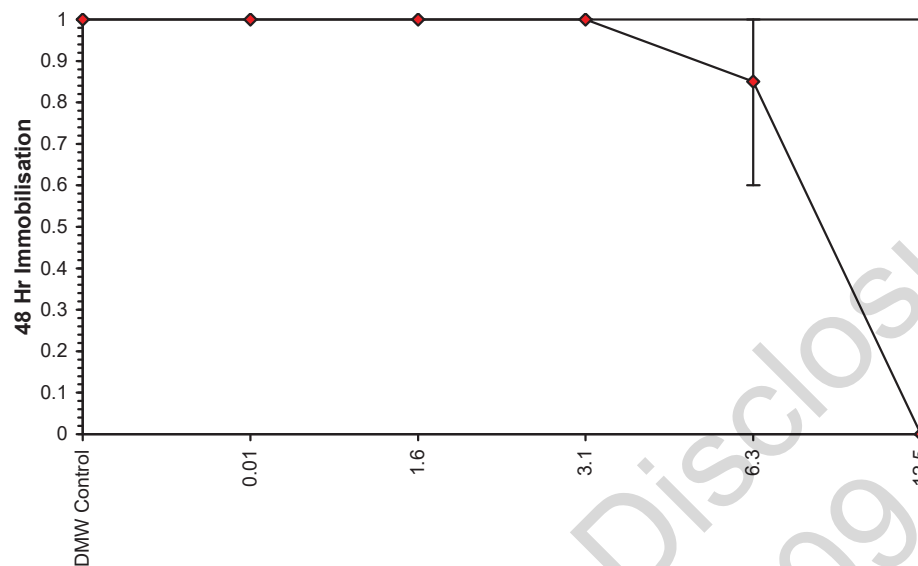
Trimmed Spearman-Kärber				
Trim Level	EC50	95% CL		
0.0%	7.9930	7.1509	8.9343	
5.0%	8.1735	7.1737	9.3126	
10.0%	8.3025	7.0068	9.8377	
20.0%	8.3535	7.7443	9.0106	
Auto-0.0%	7.9930	7.1509	8.9343	



Ceriodaphnia Acute Toxicity Test-48 Hr Immobilisation

Start Date:	1/09/2011 14:30	Test ID:	PR0787/02	Sample ID:	Lady Isabella Pit
End Date:	3/09/2011 14:30	Lab ID:	4927	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 101	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



Ceriodaphnia Acute Toxicity Test-48 Hr Immobilisation

Start Date:	1/09/2011 14:30	Test ID:	PR0787/02	Sample ID:	Lady Isabella Pit
End Date:	3/09/2011 14:30	Lab ID:	4927	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 101	Test Species:	CD-Ceriodaphnia dubia
Comments:					

		Auxiliary Data Summary					
Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	% Survival	100.00	100.00	100.00	0.00	0.00	4
0.01		100.00	100.00	100.00	0.00	0.00	4
1.6		100.00	100.00	100.00	0.00	0.00	4
3.1		100.00	100.00	100.00	0.00	0.00	4
6.3		85.00	60.00	100.00	19.15	5.15	4
12.5		0.00	0.00	0.00	0.00		4
DMW Control	pH	8.20	8.20	8.20	0.00	0.00	1
0.01		8.10	8.10	8.10	0.00	0.00	1
1.6		8.10	8.10	8.10	0.00	0.00	1
3.1		8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.00	8.00	8.00	0.00	0.00	1
DMW Control	DO %	97.50	97.50	97.50	0.00	0.00	1
0.01		98.70	98.70	98.70	0.00	0.00	1
1.6		99.80	99.80	99.80	0.00	0.00	1
3.1		99.30	99.30	99.30	0.00	0.00	1
6.3		99.00	99.00	99.00	0.00	0.00	1
12.5		98.30	98.30	98.30	0.00	0.00	1
DMW Control	Cond uS/cm	171.40	171.40	171.40	0.00	0.00	1
0.01		170.00	170.00	170.00	0.00	0.00	1
1.6		175.10	175.10	175.10	0.00	0.00	1
3.1		180.10	180.10	180.10	0.00	0.00	1
6.3		190.10	190.10	190.10	0.00	0.00	1
12.5		210.00	210.00	210.00	0.00	0.00	1

Ceriodaphnia Acute Toxicity Test-48 Hr Immobilisation

Start Date: 1/09/2011 14:30 Test ID: PR0787/02 Sample ID: Lady Isabella Pit
 End Date: 3/09/2011 14:30 Lab ID: 4927 Sample Type: AQ-Aqueous
 Sample Date: Protocol: ESA 101 Test Species: CD-Ceriodaphnia dubia
 Comments:

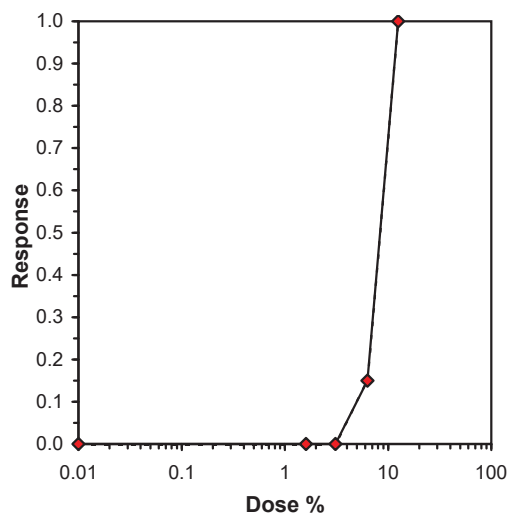
Conc-%	1	2	3	4
DMW Control	1.0000	1.0000	1.0000	1.0000
0.01	1.0000	1.0000	1.0000	1.0000
1.6	1.0000	1.0000	1.0000	1.0000
3.1	1.0000	1.0000	1.0000	1.0000
6.3	1.0000	1.0000	0.6000	0.8000
12.5	0.0000	0.0000	0.0000	0.0000

Conc-%	Transform: Arcsin Square Root							Rank Sum	1-Tailed Critical	Isotonic	
	Mean	N-Mean	Mean	Min	Max	CV%	N			Mean	N-Mean
DMW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4			1.0000	1.0000
0.01	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000
1.6	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000
3.1	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000
6.3	0.8500	0.8500	1.1709	0.8861	1.3453	18.840	4	14.00	10.00	0.8500	0.8500
12.5	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	4			0.0000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.591406	0.905	-1.10947	6.797125
Equality of variance cannot be confirmed				
Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	6.3	12.5	8.87412	15.87302
Treatments vs DMW Control				

Log-Logit Interpolation (200 Resamples)

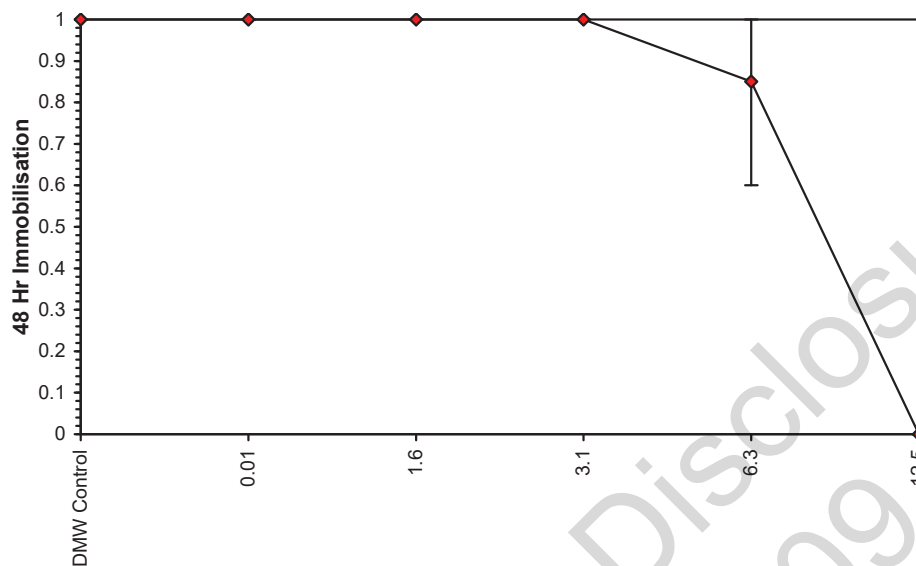
Point	%	SD	95% CL(Exp)		Skew
IC05	5.6493	0.6903	5.1173	9.4073	2.3064
IC10	6.0440	0.6535	5.4151	9.5340	2.1957
IC15	6.3000	0.6280	5.6065	9.6101	2.2213
IC20	6.4442	0.6104	5.7872	9.6988	2.2617
IC25	6.5655	0.5986	5.9400	9.7724	2.2859
IC40	6.8659	0.5754	6.2802	9.9505	2.2888
IC50	7.0471	0.5616	6.4726	10.0553	2.2827



Ceriodaphnia Acute Toxicity Test-48 Hr Immobilisation

Start Date:	1/09/2011 14:30	Test ID:	PR0787/02	Sample ID:	Lady Isabella Pit
End Date:	3/09/2011 14:30	Lab ID:	4927	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 101	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



Ceriodaphnia Acute Toxicity Test-48 Hr Immobilisation

Start Date:	1/09/2011 14:30	Test ID:	PR0787/02	Sample ID:	Lady Isabella Pit
End Date:	3/09/2011 14:30	Lab ID:	4927	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 101	Test Species:	CD-Ceriodaphnia dubia
Comments:					

		Auxiliary Data Summary					
Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	% Survival	100.00	100.00	100.00	0.00	0.00	4
0.01		100.00	100.00	100.00	0.00	0.00	4
1.6		100.00	100.00	100.00	0.00	0.00	4
3.1		100.00	100.00	100.00	0.00	0.00	4
6.3		85.00	60.00	100.00	19.15	5.15	4
12.5		0.00	0.00	0.00	0.00		4
DMW Control	pH	8.20	8.20	8.20	0.00	0.00	1
0.01		8.10	8.10	8.10	0.00	0.00	1
1.6		8.10	8.10	8.10	0.00	0.00	1
3.1		8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.00	8.00	8.00	0.00	0.00	1
DMW Control	DO %	97.50	97.50	97.50	0.00	0.00	1
0.01		98.70	98.70	98.70	0.00	0.00	1
1.6		99.80	99.80	99.80	0.00	0.00	1
3.1		99.30	99.30	99.30	0.00	0.00	1
6.3		99.00	99.00	99.00	0.00	0.00	1
12.5		98.30	98.30	98.30	0.00	0.00	1
DMW Control	Cond uS/cm	171.40	171.40	171.40	0.00	0.00	1
0.01		170.00	170.00	170.00	0.00	0.00	1
1.6		175.10	175.10	175.10	0.00	0.00	1
3.1		180.10	180.10	180.10	0.00	0.00	1
6.3		190.10	190.10	190.10	0.00	0.00	1
12.5		210.00	210.00	210.00	0.00	0.00	1

Ceriodaphnia Acute Toxicity Test-48 Hr Immobilisation

Start Date: 2/09/2011 11:30 Test ID: PR0787/04 Sample ID: Content Pit
End Date: 4/09/2011 11:30 Lab ID: 4928 Sample Type: AQ-Aqueous
Sample Date: Protocol: ESA 101 Test Species: CD-Ceriodaphnia dubia
Comments:

Conc.-%	1	2	3	4
DMW Control	1.0000	1.0000	1.0000	1.0000
0.01	1.0000	1.0000	1.0000	0.8000
1.6	1.0000	1.0000	1.0000	1.0000
3.1	1.0000	1.0000	1.0000	1.0000
6.3	0.8000	0.6000	0.8000	0.8000
12.5	0.0000	0.0000	0.0000	0.2000

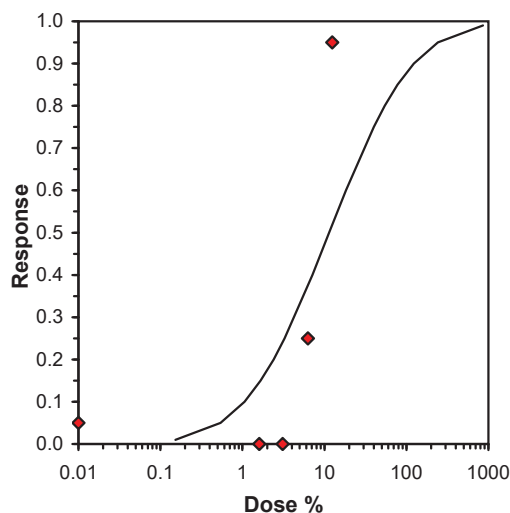
Conc.-%	Transform: Arcsin Square Root							Rank Sum	1-Tailed Critical	Number Resp	Total Number
	Mean	N-Mean	Mean	Min	Max	CV%	N				
DMW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4			0	20
0.01	0.9500	0.9500	1.2857	1.1071	1.3453	9.261	4	16.00	10.00	1	20
1.6	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	0	20
3.1	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	0	20
*6.3	0.7500	0.7500	1.0519	0.8861	1.1071	10.508	4	10.00	10.00	5	20
*12.5	0.0500	0.0500	0.2850	0.2255	0.4636	41.771	4	10.00	10.00	19	20

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.853076	0.916	-0.49918	2.400092
Equality of variance cannot be confirmed				
Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	3.1	6.3	4.419276	32.25806
Treatments vs DMW Control				

Maximum Likelihood-Probit											
Parameter	Value	SE	95% Fiducial Limits		Control	Chi-Sq	Critical	P-value	Mu	Sigma	Iter
Slope	1.240857	1.717288	-4.22432	6.706032	0	62.89409	7.814728	1.4E-13	1.057567	0.805895	50
Intercept	3.68771	1.330596	-0.54684	7.922262							
TSCR											

Point	Probits	%	95% Fiducial Limits
EC01	2.674	0.152327	
EC05	3.355	0.539496	
EC10	3.718	1.058697	
EC15	3.964	1.668442	
EC20	4.158	2.39502	
EC25	4.326	3.265875	
EC40	4.747	7.135036	
EC50	5.000	11.4174	
EC60	5.253	18.26999	
EC75	5.674	39.91489	
EC80	5.842	54.42837	
EC85	6.036	78.13101	
EC90	6.282	123.1297	
EC95	6.645	241.6272	
EC99	7.326	855.7735	

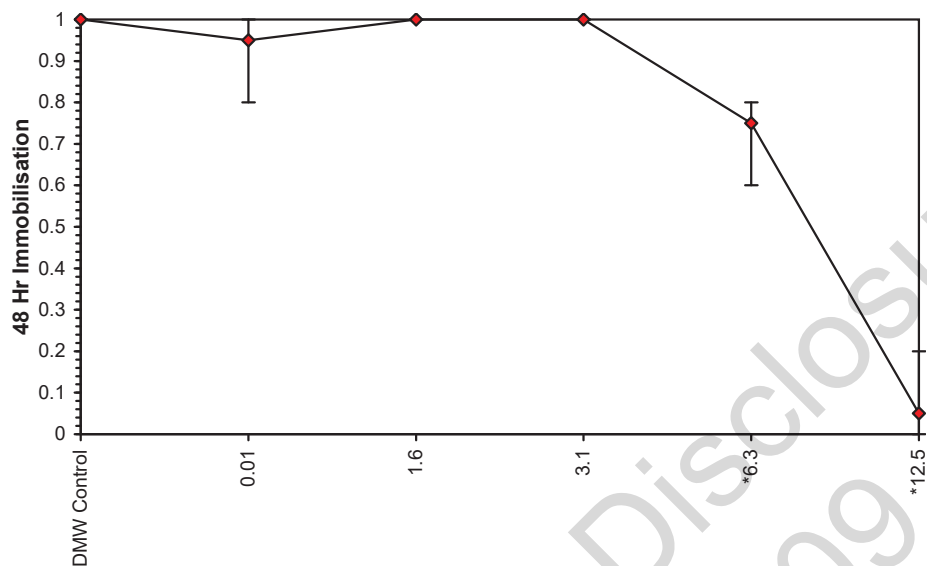
Significant heterogeneity detected (p = 1.41E-13)



Ceriodaphnia Acute Toxicity Test-48 Hr Immobilisation

Start Date: 2/09/2011 11:30	Test ID: PR0787/04	Sample ID:	Content Pit
End Date: 4/09/2011 11:30	Lab ID: 4928	Sample Type: AQ-Aqueous	
Sample Date:	Protocol: ESA 101	Test Species: CD-Ceriodaphnia dubia	
Comments:			

Dose-Response Plot



Ceriodaphnia Acute Toxicity Test-48 Hr Immobilisation

Start Date:	2/09/2011 11:30	Test ID:	PR0787/04	Sample ID:	Content Pit
End Date:	4/09/2011 11:30	Lab ID:	4928	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 101	Test Species:	CD-Ceriodaphnia dubia
Comments:					

		Auxiliary Data Summary					
Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	% Survival	100.00	100.00	100.00	0.00	0.00	4
0.01		95.00	80.00	100.00	10.00	3.33	4
1.6		100.00	100.00	100.00	0.00	0.00	4
3.1		100.00	100.00	100.00	0.00	0.00	4
6.3		75.00	60.00	80.00	10.00	4.22	4
12.5		5.00	0.00	20.00	10.00	63.25	4
DMW Control	pH	8.10	8.10	8.10	0.00	0.00	1
0.01		8.10	8.10	8.10	0.00	0.00	1
1.6		8.10	8.10	8.10	0.00	0.00	1
3.1		8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.00	8.00	8.00	0.00	0.00	1
DMW Control	DO %	98.40	98.40	98.40	0.00	0.00	1
0.01		97.80	97.80	97.80	0.00	0.00	1
1.6		97.60	97.60	97.60	0.00	0.00	1
3.1		97.50	97.50	97.50	0.00	0.00	1
6.3		97.90	97.90	97.90	0.00	0.00	1
12.5		98.90	98.90	98.90	0.00	0.00	1
DMW Control	Cond uS/cm	174.20	174.20	174.20	0.00	0.00	1
0.01		172.30	172.30	172.30	0.00	0.00	1
1.6		179.70	179.70	179.70	0.00	0.00	1
3.1		187.60	187.60	187.60	0.00	0.00	1
6.3		203.00	203.00	203.00	0.00	0.00	1
12.5		234.00	234.00	234.00	0.00	0.00	1

Ceriodaphnia Acute Toxicity Test-48 Hr Immobilisation

Start Date: 2/09/2011 11:30 Test ID: PR0787/04 Sample ID: Content Pit
 End Date: 4/09/2011 11:30 Lab ID: 4928 Sample Type: AQ-Aqueous
 Sample Date: Protocol: ESA 101 Test Species: CD-Ceriodaphnia dubia
 Comments:

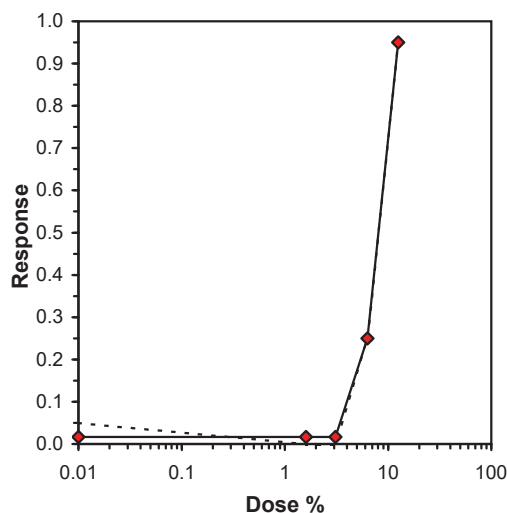
Conc-%	1	2	3	4
DMW Control	1.0000	1.0000	1.0000	1.0000
0.01	1.0000	1.0000	1.0000	0.8000
1.6	1.0000	1.0000	1.0000	1.0000
3.1	1.0000	1.0000	1.0000	1.0000
6.3	0.8000	0.6000	0.8000	0.8000
12.5	0.0000	0.0000	0.0000	0.2000

Conc-%	Transform: Arcsin Square Root							Rank Sum	1-Tailed Critical	Isotonic	
	Mean	N-Mean	Mean	Min	Max	CV%	N			Mean	N-Mean
DMW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4			1.0000	1.0000
0.01	0.9500	0.9500	1.2857	1.1071	1.3453	9.261	4	16.00	10.00	0.9833	0.9833
1.6	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	0.9833	0.9833
3.1	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	0.9833	0.9833
*6.3	0.7500	0.7500	1.0519	0.8861	1.1071	10.508	4	10.00	10.00	0.7500	0.7500
*12.5	0.0500	0.0500	0.2850	0.2255	0.4636	41.771	4	10.00	10.00	0.0500	0.0500

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.853076	0.916	-0.49918	2.400092
Equality of variance cannot be confirmed				
Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	3.1	6.3	4.419276	32.25806
Treatments vs DMW Control				

Log-Logit Interpolation (200 Resamples)

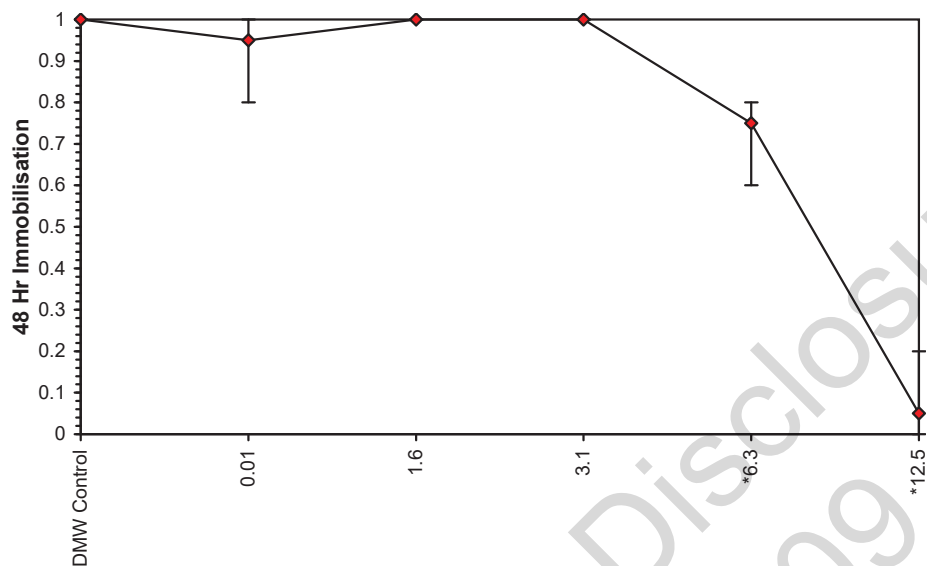
Point	%	SD	95% CL(Exp)		Skew
IC05	4.1060	0.7889	2.4964	6.3487	0.1760
IC10	4.9010	0.5514	3.7393	6.4615	-0.0635
IC15	5.4541	0.3977	4.3668	6.5114	-0.5569
IC20	5.9044	0.3172	4.7999	6.5373	-0.9318
IC25	6.3000	0.2704	5.1815	6.9811	-0.7487
IC40	7.1115	0.3702	6.1288	8.3027	0.2089
IC50	7.6273	0.5244	6.1205	9.1715	-0.0889



Ceriodaphnia Acute Toxicity Test-48 Hr Immobilisation

Start Date: 2/09/2011 11:30	Test ID: PR0787/04	Sample ID:	Content Pit
End Date: 4/09/2011 11:30	Lab ID: 4928	Sample Type: AQ-Aqueous	
Sample Date:	Protocol: ESA 101	Test Species: CD-Ceriodaphnia dubia	
Comments:			

Dose-Response Plot



Ceriodaphnia Acute Toxicity Test-48 Hr Immobilisation

Start Date:	2/09/2011 11:30	Test ID:	PR0787/04	Sample ID:	Content Pit
End Date:	4/09/2011 11:30	Lab ID:	4928	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 101	Test Species:	CD-Ceriodaphnia dubia
Comments:					

		Auxiliary Data Summary					
Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	% Survival	100.00	100.00	100.00	0.00	0.00	4
0.01		95.00	80.00	100.00	10.00	3.33	4
1.6		100.00	100.00	100.00	0.00	0.00	4
3.1		100.00	100.00	100.00	0.00	0.00	4
6.3		75.00	60.00	80.00	10.00	4.22	4
12.5		5.00	0.00	20.00	10.00	63.25	4
DMW Control	pH	8.10	8.10	8.10	0.00	0.00	1
0.01		8.10	8.10	8.10	0.00	0.00	1
1.6		8.10	8.10	8.10	0.00	0.00	1
3.1		8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.00	8.00	8.00	0.00	0.00	1
DMW Control	DO %	98.40	98.40	98.40	0.00	0.00	1
0.01		97.80	97.80	97.80	0.00	0.00	1
1.6		97.60	97.60	97.60	0.00	0.00	1
3.1		97.50	97.50	97.50	0.00	0.00	1
6.3		97.90	97.90	97.90	0.00	0.00	1
12.5		98.90	98.90	98.90	0.00	0.00	1
DMW Control	Cond uS/cm	174.20	174.20	174.20	0.00	0.00	1
0.01		172.30	172.30	172.30	0.00	0.00	1
1.6		179.70	179.70	179.70	0.00	0.00	1
3.1		187.60	187.60	187.60	0.00	0.00	1
6.3		203.00	203.00	203.00	0.00	0.00	1
12.5		234.00	234.00	234.00	0.00	0.00	1

**Statistical Printouts for the
Chronic Test with *Ceriodaphnia
dubia***

Ceriodaphnia Partial Life-Cycle Test-8 day survival

Start Date: 26/08/2011 12:30 Test ID: PR0787/11 Sample ID: Lady Isabella Pit
 End Date: 2/09/2011 12:30 Lab ID: 4927 Sample Type: AQ-Aqueous
 Sample Date: Protocol: ESA 102 Test Species: CD-Ceriodaphnia dubia
 Comments:

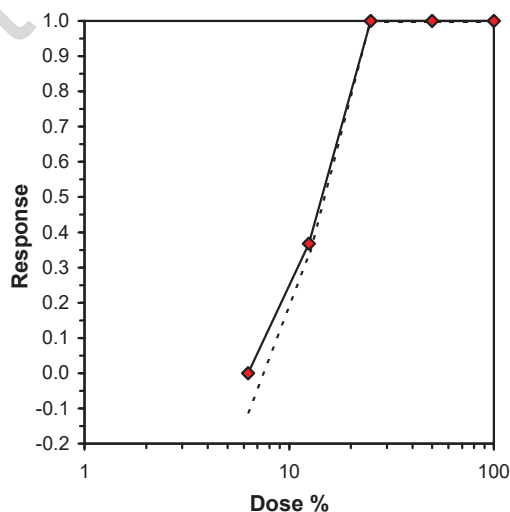
Conc-%	1	2	3	4	5	6	7	8	9	10
DMW Control	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000
6.3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12.5	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000	0.0000	0.0000	1.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Conc-%	Mean	N-Mean	Resp	Not Resp	Total	N	Fisher's Exact P	1-Tailed Critical	Number Resp	Total Number
DMW Control	0.9000	1.0000	1	9	10	10			1	10
6.3	1.0000	1.1111	0	10	10	10	0.5000	0.0500	0	10
12.5	0.6000	0.6667	4	6	10	10	0.1517	0.0500	4	10
25	0.0000	0.0000	10	0	10	10			10	10
50	0.0000	0.0000	10	0	10	10			10	10
100	0.0000	0.0000	10	0	10	10			10	10

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Fisher's Exact Test	12.5	25	17.67767	8
Treatments vs DMW Control				

Trimmed Spearman-Kärber

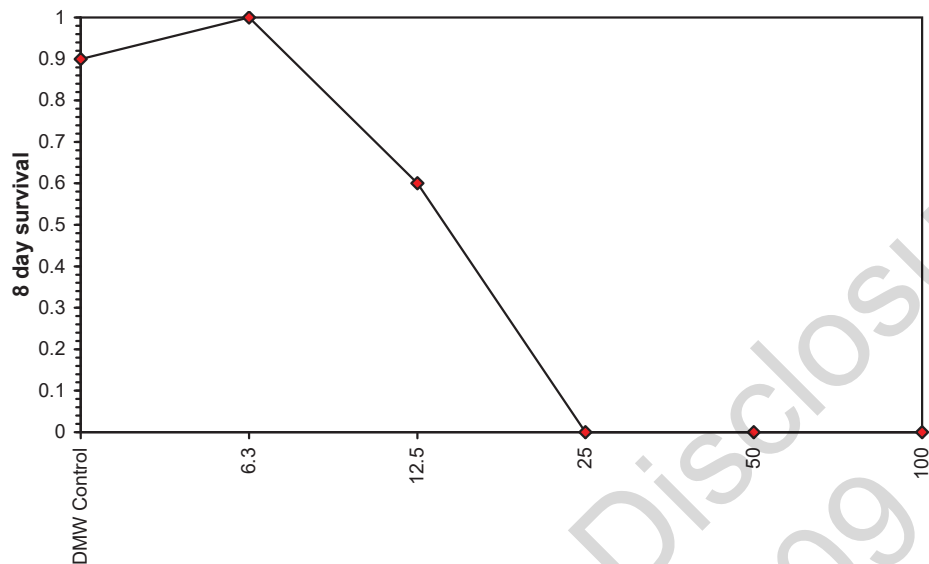
Trim Level	EC50	95% CL	
0.0%	13.714	11.113	16.923
5.0%	13.835	10.937	17.500
10.0%	13.955	10.662	18.264
20.0%	14.184	9.660	20.826
Auto-0.0%	13.714	11.113	16.923



Ceriodaphnia Partial Life-Cycle Test-8 day survival

Start Date:	26/08/2011 12:30	Test ID:	PR0787/11	Sample ID:	Lady Isabella Pit
End Date:	2/09/2011 12:30	Lab ID:	4927	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



Ceriodaphnia Partial Life-Cycle Test-8 day survival

Start Date:	26/08/2011 12:30	Test ID:	PR0787/11	Sample ID:	Lady Isabella Pit
End Date:	2/09/2011 12:30	Lab ID:	4927	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	No of Young	15.40	0.00	21.00	7.73	18.06	10
6.3		11.00	6.00	15.00	2.79	15.18	10
12.5		1.30	0.00	5.00	2.11	111.76	10
25		0.00	0.00	0.00	0.00		10
50		0.00	0.00	0.00	0.00		10
100		0.00	0.00	0.00	0.00		10
DMW Control	% survival	90.00	0.00	100.00	31.62	6.25	10
6.3		100.00	100.00	100.00	0.00	0.00	10
12.5		60.00	0.00	100.00	51.64	11.98	10
25		0.00	0.00	0.00	0.00		10
50		0.00	0.00	0.00	0.00		10
100		0.00	0.00	0.00	0.00		10
DMW Control	pH	8.05	8.00	8.10	0.07	3.30	2
6.3		8.00	8.00	8.00	0.00	0.00	1
12.5		7.80	7.80	7.80	0.00	0.00	1
25		7.40	7.40	7.40	0.00	0.00	1
50		4.50	4.50	4.50	0.00	0.00	1
100		0.00	0.00	0.00	0.00		0
DMW Control	DO %	100.15	99.80	100.50	0.49	0.70	2
6.3		98.70	98.70	98.70	0.00	0.00	1
12.5		99.10	99.10	99.10	0.00	0.00	1
25		100.30	100.30	100.30	0.00	0.00	1
50		99.90	99.90	99.90	0.00	0.00	1
100		0.00	0.00	0.00	0.00		0
DMW Control	Cond uS/cm	183.80	172.40	195.20	16.12	2.18	2
6.3		213.00	213.00	213.00	0.00	0.00	1
12.5		254.00	254.00	254.00	0.00	0.00	1
25		334.00	334.00	334.00	0.00	0.00	1
50		518.00	518.00	518.00	0.00	0.00	1
100		0.00	0.00	0.00	0.00		0

Ceriodaphnia Partial Life-Cycle Test-8 day survival

Start Date: 26/08/2011 12:30 Test ID: PR0787/11 Sample ID: Lady Isabella Pit
 End Date: 2/09/2011 12:30 Lab ID: 4927 Sample Type: AQ-Aqueous
 Sample Date: Protocol: ESA 102 Test Species: CD-Ceriodaphnia dubia
 Comments:

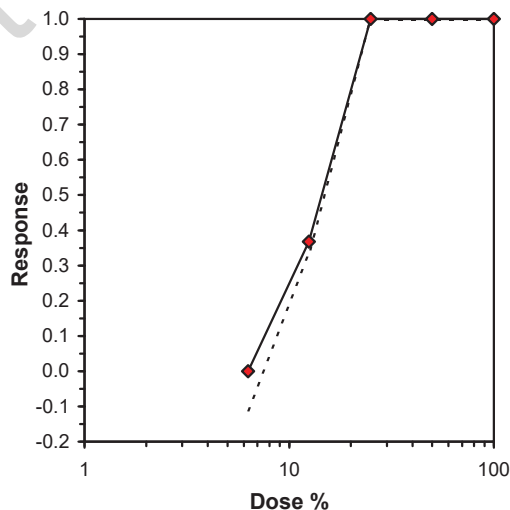
Conc.-%	1	2	3	4	5	6	7	8	9	10
DMW Control	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000
6.3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12.5	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000	0.0000	0.0000	1.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Conc.-%	Mean	N-Mean	Resp	Not Resp	Total	N	Fisher's Exact P	1-Tailed Critical	Isotonic Mean	N-Mean
DMW Control	0.9000	1.0000	1	9	10	10			0.9500	1.0000
6.3	1.0000	1.1111	0	10	10	10	0.5000	0.0500	0.9500	1.0000
12.5	0.6000	0.6667	4	6	10	10	0.1517	0.0500	0.6000	0.6316
25	0.0000	0.0000	10	0	10	10			0.0000	0.0000
50	0.0000	0.0000	10	0	10	10			0.0000	0.0000
100	0.0000	0.0000	10	0	10	10			0.0000	0.0000

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Fisher's Exact Test	12.5	25	17.67767	8
Treatments vs DMW Control				

Log-Logit Interpolation (200 Resamples)

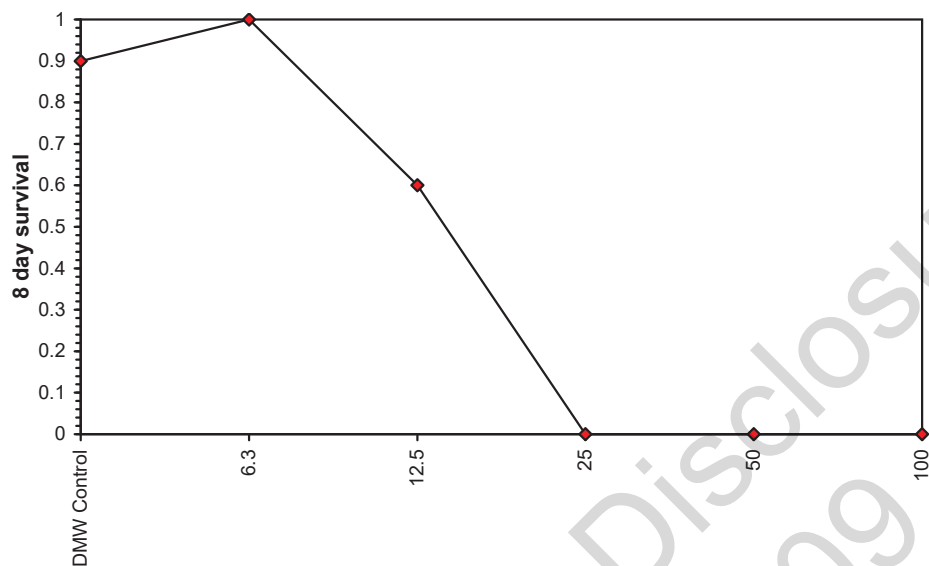
Point	%	SD	95% CL		Skew
IC05	7.689	1.763	7.067	12.216	1.2854
IC10	8.691	1.671	7.709	12.850	1.0963
IC15	9.524	1.555	8.282	13.124	0.9203
IC20	10.266	1.447	8.814	13.354	0.7620
IC25	10.954	1.341	9.322	13.557	0.6831
IC40	12.614	1.029	10.811	14.089	1.1143
IC50	12.973	0.896	11.764	14.423	1.8739



Ceriodaphnia Partial Life-Cycle Test-8 day survival

Start Date:	26/08/2011 12:30	Test ID:	PR0787/11	Sample ID:	Lady Isabella Pit
End Date:	2/09/2011 12:30	Lab ID:	4927	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



Ceriodaphnia Partial Life-Cycle Test-8 day survival

Start Date:	26/08/2011 12:30	Test ID:	PR0787/11	Sample ID:	Lady Isabella Pit
End Date:	2/09/2011 12:30	Lab ID:	4927	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	No of Young	15.40	0.00	21.00	7.73	18.06	10
6.3		11.00	6.00	15.00	2.79	15.18	10
12.5		1.30	0.00	5.00	2.11	111.76	10
25		0.00	0.00	0.00	0.00		10
50		0.00	0.00	0.00	0.00		10
100		0.00	0.00	0.00	0.00		10
DMW Control	% survival	90.00	0.00	100.00	31.62	6.25	10
6.3		100.00	100.00	100.00	0.00	0.00	10
12.5		60.00	0.00	100.00	51.64	11.98	10
25		0.00	0.00	0.00	0.00		10
50		0.00	0.00	0.00	0.00		10
100		0.00	0.00	0.00	0.00		10
DMW Control	pH	8.05	8.00	8.10	0.07	3.30	2
6.3		8.00	8.00	8.00	0.00	0.00	1
12.5		7.80	7.80	7.80	0.00	0.00	1
25		7.40	7.40	7.40	0.00	0.00	1
50		4.50	4.50	4.50	0.00	0.00	1
100		0.00	0.00	0.00	0.00		0
DMW Control	DO %	100.15	99.80	100.50	0.49	0.70	2
6.3		98.70	98.70	98.70	0.00	0.00	1
12.5		99.10	99.10	99.10	0.00	0.00	1
25		100.30	100.30	100.30	0.00	0.00	1
50		99.90	99.90	99.90	0.00	0.00	1
100		0.00	0.00	0.00	0.00		0
DMW Control	Cond uS/cm	183.80	172.40	195.20	16.12	2.18	2
6.3		213.00	213.00	213.00	0.00	0.00	1
12.5		254.00	254.00	254.00	0.00	0.00	1
25		334.00	334.00	334.00	0.00	0.00	1
50		518.00	518.00	518.00	0.00	0.00	1
100		0.00	0.00	0.00	0.00		0

Ceriodaphnia Partial Life-Cycle Test-8 day survival

Start Date: 26/08/2011 12:30 Test ID: PR0787/12 Sample ID: Content Pit
 End Date: 2/09/2011 12:30 Lab ID: 4928 Sample Type: AQ-Aqueous
 Sample Date: Protocol: ESA 102 Test Species: CD-Ceriodaphnia dubia
 Comments:

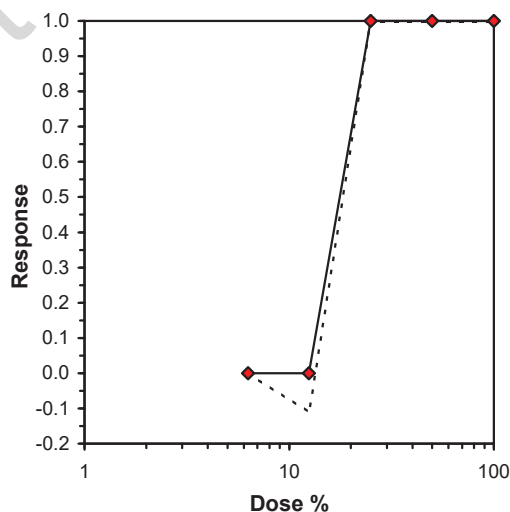
Conc-%	1	2	3	4	5	6	7	8	9	10
DMW Control	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000
6.3	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12.5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Conc-%	Mean	N-Mean	Resp	Not Resp	Total	N	Fisher's Exact P	1-Tailed Critical	Number Resp	Total Number
DMW Control	0.9000	1.0000	1	9	10	10			1	10
6.3	0.9000	1.0000	1	9	10	10	0.7632	0.0500	1	10
12.5	1.0000	1.1111	0	10	10	10	0.5000	0.0500	0	10
25	0.0000	0.0000	10	0	10	10			10	10
50	0.0000	0.0000	10	0	10	10			10	10
100	0.0000	0.0000	10	0	10	10			10	10

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Fisher's Exact Test	12.5	25	17.67767	8
Treatments vs DMW Control				

Graphical Method

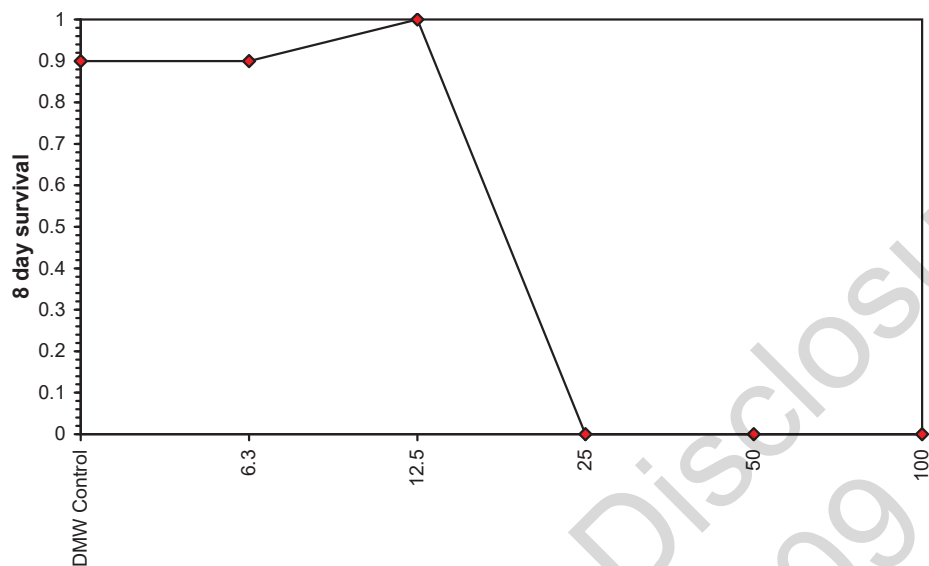
Trim Level	EC50
0.0%	17.678
	17.678



Ceriodaphnia Partial Life-Cycle Test-8 day survival

Start Date:	26/08/2011 12:30	Test ID:	PR0787/12	Sample ID:	Content Pit
End Date:	2/09/2011 12:30	Lab ID:	4928	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



Ceriodaphnia Partial Life-Cycle Test-8 day survival

Start Date:	26/08/2011 12:30	Test ID:	PR0787/12	Sample ID:	Content Pit
End Date:	2/09/2011 12:30	Lab ID:	4928	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	No of Young	15.40	0.00	21.00	7.73	18.06	10
6.3		10.50	5.00	13.00	2.46	14.94	10
12.5		2.40	0.00	8.00	2.46	65.33	10
25		0.00	0.00	0.00	0.00		10
50		0.00	0.00	0.00	0.00		10
100		0.00	0.00	0.00	0.00		10
DMW Control	% survival	90.00	0.00	100.00	31.62	6.25	10
6.3		90.00	0.00	100.00	31.62	6.25	10
12.5		100.00	100.00	100.00	0.00	0.00	10
25		0.00	0.00	0.00	0.00		10
50		0.00	0.00	0.00	0.00		10
100		0.00	0.00	0.00	0.00		10
DMW Control	pH	8.00	8.00	8.00	0.00	0.00	1
6.3		7.90	7.90	7.90	0.00	0.00	1
12.5		7.80	7.80	7.80	0.00	0.00	1
25		7.70	7.70	7.70	0.00	0.00	1
50		7.40	7.40	7.40	0.00	0.00	1
100		4.30	4.30	4.30	0.00	0.00	1
DMW Control	DO %	100.50	100.50	100.50	0.00	0.00	1
6.3		100.20	100.20	100.20	0.00	0.00	1
12.5		98.60	98.60	98.60	0.00	0.00	1
25		99.60	99.60	99.60	0.00	0.00	1
50		99.90	99.90	99.90	0.00	0.00	1
100		98.60	98.60	98.60	0.00	0.00	1
DMW Control	Cond uS/cm	172.40	172.40	172.40	0.00	0.00	1
6.3		206.00	206.00	206.00	0.00	0.00	1
12.5		236.00	236.00	236.00	0.00	0.00	1
25		300.00	300.00	300.00	0.00	0.00	1
50		428.00	428.00	428.00	0.00	0.00	1
100		709.00	709.00	709.00	0.00	0.00	1

Ceriodaphnia Partial Life-Cycle Test-Reproduction

Start Date: 26/08/2011 12:30 Test ID: PR0787/11 Sample ID: Lady Isabella Pit
 End Date: 2/09/2011 12:30 Lab ID: 4927 Sample Type: AQ-Aqueous
 Sample Date: Protocol: ESA 102 Test Species: CD-Ceriodaphnia dubia
 Comments:

Conc.-%	1	2	3	4	5	6	7	8	9	10
DMW Control	18.000	21.000	17.000	21.000	17.000	19.000	19.000	2.000	20.000	
6.3	11.000	11.000	11.000	9.000	10.000	13.000	9.000	15.000	15.000	6.000
12.5	5.000	4.000	4.000	0.000	0.000	0.000	0.000			
25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
50	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

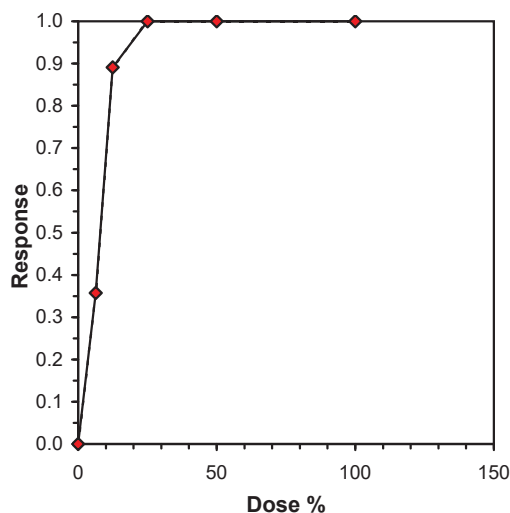
Conc.-%	Transform: Untransformed							Rank Sum	1-Tailed Critical	Isotonic	
	Mean	N-Mean	Mean	Min	Max	CV%	N			Mean	N-Mean
DMW Control	17.111	1.0000	17.1111	2.0000	21.0000	34.257	9			17.111	1.0000
*6.3	11.000	0.6429	11.0000	6.0000	15.0000	25.353	10	65.00	75.00	11.000	0.6429
*12.5	1.857	0.1085	1.8571	0.0000	5.0000	126.007	7	31.00	40.00	1.857	0.1085
25	0.000	0.0000	0.0000	0.0000	0.0000	0.000	10			0.000	0.0000
50	0.000	0.0000	0.0000	0.0000	0.0000	0.000	10			0.000	0.0000
100	0.000	0.0000	0.0000	0.0000	0.0000	0.000	10			0.000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.770363	0.92	-2.41666	8.650304
Bartlett's Test indicates equal variances (p = 0.03)	6.992698	9.21034		
Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Wilcoxon Rank Sum Test	<6.3	6.3		
Treatments vs DMW Control				

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL		Skew
IC05*	0.8820	0.5746	0.6221	2.1627	5.8446
IC10*	1.7640	0.8582	1.2442	4.3253	3.0432
IC15*	2.6460	1.0725	1.8664	6.3379	2.1057
IC20*	3.5280	1.1424	2.4885	6.7738	1.4521
IC25*	4.4100	1.1520	3.1106	7.2130	0.9268
IC40	6.7973	0.9292	4.9770	8.5366	0.1075
IC50	7.9576	0.8006	6.2212	9.4038	-0.0968

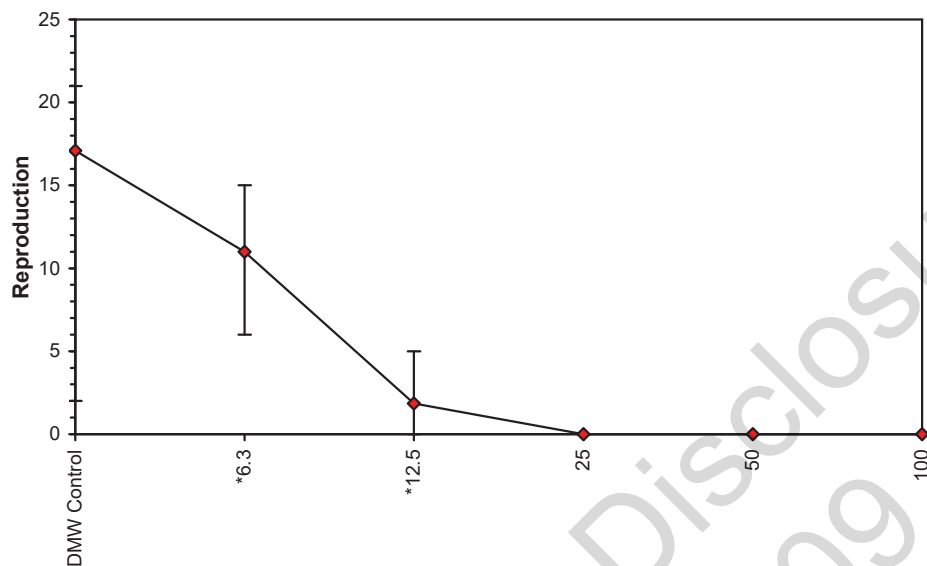
* indicates IC estimate less than the lowest concentration



Ceriodaphnia Partial Life-Cycle Test-Reproduction

Start Date:	26/08/2011 12:30	Test ID:	PR0787/11	Sample ID:	Lady Isabella Pit
End Date:	2/09/2011 12:30	Lab ID:	4927	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



Ceriodaphnia Partial Life-Cycle Test-Reproduction

Start Date:	26/08/2011 12:30	Test ID:	PR0787/11	Sample ID:	Lady Isabella Pit
End Date:	2/09/2011 12:30	Lab ID:	4927	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	No of Young	17.11	2.00	21.00	5.86	14.15	9
6.3		11.00	6.00	15.00	2.79	15.18	10
12.5		1.86	0.00	5.00	2.34	82.37	7
25		0.00	0.00	0.00	0.00		10
50		0.00	0.00	0.00	0.00		10
100		0.00	0.00	0.00	0.00		10
DMW Control	% survival	88.89	0.00	100.00	33.33	6.50	9
6.3		100.00	100.00	100.00	0.00	0.00	10
12.5		57.14	0.00	100.00	53.45	12.79	7
25		0.00	0.00	0.00	0.00		10
50		0.00	0.00	0.00	0.00		10
100		0.00	0.00	0.00	0.00		10
DMW Control	pH	8.00	8.00	8.00	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.00	8.00	8.00	0.00	0.00	1
25		7.80	7.80	7.80	0.00	0.00	1
50		7.40	7.40	7.40	0.00	0.00	1
100		4.50	4.50	4.50	0.00	0.00	1
DMW Control	DO %	100.50	100.50	100.50	0.00	0.00	1
6.3		99.80	99.80	99.80	0.00	0.00	1
12.5		98.70	98.70	98.70	0.00	0.00	1
25		99.10	99.10	99.10	0.00	0.00	1
50		100.30	100.30	100.30	0.00	0.00	1
100		99.90	99.90	99.90	0.00	0.00	1
DMW Control	Cond uS/cm	172.40	172.40	172.40	0.00	0.00	1
6.3		195.20	195.20	195.20	0.00	0.00	1
12.5		213.00	213.00	213.00	0.00	0.00	1
25		254.00	254.00	254.00	0.00	0.00	1
50		334.00	334.00	334.00	0.00	0.00	1
100		518.00	518.00	518.00	0.00	0.00	1

Ceriodaphnia Partial Life-Cycle Test-8 day survival

Start Date: 26/08/2011 12:30 Test ID: PR0787/12 Sample ID: Content Pit
 End Date: 2/09/2011 12:30 Lab ID: 4928 Sample Type: AQ-Aqueous
 Sample Date: Protocol: ESA 102 Test Species: CD-Ceriodaphnia dubia
 Comments:

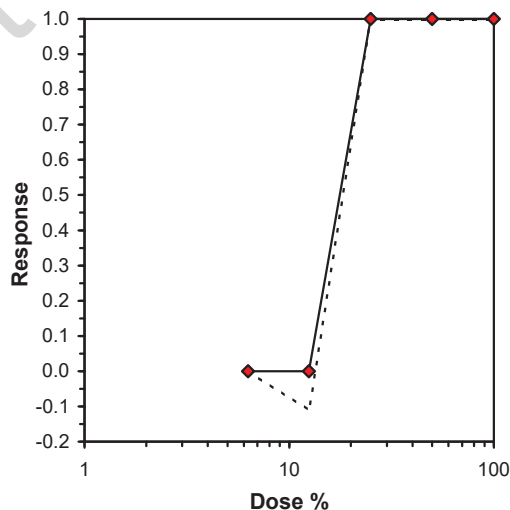
Conc-%	1	2	3	4	5	6	7	8	9	10
DMW Control	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000
6.3	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12.5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Conc-%	Mean	N-Mean	Resp	Not Resp	Total	N	Fisher's Exact P	1-Tailed Critical	Isotonic Mean	N-Mean
DMW Control	0.9000	1.0000	1	9	10	10			0.9333	1.0000
6.3	0.9000	1.0000	1	9	10	10	0.7632	0.0500	0.9333	1.0000
12.5	1.0000	1.1111	0	10	10	10	0.5000	0.0500	0.9333	1.0000
25	0.0000	0.0000	10	0	10	10			0.0000	0.0000
50	0.0000	0.0000	10	0	10	10			0.0000	0.0000
100	0.0000	0.0000	10	0	10	10			0.0000	0.0000

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Fisher's Exact Test	12.5	25	17.67767	8
Treatments vs DMW Control				

Log-Logit Interpolation (200 Resamples)

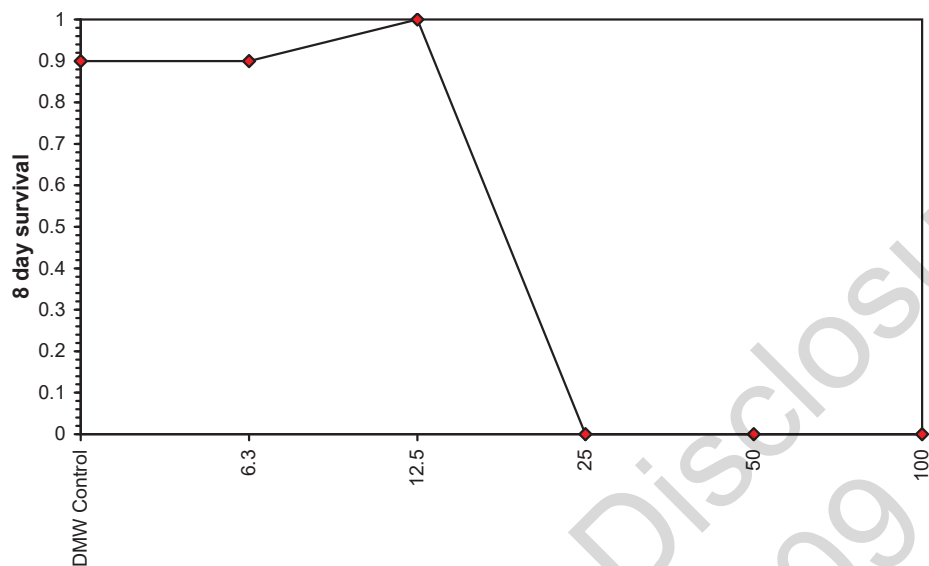
Point	%	SD	95% CL		Skew
IC05	12.942	2.811	4.907	15.872	-1.8517
IC10	13.253	1.514	12.500	16.326	-1.4444
IC15	13.502	1.278	12.864	16.614	0.1569
IC20	13.715	1.146	13.144	16.833	1.8994
IC25	13.906	1.141	13.344	17.017	1.8973
IC40	14.415	1.120	13.833	17.467	1.8827
IC50	14.738	1.100	14.157	17.735	1.8735



Ceriodaphnia Partial Life-Cycle Test-8 day survival

Start Date:	26/08/2011 12:30	Test ID:	PR0787/12	Sample ID:	Content Pit
End Date:	2/09/2011 12:30	Lab ID:	4928	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



Ceriodaphnia Partial Life-Cycle Test-8 day survival

Start Date:	26/08/2011 12:30	Test ID:	PR0787/12	Sample ID:	Content Pit
End Date:	2/09/2011 12:30	Lab ID:	4928	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	No of Young	15.40	0.00	21.00	7.73	18.06	10
6.3		10.50	5.00	13.00	2.46	14.94	10
12.5		2.40	0.00	8.00	2.46	65.33	10
25		0.00	0.00	0.00	0.00		10
50		0.00	0.00	0.00	0.00		10
100		0.00	0.00	0.00	0.00		10
DMW Control	% survival	90.00	0.00	100.00	31.62	6.25	10
6.3		90.00	0.00	100.00	31.62	6.25	10
12.5		100.00	100.00	100.00	0.00	0.00	10
25		0.00	0.00	0.00	0.00		10
50		0.00	0.00	0.00	0.00		10
100		0.00	0.00	0.00	0.00		10
DMW Control	pH	8.00	8.00	8.00	0.00	0.00	1
6.3		7.90	7.90	7.90	0.00	0.00	1
12.5		7.80	7.80	7.80	0.00	0.00	1
25		7.70	7.70	7.70	0.00	0.00	1
50		7.40	7.40	7.40	0.00	0.00	1
100		4.30	4.30	4.30	0.00	0.00	1
DMW Control	DO %	100.50	100.50	100.50	0.00	0.00	1
6.3		100.20	100.20	100.20	0.00	0.00	1
12.5		98.60	98.60	98.60	0.00	0.00	1
25		99.60	99.60	99.60	0.00	0.00	1
50		99.90	99.90	99.90	0.00	0.00	1
100		98.60	98.60	98.60	0.00	0.00	1
DMW Control	Cond uS/cm	172.40	172.40	172.40	0.00	0.00	1
6.3		206.00	206.00	206.00	0.00	0.00	1
12.5		236.00	236.00	236.00	0.00	0.00	1
25		300.00	300.00	300.00	0.00	0.00	1
50		428.00	428.00	428.00	0.00	0.00	1
100		709.00	709.00	709.00	0.00	0.00	1

Ceriodaphnia Partial Life-Cycle Test-Reproduction

Start Date: 26/08/2011 12:30 Test ID: PR0787/12 Sample ID: Content Pit
 End Date: 2/09/2011 12:30 Lab ID: 4928 Sample Type: AQ-Aqueous
 Sample Date: Protocol: ESA 102 Test Species: CD-Ceriodaphnia dubia
 Comments:

Conc.-%	1	2	3	4	5	6	7	8	9	10
DMW Control	18.000	21.000	17.000	21.000	17.000	19.000	19.000	2.000	20.000	
6.3	9.000	5.000	12.000	12.000	12.000	13.000	12.000	11.000	11.000	8.000
12.5	5.000	2.000	1.000	2.000	8.000	0.000	1.000	0.000	2.000	3.000
25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
50	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

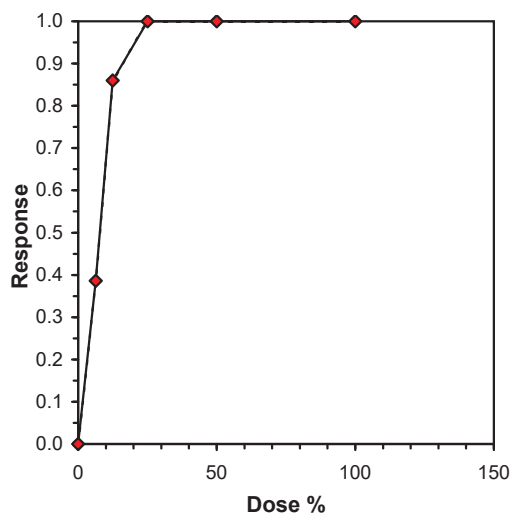
Conc.-%	Transform: Untransformed							Rank Sum	1-Tailed Critical	Isotonic	
	Mean	N-Mean	Mean	Min	Max	CV%	N			Mean	N-Mean
DMW Control	17.111	1.0000	17.1111	2.0000	21.0000	34.257	9			17.111	1.0000
*6.3	10.500	0.6136	10.5000	5.0000	13.0000	23.436	10	65.00	75.00	10.500	0.6136
*12.5	2.400	0.1403	2.4000	0.0000	8.0000	102.439	10	59.50	75.00	2.400	0.1403
25	0.000	0.0000	0.0000	0.0000	0.0000	0.000	10			0.000	0.0000
50	0.000	0.0000	0.0000	0.0000	0.0000	0.000	10			0.000	0.0000
100	0.000	0.0000	0.0000	0.0000	0.0000	0.000	10			0.000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.790518	0.926	-2.48739	9.563851
Bartlett's Test indicates equal variances (p = 0.01)	8.84052	9.21034		
Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Wilcoxon Rank Sum Test	<6.3	6.3		
Treatments vs DMW Control				

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL		Skew
IC05*	0.8153	0.3869	0.6216	1.7678	6.0532
IC10*	1.6306	0.6394	1.2433	3.5357	3.7311
IC15*	2.4459	0.8569	1.8649	5.3035	2.7370
IC20*	3.2612	0.9586	2.4866	6.5144	2.0032
IC25*	4.0765	1.0045	3.1082	7.0492	1.4272
IC40	6.4786	0.9301	4.9731	8.4032	0.4005
IC50	7.7883	0.8429	6.2164	9.5221	0.0849

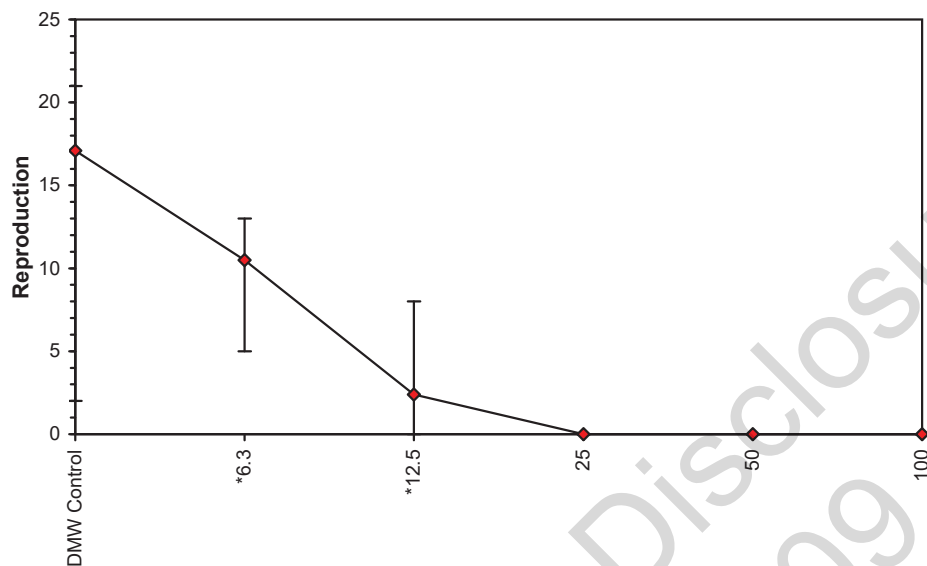
* indicates IC estimate less than the lowest concentration



Ceriodaphnia Partial Life-Cycle Test-Reproduction

Start Date: 26/08/2011 12:30	Test ID: PR0787/12	Sample ID:	Content Pit
End Date: 2/09/2011 12:30	Lab ID: 4928	Sample Type:	AQ-Aqueous
Sample Date:	Protocol: ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:			

Dose-Response Plot



Ceriodaphnia Partial Life-Cycle Test-Reproduction

Start Date:	26/08/2011 12:30	Test ID:	PR0787/12	Sample ID:	Content Pit
End Date:	2/09/2011 12:30	Lab ID:	4928	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	No of Young	18.86	17.00	21.00	1.68	6.87	7
		0.00	0.00	0.00	0.00		0
DMW Control		11.00	2.00	20.00	12.73	32.43	2
6.3		10.50	5.00	13.00	2.46	14.94	10
12.5		2.40	0.00	8.00	2.46	65.33	10
25		0.00	0.00	0.00	0.00		10
50		0.00	0.00	0.00	0.00		10
DMW Control	% survival	100.00	100.00	100.00	0.00	0.00	7
		0.00	0.00	0.00	0.00		0
DMW Control		50.00	0.00	100.00	70.71	16.82	2
6.3		90.00	0.00	100.00	31.62	6.25	10
12.5		100.00	100.00	100.00	0.00	0.00	10
25		0.00	0.00	0.00	0.00		10
50		0.00	0.00	0.00	0.00		10
DMW Control	pH	8.00	8.00	8.00	0.00	0.00	1
		0.00	0.00	0.00	0.00		0
DMW Control		0.00	0.00	0.00	0.00		0
6.3		7.90	7.90	7.90	0.00	0.00	1
12.5		7.80	7.80	7.80	0.00	0.00	1
25		7.70	7.70	7.70	0.00	0.00	1
50		7.40	7.40	7.40	0.00	0.00	1
DMW Control	DO %	100.50	100.50	100.50	0.00	0.00	1
		0.00	0.00	0.00	0.00		0
DMW Control		0.00	0.00	0.00	0.00		0
6.3		100.20	100.20	100.20	0.00	0.00	1
12.5		98.60	98.60	98.60	0.00	0.00	1
25		99.60	99.60	99.60	0.00	0.00	1
50		99.90	99.90	99.90	0.00	0.00	1
DMW Control	Cond uS/cm	172.40	172.40	172.40	0.00	0.00	1
		0.00	0.00	0.00	0.00		0
DMW Control		0.00	0.00	0.00	0.00		0
6.3		206.00	206.00	206.00	0.00	0.00	1
12.5		236.00	236.00	236.00	0.00	0.00	1
25		300.00	300.00	300.00	0.00	0.00	1
50		428.00	428.00	428.00	0.00	0.00	1

Ceriodaphnia Partial Life-Cycle Test-7 Day Survival

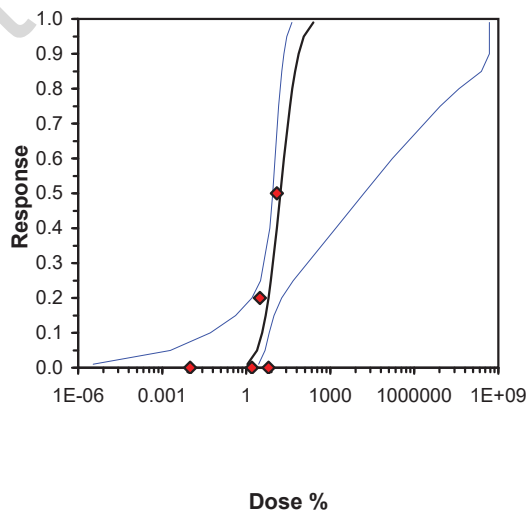
Start Date: 9/09/2011 13:30 Test ID: PR0787/21 Sample ID: Lady Isabella Pit
 End Date: 16/09/2011 13:30 Lab ID: 4927 Sample Type: AQ-Aqueous
 Sample Date: Protocol: ESA 102 Test Species: CD-Ceriodaphnia dubia
 Comments:

Conc-%	1	2	3	4	5	6	7	8	9	10
DMW Control	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
0.01	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1.6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3.1	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000
6.3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12.5	1.0000	0.0000	0.0000	0.0000	1.0000	1.0000	0.0000	1.0000	0.0000	1.0000

Conc-%	Mean	N-Mean	Resp	Not Resp	Total	N	Fisher's Exact P	1-Tailed Critical	Number Resp	Total Number
DMW Control	1.0000	1.0000	0	9	9	9			0	9
0.01	1.0000	1.0000	0	10	10	10	1.0000	0.0500	0	10
1.6	1.0000	1.0000	0	10	10	10	1.0000	0.0500	0	10
3.1	0.8000	0.8000	2	8	10	10	0.2632	0.0500	2	10
6.3	1.0000	1.0000	0	10	10	10	1.0000	0.0500	0	10
*12.5	0.5000	0.5000	5	5	10	10	0.0217	0.0500	5	10

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Fisher's Exact Test	6.3	12.5	8.87412	15.87302
Treatments vs DMW Control				

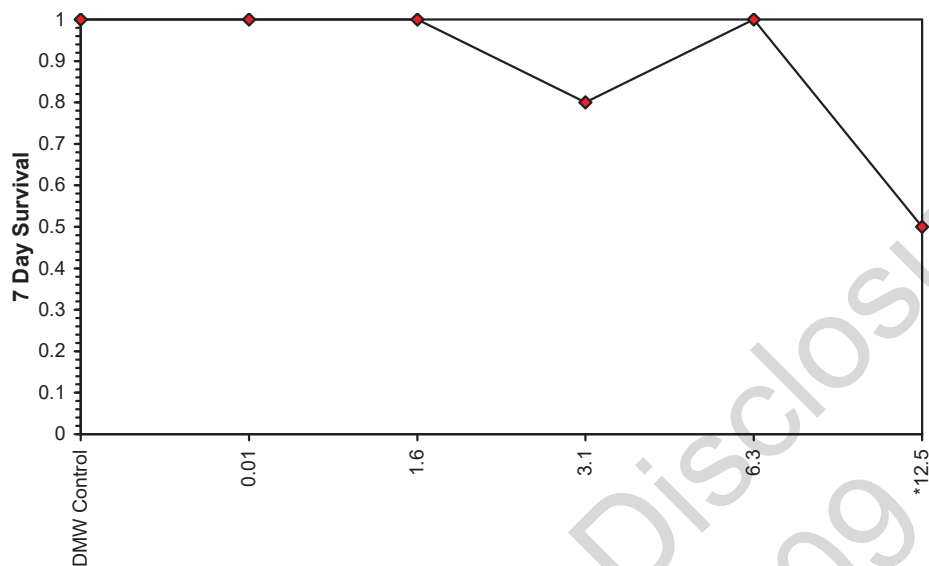
Maximum Likelihood-Probit											
Parameter	Value	SE	95% Fiducial Limits		Control	Chi-Sq	Critical	P-value	Mu	Sigma	Iter
Slope	1.974433	0.882738	0.244267	3.7046	0	5.406499	7.814728	0.14	1.219998	0.506474	4
Intercept	2.591196	0.760704	1.100217	4.082175							
TSCR											
Point	Probits	%	95% Fiducial Limits								
EC01	2.674	1.100936	3.47E-06	2.809165							
EC05	3.355	2.437369	0.001965	4.670443							
EC10	3.718	3.72327	0.052922	6.676147							
EC15	3.964	4.955308	0.419576	9.885671							
EC20	4.158	6.21925	1.598473	18.37543							
EC25	4.326	7.557634	3.279402	48.02638							
EC40	4.747	12.35048	6.876087	1576.611							
EC50	5.000	16.59578	8.751899	15795.21							
EC60	5.253	22.30034	10.72981	164284.8							
EC75	5.674	36.44261	14.55439	8336551							
EC80	5.842	44.28507	16.32868	39843874							
EC85	6.036	55.5808	18.62488	2.47E+08							
EC90	6.282	73.97258	21.918	4.85E+08							
EC95	6.645	112.9988	27.79376	4.85E+08							
EC99	7.326	250.1691	43.08025	4.85E+08							



Ceriodaphnia Partial Life-Cycle Test-7 Day Survival

Start Date:	9/09/2011 13:30	Test ID:	PR0787/21	Sample ID:	Lady Isabella Pit
End Date:	16/09/2011 13:30	Lab ID:	4927	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



Ceriodaphnia Partial Life-Cycle Test-7 Day Survival

Start Date:	9/09/2011 13:30	Test ID:	PR0787/21	Sample ID:	Lady Isabella Pit
End Date:	16/09/2011 13:30	Lab ID:	4927	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	No of Young	15.33	12.00	18.00	1.73	8.58	9
0.01		12.50	6.00	16.00	2.95	13.75	10
1.6		12.90	7.00	18.00	3.21	13.89	10
3.1		12.80	2.00	17.00	5.29	17.96	10
6.3		13.20	6.00	16.00	2.90	12.90	10
12.5		2.20	0.00	6.00	2.25	68.20	10
DMW Control	% survival	100.00	100.00	100.00	0.00	0.00	9
0.01		100.00	100.00	100.00	0.00	0.00	10
1.6		100.00	100.00	100.00	0.00	0.00	10
3.1		80.00	0.00	100.00	42.16	8.12	10
6.3		100.00	100.00	100.00	0.00	0.00	10
12.5		50.00	0.00	100.00	52.70	14.52	10
DMW Control	pH	8.20	8.20	8.20	0.00	0.00	1
0.01		8.20	8.20	8.20	0.00	0.00	1
1.6		8.20	8.20	8.20	0.00	0.00	1
3.1		8.20	8.20	8.20	0.00	0.00	1
6.3		8.20	8.20	8.20	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
DMW Control	DO %	101.60	101.60	101.60	0.00	0.00	1
0.01		101.50	101.50	101.50	0.00	0.00	1
1.6		102.10	102.10	102.10	0.00	0.00	1
3.1		103.30	103.30	103.30	0.00	0.00	1
6.3		101.90	101.90	101.90	0.00	0.00	1
12.5		101.30	101.30	101.30	0.00	0.00	1
DMW Control	Cond uS/cm	185.00	185.00	185.00	0.00	0.00	1
0.01		179.60	179.60	179.60	0.00	0.00	1
1.6		184.40	184.40	184.40	0.00	0.00	1
3.1		188.50	188.50	188.50	0.00	0.00	1
6.3		199.60	199.60	199.60	0.00	0.00	1
12.5		230.00	230.00	230.00	0.00	0.00	1

Ceriodaphnia Partial Life-Cycle Test-Reproduction

Start Date: 9/09/2011 13:30 Test ID: PR0787/21 Sample ID: Lady Isabella Pit
 End Date: 16/09/2011 13:30 Lab ID: 4927 Sample Type: AQ-Aqueous
 Sample Date: Protocol: ESA 102 Test Species: CD-Ceriodaphnia dubia
 Comments:

Conc.-%	1	2	3	4	5	6	7	8	9	10
DMW Control	16.000	18.000	12.000	16.000	14.000	14.000	16.000	16.000	16.000	
0.01	16.000	14.000	14.000	6.000	14.000	14.000	13.000	14.000	10.000	10.000
1.6	16.000	15.000	13.000	18.000	12.000	14.000	7.000	12.000	9.000	13.000
3.1	15.000	14.000	14.000	2.000	17.000	16.000	16.000	14.000	4.000	16.000
6.3	14.000	16.000	6.000	16.000	13.000	12.000	12.000	15.000	14.000	14.000
12.5	4.000	0.000	2.000	0.000	2.000	5.000	0.000	3.000	0.000	6.000

Conc.-%	Mean	N-Mean	Transform: Untransformed					Rank Sum	1-Tailed Critical	Isotonic	
			Mean	Min	Max	CV%	N			Mean	N-Mean
DMW Control	15.333	1.0000	15.333	12.000	18.000	11.296	9			15.333	1.0000
0.01	12.500	0.8152	12.500	6.000	16.000	23.627	10	71.50	71.00	12.850	0.8380
1.6	12.900	0.8413	12.900	7.000	18.000	24.906	10	77.00	71.00	12.850	0.8380
3.1	12.800	0.8348	12.800	2.000	17.000	41.307	10	88.50	71.00	12.850	0.8380
6.3	13.200	0.8609	13.200	6.000	16.000	21.957	10	77.00	71.00	12.850	0.8380
*12.5	2.200	0.1435	2.200	0.000	6.000	102.315	10	55.00	71.00	2.200	0.1435

Auxiliary Tests

Kolmogorov D Test indicates non-normal distribution ($p \leq 0.05$) Statistic: 1.249807 Critical: 0.895 Skew: -1.39586 Kurt: 2.399427
 Bartlett's Test indicates equal variances ($p = 0.03$) Statistic: 12.16477 Critical: 15.08627

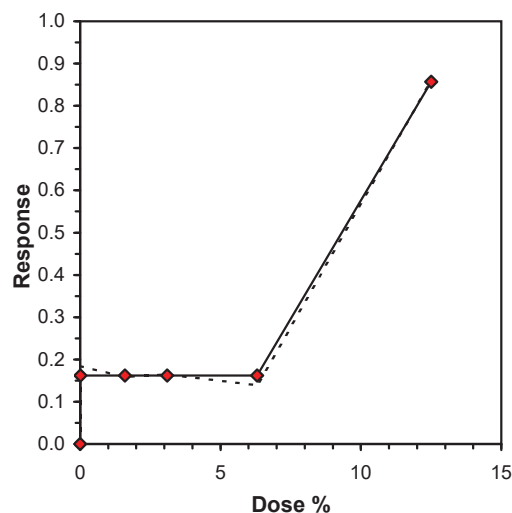
Hypothesis Test (1-tail, 0.05)

NOEC LOEC ChV TU
 Wilcoxon Rank Sum Test 6.3 12.5 8.87412 15.87302
 Treatments vs DMW Control

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL		Skew
IC05*	0.0031	0.5556	0.0022	0.0079	9.6197
IC10*	0.0062	1.7268	0.0043	6.4369	2.6103
IC15*	0.0093	2.7992	0.0065	6.8584	0.5835
IC20	6.6396	2.5280	0.0087	7.2435	-1.0753
IC25	7.0859	1.3475	2.2388	7.6649	-2.6799
IC40	8.4249	0.4211	7.2840	8.9689	-0.7046
IC50	9.3175	0.3808	8.3529	9.8986	-0.3011

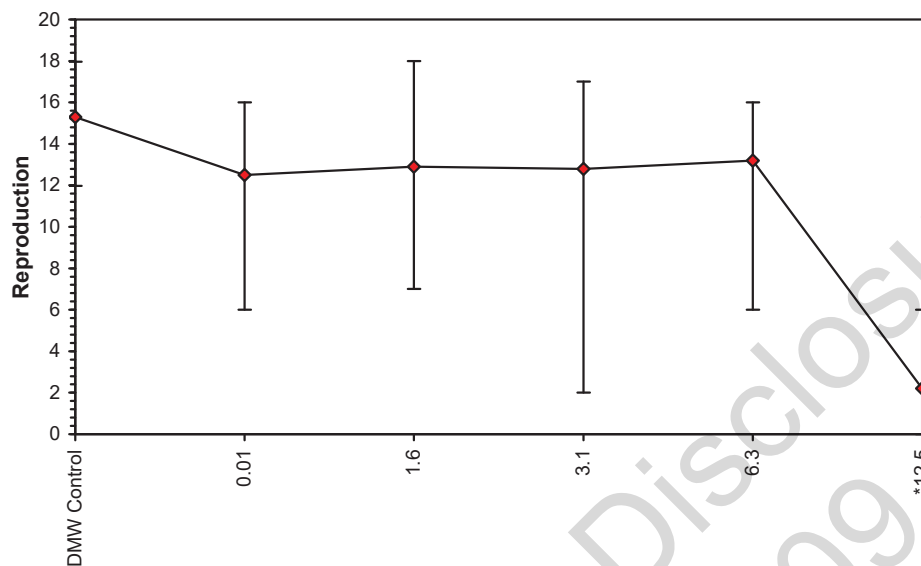
* indicates IC estimate less than the lowest concentration



Ceriodaphnia Partial Life-Cycle Test-Reproduction

Start Date:	9/09/2011 13:30	Test ID:	PR0787/21	Sample ID:	Lady Isabella Pit
End Date:	16/09/2011 13:30	Lab ID:	4927	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



Ceriodaphnia Partial Life-Cycle Test-Reproduction

Start Date:	9/09/2011 13:30	Test ID:	PR0787/21	Sample ID:	Lady Isabella Pit
End Date:	16/09/2011 13:30	Lab ID:	4927	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	No of Young	15.33	12.00	18.00	1.73	8.58	9
0.01		12.50	6.00	16.00	2.95	13.75	10
1.6		12.90	7.00	18.00	3.21	13.89	10
3.1		12.80	2.00	17.00	5.29	17.96	10
6.3		13.20	6.00	16.00	2.90	12.90	10
12.5		2.20	0.00	6.00	2.25	68.20	10
DMW Control	% survival	100.00	100.00	100.00	0.00	0.00	9
0.01		100.00	100.00	100.00	0.00	0.00	10
1.6		100.00	100.00	100.00	0.00	0.00	10
3.1		80.00	0.00	100.00	42.16	8.12	10
6.3		100.00	100.00	100.00	0.00	0.00	10
12.5		50.00	0.00	100.00	52.70	14.52	10
DMW Control	pH	8.20	8.20	8.20	0.00	0.00	1
0.01		8.20	8.20	8.20	0.00	0.00	1
1.6		8.20	8.20	8.20	0.00	0.00	1
3.1		8.20	8.20	8.20	0.00	0.00	1
6.3		8.20	8.20	8.20	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
DMW Control	DO %	101.60	101.60	101.60	0.00	0.00	1
0.01		101.50	101.50	101.50	0.00	0.00	1
1.6		102.10	102.10	102.10	0.00	0.00	1
3.1		103.30	103.30	103.30	0.00	0.00	1
6.3		101.90	101.90	101.90	0.00	0.00	1
12.5		101.30	101.30	101.30	0.00	0.00	1
DMW Control	Cond uS/cm	185.00	185.00	185.00	0.00	0.00	1
0.01		179.60	179.60	179.60	0.00	0.00	1
1.6		184.40	184.40	184.40	0.00	0.00	1
3.1		188.50	188.50	188.50	0.00	0.00	1
6.3		199.60	199.60	199.60	0.00	0.00	1
12.5		230.00	230.00	230.00	0.00	0.00	1

Ceriodaphnia Partial Life-Cycle Test-7 Day Survival

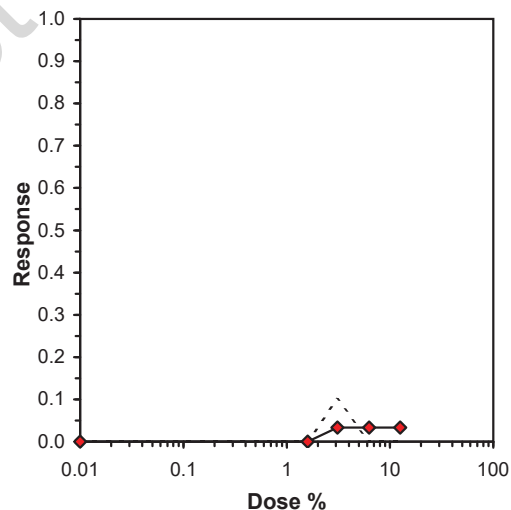
Start Date:	9/09/2011 13:30	Test ID:	PR0787/22
End Date:	16/09/2011 13:30	Lab ID:	4928
Sample Date:		Protocol:	ESA 102
Comments:		Sample ID:	Content Pit
		Sample Type:	AQ-Aqueous
		Test Species:	CD-Ceriodaphnia dubia

Conc-%	1	2	3	4	5	6	7	8	9	10
DMW Control	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
0.01	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1.6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3.1	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6.3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12.5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Conc-%	Mean	N-Mean	Resp	Not Resp	Total	N	Fisher's Exact P	1-Tailed Critical	Isotonic Mean	Isotonic N-Mean
DMW Control	1.0000	1.0000	0	9	9	9			1.0000	1.0000
0.01	1.0000	1.0000	0	10	10	10	1.0000	0.0500	1.0000	1.0000
1.6	1.0000	1.0000	0	10	10	10	1.0000	0.0500	1.0000	1.0000
3.1	0.9000	0.9000	1	9	10	10	0.5263	0.0500	0.9667	0.9667
6.3	1.0000	1.0000	0	10	10	10	1.0000	0.0500	0.9667	0.9667
12.5	1.0000	1.0000	0	10	10	10	1.0000	0.0500	0.9667	0.9667

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Fisher's Exact Test	12.5	>12.5		8
Treatments vs DMW Control				

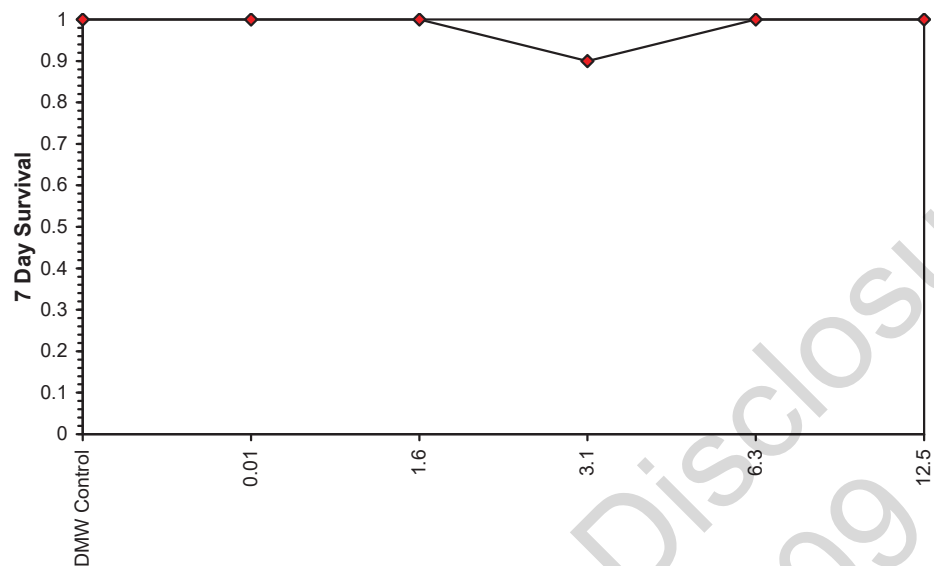
Log-Logit Interpolation (200 Resamples)				
Point	%	SD	95% CL	Skew
IC05	>12.5			
IC10	>12.5			
IC15	>12.5			
IC20	>12.5			
IC25	>12.5			
IC40	>12.5			
IC50	>12.5			



Ceriodaphnia Partial Life-Cycle Test-7 Day Survival

Start Date:	9/09/2011 13:30	Test ID:	PR0787/22	Sample ID:	Content Pit
End Date:	16/09/2011 13:30	Lab ID:	4928	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



Ceriodaphnia Partial Life-Cycle Test-7 Day Survival

Start Date:	9/09/2011 13:30	Test ID:	PR0787/22	Sample ID:	Content Pit
End Date:	16/09/2011 13:30	Lab ID:	4928	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	No of Young	15.33	12.00	18.00	1.73	8.58	9
0.01		15.60	10.00	18.00	2.37	9.86	10
1.6		14.80	12.00	17.00	1.40	7.99	10
3.1		13.30	3.00	17.00	4.42	15.81	10
6.3		7.80	6.00	9.00	0.92	12.29	10
12.5		7.70	6.00	11.00	1.42	15.47	10
DMW Control	% survival	100.00	100.00	100.00	0.00	0.00	9
0.01		100.00	100.00	100.00	0.00	0.00	10
1.6		100.00	100.00	100.00	0.00	0.00	10
3.1		90.00	0.00	100.00	31.62	6.25	10
6.3		100.00	100.00	100.00	0.00	0.00	10
12.5		100.00	100.00	100.00	0.00	0.00	10
DMW Control	pH	8.20	8.20	8.20	0.00	0.00	1
0.01		8.20	8.20	8.20	0.00	0.00	1
1.6		8.20	8.20	8.20	0.00	0.00	1
3.1		8.20	8.20	8.20	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
DMW Control	DO %	101.60	101.60	101.60	0.00	0.00	1
0.01		102.80	102.80	102.80	0.00	0.00	1
1.6		102.70	102.70	102.70	0.00	0.00	1
3.1		101.90	101.90	101.90	0.00	0.00	1
6.3		103.50	103.50	103.50	0.00	0.00	1
12.5		101.70	101.70	101.70	0.00	0.00	1
DMW Control	Cond uS/cm	185.00	185.00	185.00	0.00	0.00	1
0.01		180.20	180.20	180.20	0.00	0.00	1
1.6		188.70	188.70	188.70	0.00	0.00	1
3.1		196.30	196.30	196.30	0.00	0.00	1
6.3		212.00	212.00	212.00	0.00	0.00	1
12.5		243.00	243.00	243.00	0.00	0.00	1

Ceriodaphnia Partial Life-Cycle Test-Reproduction

Start Date: 9/09/2011 13:30 Test ID: PR0787/22 Sample ID: Content Pit
 End Date: 16/09/2011 13:30 Lab ID: 4928 Sample Type: AQ-Aqueous
 Sample Date: Protocol: ESA 102 Test Species: CD-Ceriodaphnia dubia
 Comments:

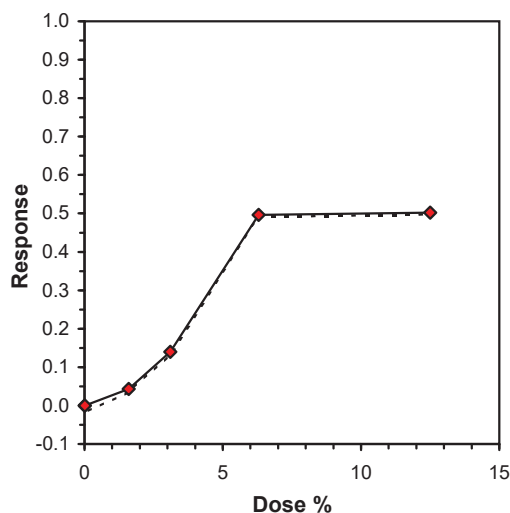
Conc-%	1	2	3	4	5	6	7	8	9	10
DMW Control	16.000	18.000	12.000	16.000	14.000	14.000	16.000	16.000	16.000	
0.01	16.000	18.000	18.000	15.000	17.000	10.000	14.000	15.000	16.000	17.000
1.6	16.000	12.000	15.000	14.000	15.000	14.000	14.000	17.000	16.000	15.000
3.1	16.000	3.000	17.000	16.000	8.000	14.000	13.000	15.000	16.000	15.000
6.3	9.000	8.000	8.000	9.000	8.000	7.000	8.000	7.000	6.000	8.000
12.5	6.000	7.000	6.000	8.000	7.000	8.000	11.000	8.000	8.000	8.000

Conc-%	Mean	N-Mean	Transform: Untransformed					Rank Sum	1-Tailed Critical	Isotonic	
			Mean	Min	Max	CV%	N			Mean	N-Mean
DMW Control	15.333	1.0000	15.333	12.000	18.000	11.296	9			15.467	1.0000
0.01	15.600	1.0174	15.600	10.000	18.000	15.169	10	107.00	71.00	15.467	1.0000
1.6	14.800	0.9652	14.800	12.000	17.000	9.449	10	89.50	71.00	14.800	0.9569
3.1	13.300	0.8674	13.300	3.000	17.000	33.259	10	88.50	71.00	13.300	0.8599
*6.3	7.800	0.5087	7.800	6.000	9.000	11.781	10	55.00	71.00	7.800	0.5043
*12.5	7.700	0.5022	7.700	6.000	11.000	18.417	10	55.00	71.00	7.700	0.4978

Auxiliary Tests		Statistic	Critical	Skew	Kurt
Kolmogorov D Test indicates non-normal distribution (p <= 0.05)		1.396618	0.895	-1.99917	7.192844
Bartlett's Test indicates unequal variances (p = 4.19E-05)		27.68608	15.08627		
Hypothesis Test (1-tail, 0.05)		NOEC	LOEC	ChV	TU
Wilcoxon Rank Sum Test		3.1	6.3	4.419276	32.25806
Treatments vs DMW Control					

Linear Interpolation (200 Resamples)

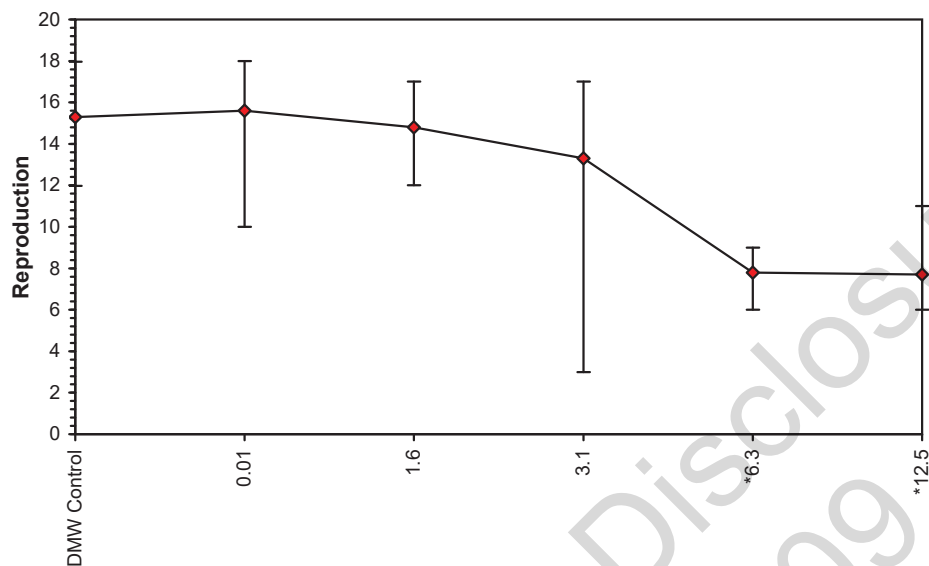
Point	%	SD	95% CL	Skew
IC05	1.707	0.920	0.007	3.428
IC10	2.480	0.734	1.252	3.767
IC15	3.189	0.652	1.926	4.103
IC20	3.639	0.615	2.286	4.445
IC25	4.089	0.601	2.571	4.788
IC40	5.439	0.422	4.326	5.906
IC50	10.433			



Ceriodaphnia Partial Life-Cycle Test-Reproduction

Start Date:	9/09/2011 13:30	Test ID:	PR0787/22	Sample ID:	Content Pit
End Date:	16/09/2011 13:30	Lab ID:	4928	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



Ceriodaphnia Partial Life-Cycle Test-Reproduction

Start Date:	9/09/2011 13:30	Test ID:	PR0787/22	Sample ID:	Content Pit
End Date:	16/09/2011 13:30	Lab ID:	4928	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	No of Young	15.33	12.00	18.00	1.73	8.58	9
0.01		15.60	10.00	18.00	2.37	9.86	10
1.6		14.80	12.00	17.00	1.40	7.99	10
3.1		13.30	3.00	17.00	4.42	15.81	10
6.3		7.80	6.00	9.00	0.92	12.29	10
12.5		7.70	6.00	11.00	1.42	15.47	10
DMW Control	% survival	100.00	100.00	100.00	0.00	0.00	9
0.01		100.00	100.00	100.00	0.00	0.00	10
1.6		100.00	100.00	100.00	0.00	0.00	10
3.1		90.00	0.00	100.00	31.62	6.25	10
6.3		100.00	100.00	100.00	0.00	0.00	10
12.5		100.00	100.00	100.00	0.00	0.00	10
DMW Control	pH	8.20	8.20	8.20	0.00	0.00	1
0.01		8.20	8.20	8.20	0.00	0.00	1
1.6		8.20	8.20	8.20	0.00	0.00	1
3.1		8.20	8.20	8.20	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
DMW Control	DO %	101.60	101.60	101.60	0.00	0.00	1
0.01		102.80	102.80	102.80	0.00	0.00	1
1.6		102.70	102.70	102.70	0.00	0.00	1
3.1		101.90	101.90	101.90	0.00	0.00	1
6.3		103.50	103.50	103.50	0.00	0.00	1
12.5		101.70	101.70	101.70	0.00	0.00	1
DMW Control	Cond uS/cm	185.00	185.00	185.00	0.00	0.00	1
0.01		180.20	180.20	180.20	0.00	0.00	1
1.6		188.70	188.70	188.70	0.00	0.00	1
3.1		196.30	196.30	196.30	0.00	0.00	1
6.3		212.00	212.00	212.00	0.00	0.00	1
12.5		243.00	243.00	243.00	0.00	0.00	1

Statistical Printouts for the Duckweed Growth Inhibition Tests

Duckweed Growth Inhibition Test-Specific Growth Rate

Start Date: 26/08/2011 16:00 Test ID: PR0787/06 Sample ID: Lady Isabella Pit
 End Date: 2/09/2011 16:00 Lab ID: 4927 Sample Type: AQ-Aqueous
 Sample Date: Protocol: ESA 112 Test Species: LD-Lemna disperma
 Comments:

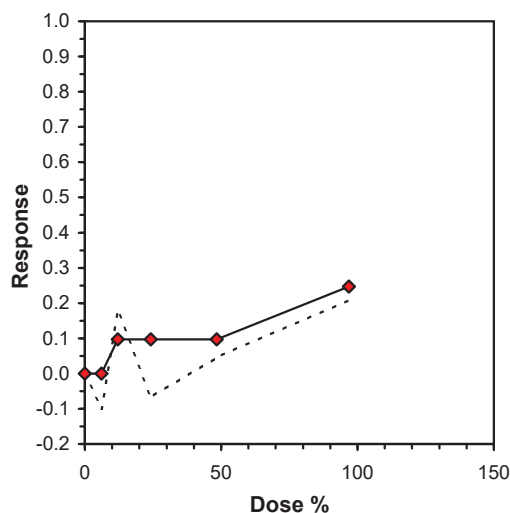
Conc-%	1	2	3	4
SIS Control	0.2369	0.4555	0.3216	0.3718
6.1	0.4047	0.3983	0.4383	0.2830
12.1	0.2499	0.3458	0.2878	0.2560
24.2	0.4005	0.3961	0.2728	0.4109
48.4	0.4129	0.3325	0.2369	0.3393
96.8	0.2728	0.2618	0.3550	0.2067

Conc-%	Transform: Untransformed							t-Stat	1-Tailed Critical	MSD	Isotonic	
	Mean	N-Mean	Mean	Min	Max	CV%	N				Mean	N-Mean
SIS Control	0.3465	1.0000	0.3465	0.2369	0.4555	26.430	4				0.3638	1.0000
6.1	0.3811	1.1000	0.3811	0.2830	0.4383	17.765	4	-0.716	2.410	0.1166	0.3638	1.0000
12.1	0.2849	0.8222	0.2849	0.2499	0.3458	15.404	4	1.273	2.410	0.1166	0.3284	0.9029
24.2	0.3701	1.0682	0.3701	0.2728	0.4109	17.604	4	-0.488	2.410	0.1166	0.3284	0.9029
48.4	0.3304	0.9536	0.3304	0.2369	0.4129	21.851	4	0.332	2.410	0.1166	0.3284	0.9029
96.8	0.2741	0.7911	0.2741	0.2067	0.3550	22.332	4	1.496	2.410	0.1166	0.2741	0.7534

Auxiliary Tests				Statistic			Critical		Skew		Kurt	
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)				0.956918			0.916		-0.30698		-0.55157	
Bartlett's Test indicates equal variances (p = 0.92)				1.439048			15.08627					
Hypothesis Test (1-tail, 0.05)		NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df	
Dunnett's Test		96.8	>96.8		1.033058	0.116611	0.336588	0.007714	0.004682	0.198358	5, 18	
Treatments vs SIS Control												

Linear Interpolation (200 Resamples)

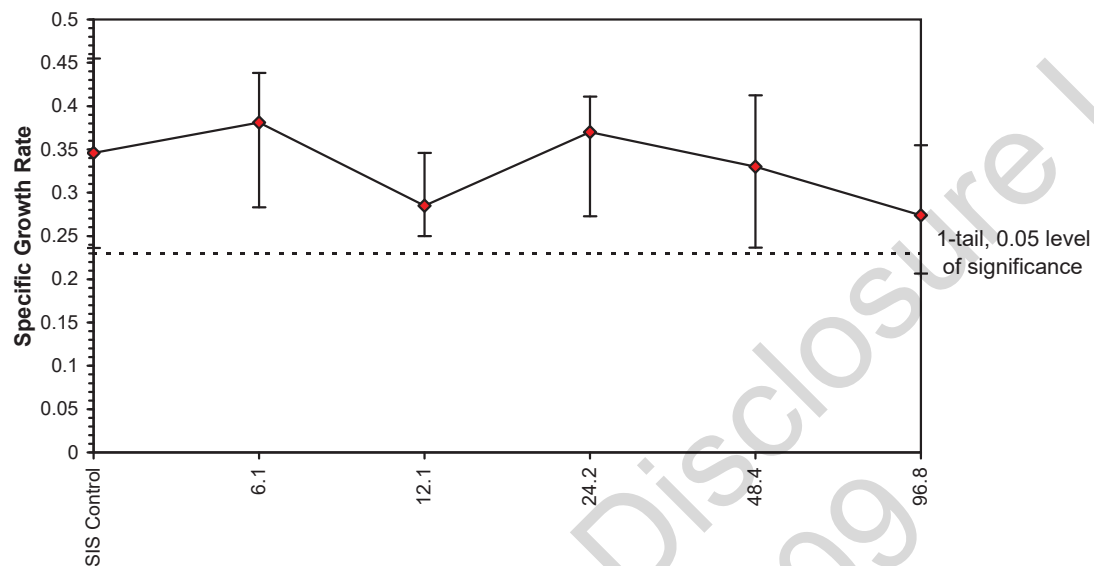
Point	%	SD	95% CL(Exp)	Skew
IC05	9.189			
IC10	49.333			
IC15	65.525			
IC20	81.716			
IC25	>96.8			
IC40	>96.8			
IC50	>96.8			



Duckweed Growth Inhibition Test-Specific Growth Rate

Start Date:	26/08/2011 16:00	Test ID:	PR0787/06	Sample ID:	Lady Isabella Pit
End Date:	2/09/2011 16:00	Lab ID:	4927	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 112	Test Species:	LD-Lemna disperma
Comments:					

Dose-Response Plot



Duckweed Growth Inhibition Test-Specific Growth Rate

Start Date: 26/08/2011 16:00 Test ID: PR0787/06 Sample ID: Lady Isabella Pit
 End Date: 2/09/2011 16:00 Lab ID: 4927 Sample Type: AQ-Aqueous
 Sample Date: Protocol: ESA 112 Test Species: LD-Lemna disperma
 Comments:

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
SIS Control	Specific Growth Rate	0.35	0.24	0.46	0.09	87.34	4
6.1		0.38	0.28	0.44	0.07	68.28	4
12.1		0.28	0.25	0.35	0.04	73.54	4
24.2		0.37	0.27	0.41	0.07	68.97	4
48.4		0.33	0.24	0.41	0.07	81.33	4
96.8		0.27	0.21	0.35	0.06	90.27	4
SIS Control	pH	6.40	6.40	6.40	0.00	0.00	1
6.1		6.40	6.40	6.40	0.00	0.00	1
12.1		6.40	6.40	6.40	0.00	0.00	1
24.2		6.40	6.40	6.40	0.00	0.00	1
48.4		6.30	6.30	6.30	0.00	0.00	1
96.8		6.20	6.20	6.20	0.00	0.00	1
SIS Control	Cond uS/cm	290.00	290.00	290.00	0.00	0.00	1
6.1		317.00	317.00	317.00	0.00	0.00	1
12.1		347.00	347.00	347.00	0.00	0.00	1
24.2		406.00	406.00	406.00	0.00	0.00	1
48.4		520.00	520.00	520.00	0.00	0.00	1
96.8		747.00	747.00	747.00	0.00	0.00	1

Duckweed Growth Inhibition Test-Specific Growth Rate

Start Date: 26/08/2011 16:00 Test ID: PR0787/07 Sample ID: Content Pit
 End Date: 2/09/2011 16:00 Lab ID: 4928 Sample Type: AQ-Aqueous
 Sample Date: Protocol: ESA 112 Test Species: LD-Lemna disperma
 Comments:

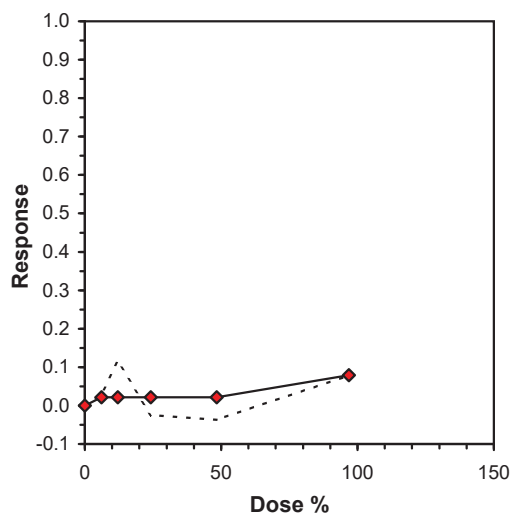
Conc-%	1	2	3	4
SIS Control	0.2369	0.4555	0.3216	0.3718
6.1	0.2780	0.4129	0.3359	0.3139
12.1	0.3426	0.3608	0.2226	0.3015
24.2	0.3359	0.3845	0.2925	0.4068
48.4	0.3015	0.4005	0.3139	0.4206
96.8	0.3636	0.3015	0.2971	0.3139

Conc-%	Mean	N-Mean	Transform: Untransformed					t-Stat	1-Tailed Critical	MSD	Isotonic	
			Mean	Min	Max	CV%	N				Mean	N-Mean
SIS Control	0.3465	1.0000	0.3465	0.2369	0.4555	26.430	4				0.3465	1.0000
6.1	0.3352	0.9675	0.3352	0.2780	0.4129	17.023	4	0.260	2.410	0.1045	0.3390	0.9786
12.1	0.3069	0.8857	0.3069	0.2226	0.3608	20.015	4	0.913	2.410	0.1045	0.3390	0.9786
24.2	0.3549	1.0245	0.3549	0.2925	0.4068	14.386	4	-0.196	2.410	0.1045	0.3390	0.9786
48.4	0.3591	1.0366	0.3591	0.3015	0.4206	16.758	4	-0.292	2.410	0.1045	0.3390	0.9786
96.8	0.3190	0.9208	0.3190	0.2971	0.3636	9.591	4	0.633	2.410	0.1045	0.3190	0.9208

Auxiliary Tests					Statistic	Critical	Skew	Kurt			
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)					0.983907	0.916	-0.0394	-0.47726			
Bartlett's Test indicates equal variances (p = 0.70)					3.020747	15.08627					
Hypothesis Test (1-tail, 0.05)		NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test		96.8	>96.8		1.033058	0.104535	0.30173	0.001708	0.003763	0.804956	5, 18
Treatments vs SIS Control											

Linear Interpolation (200 Resamples)

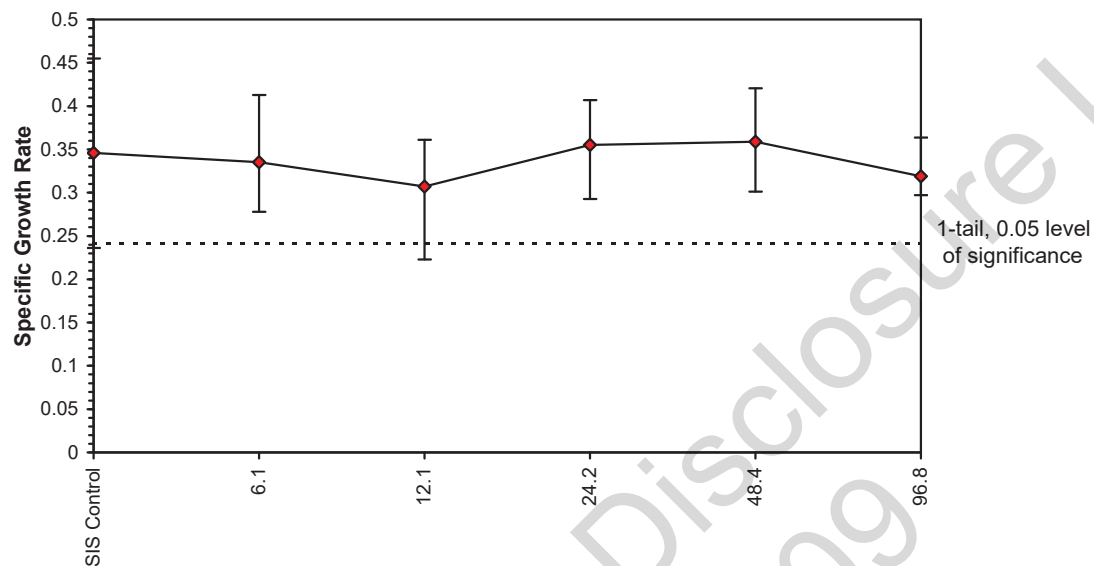
Point	%	SD	95% CL(Exp)	Skew
IC05	72.331			
IC10	>96.8			
IC15	>96.8			
IC20	>96.8			
IC25	>96.8			
IC40	>96.8			
IC50	>96.8			



Duckweed Growth Inhibition Test-Specific Growth Rate

Start Date:	26/08/2011 16:00	Test ID:	PR0787/07	Sample ID:	Content Pit
End Date:	2/09/2011 16:00	Lab ID:	4928	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 112	Test Species:	LD-Lemna disperma
Comments:					

Dose-Response Plot



Duckweed Growth Inhibition Test-Specific Growth Rate

Start Date: 26/08/2011 16:00 Test ID: PR0787/07 Sample ID: Content Pit
End Date: 2/09/2011 16:00 Lab ID: 4928 Sample Type: AQ-Aqueous
Sample Date: Protocol: ESA 112 Test Species: LD-Lemna disperma
Comments:

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
SIS Control	Specific Growth Rate	0.35	0.24	0.46	0.09	87.34	4
6.1		0.34	0.28	0.41	0.06	71.27	4
12.1		0.31	0.22	0.36	0.06	80.76	4
24.2		0.35	0.29	0.41	0.05	63.66	4
48.4		0.36	0.30	0.42	0.06	68.31	4
96.8		0.32	0.30	0.36	0.03	54.83	4
SIS Control	pH	6.40	6.40	6.40	0.00	0.00	1
6.1		6.40	6.40	6.40	0.00	0.00	1
12.1		6.40	6.40	6.40	0.00	0.00	1
24.2		6.40	6.40	6.40	0.00	0.00	1
48.4		6.30	6.30	6.30	0.00	0.00	1
96.8		6.20	6.20	6.20	0.00	0.00	1
SIS Control	Cond uS/cm	290.00	290.00	290.00	0.00	0.00	1
6.1		329.00	329.00	329.00	0.00	0.00	1
12.1		370.00	370.00	370.00	0.00	0.00	1
24.2		449.00	449.00	449.00	0.00	0.00	1
48.4		608.00	608.00	608.00	0.00	0.00	1
96.8		909.00	909.00	909.00	0.00	0.00	1

**Statistical Printouts for the Acute
Test with *Chironomus tepperi***

Chironomid Acute Toxicity Test-48hr Survival

Start Date: 26/08/2011 13:00 Test ID: PR0787/02 Sample ID: Lady Isabella Pit
 End Date: 28/08/2011 13:00 Lab ID: 4927 Sample Type: AQ-Aqueous
 Sample Date: Protocol: Test Species: CT-Chironomus tepperi
 Comments:

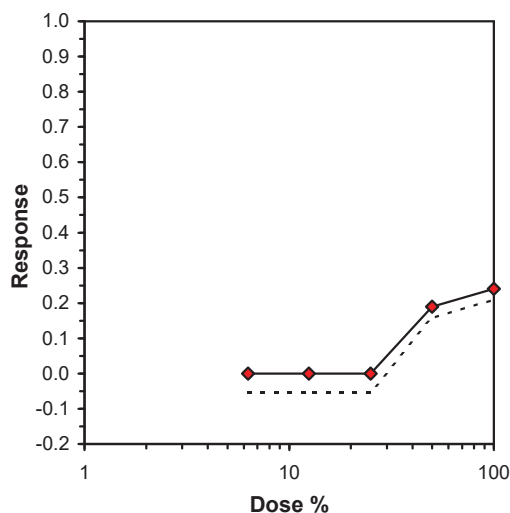
Conc-%	1	2	3	4
DMW Control	0.8000	1.0000	1.0000	1.0000
6.3	1.0000	1.0000	1.0000	1.0000
12.5	1.0000	1.0000	1.0000	1.0000
25	1.0000	1.0000	1.0000	1.0000
50	0.8000	0.6000	0.8000	1.0000
100	0.4000	1.0000	1.0000	0.6000

Conc-%	Transform: Arcsin Square Root							Rank Sum	1-Tailed Critical	Isotonic	
	Mean	N-Mean	Mean	Min	Max	CV%	N			Mean	N-Mean
DMW Control	0.9500	1.0000	1.2857	1.1071	1.3453	9.261	4			0.9875	1.0000
6.3	1.0000	1.0526	1.3453	1.3453	1.3453	0.000	4	20.00	10.00	0.9875	1.0000
12.5	1.0000	1.0526	1.3453	1.3453	1.3453	0.000	4	20.00	10.00	0.9875	1.0000
25	1.0000	1.0526	1.3453	1.3453	1.3453	0.000	4	20.00	10.00	0.9875	1.0000
50	0.8000	0.8421	1.1114	0.8861	1.3453	16.874	4	13.50	10.00	0.8000	0.8101
100	0.7500	0.7895	1.0653	0.6847	1.3453	31.308	4	15.00	10.00	0.7500	0.7595

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.826684	0.916	-0.32448	1.831942
Equality of variance cannot be confirmed				
Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	100	>100		1
Treatments vs DMW Control				

Log-Logit Interpolation (200 Resamples)

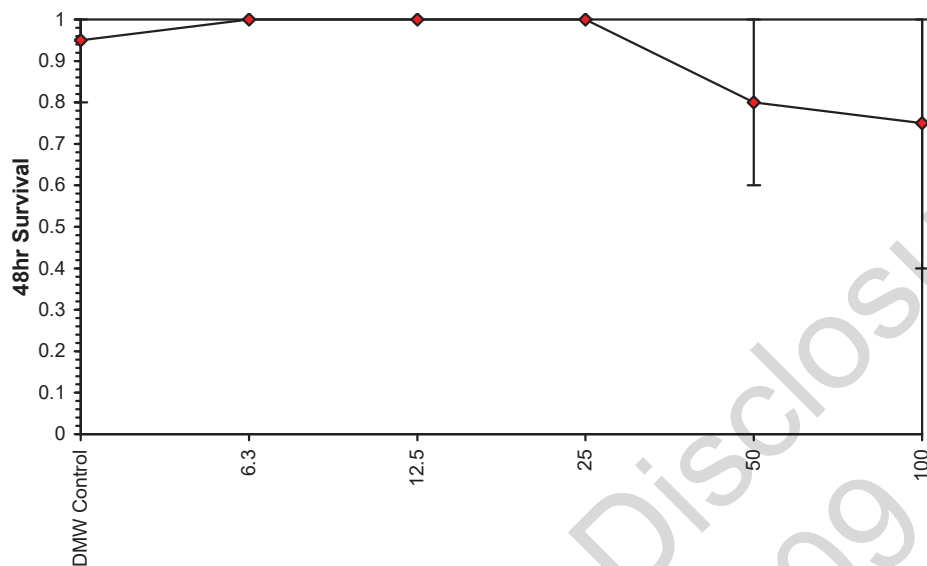
Point	%	SD	95% CL(Exp)		Skew
IC05	36.747	5.555	30.905	52.300	3.0354
IC10	42.624				
IC15	47.012				
IC20	58.003				
IC25	>100				
IC40	>100				
IC50	>100				



Chironomid Acute Toxicity Test-48hr Survival

Start Date:	26/08/2011 13:00	Test ID:	PR0787/02	Sample ID:	Lady Isabella Pit
End Date:	28/08/2011 13:00	Lab ID:	4927	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:		Test Species:	CT-Chironomus tepperi
Comments:					

Dose-Response Plot



Chironomid Acute Toxicity Test-48hr Survival

Start Date: 26/08/2011 13:00 Test ID: PR0787/02 Sample ID: Lady Isabella Pit
 End Date: 28/08/2011 13:00 Lab ID: 4927 Sample Type: AQ-Aqueous
 Sample Date: Protocol: Test Species: CT-Chironomus tepperi
 Comments:

		Auxiliary Data Summary					
Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	% Survival	95.00	80.00	100.00	10.00	3.33	4
6.3		100.00	100.00	100.00	0.00	0.00	4
12.5		100.00	100.00	100.00	0.00	0.00	4
25		100.00	100.00	100.00	0.00	0.00	4
50		80.00	60.00	100.00	16.33	5.05	4
100		75.00	40.00	100.00	30.00	7.30	4
DMW Control	pH	8.00	8.00	8.00	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.00	8.00	8.00	0.00	0.00	1
25		7.80	7.80	7.80	0.00	0.00	1
50		7.40	7.40	7.40	0.00	0.00	1
100		4.50	4.50	4.50	0.00	0.00	1
DMW Control	Cond uS/cm	172.40	172.40	172.40	0.00	0.00	1
6.3		195.20	195.20	195.20	0.00	0.00	1
12.5		213.00	213.00	213.00	0.00	0.00	1
25		254.00	254.00	254.00	0.00	0.00	1
50		334.00	334.00	334.00	0.00	0.00	1
100		518.00	518.00	518.00	0.00	0.00	1
DMW Control	DO %	100.50	100.50	100.50	0.00	0.00	1
6.3		99.80	99.80	99.80	0.00	0.00	1
12.5		98.70	98.70	98.70	0.00	0.00	1
25		99.10	99.10	99.10	0.00	0.00	1
50		100.30	100.30	100.30	0.00	0.00	1
100		99.90	99.90	99.90	0.00	0.00	1

Chironomid Acute Toxicity Test-48hr Survival

Start Date: 26/08/2011 13:00 Test ID: PR0787/03 Sample ID: Content Pit
 End Date: 28/08/2011 13:00 Lab ID: 4928 Sample Type: AQ-Aqueous
 Sample Date: Protocol: Test Species: CT-Chironomus tepperi
 Comments:

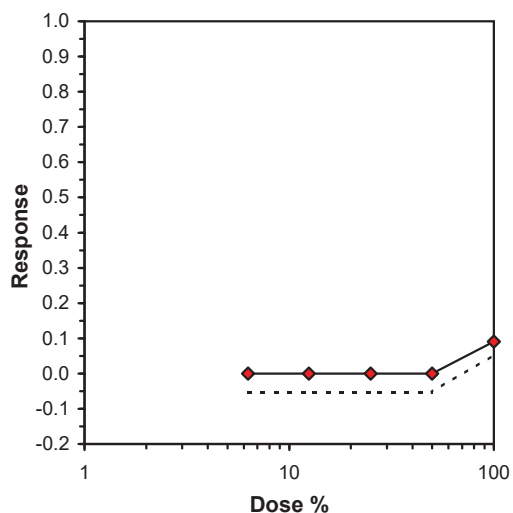
Conc-%	1	2	3	4
DMW Control	0.8000	1.0000	1.0000	1.0000
6.3	1.0000	1.0000	1.0000	1.0000
12.5	1.0000	1.0000	1.0000	1.0000
25	1.0000	1.0000	1.0000	1.0000
50	1.0000	1.0000	1.0000	1.0000
100	0.8000	0.8000	1.0000	1.0000

Conc-%	Mean	N-Mean	Transform: Arcsin Square Root					Rank Sum	1-Tailed Critical	Isotonic	
			Mean	Min	Max	CV%	N			Mean	N-Mean
DMW Control	0.9500	1.0000	1.2857	1.1071	1.3453	9.261	4			0.9900	1.0000
6.3	1.0000	1.0526	1.3453	1.3453	1.3453	0.000	4	20.00	10.00	0.9900	1.0000
12.5	1.0000	1.0526	1.3453	1.3453	1.3453	0.000	4	20.00	10.00	0.9900	1.0000
25	1.0000	1.0526	1.3453	1.3453	1.3453	0.000	4	20.00	10.00	0.9900	1.0000
50	1.0000	1.0526	1.3453	1.3453	1.3453	0.000	4	20.00	10.00	0.9900	1.0000
100	0.9000	0.9474	1.2262	1.1071	1.3453	11.212	4	16.00	10.00	0.9000	0.9091

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.771269	0.916	-0.84747	2.203684
Equality of variance cannot be confirmed				
Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	100	>100		1
Treatments vs DMW Control				

Log-Logit Interpolation (200 Resamples)

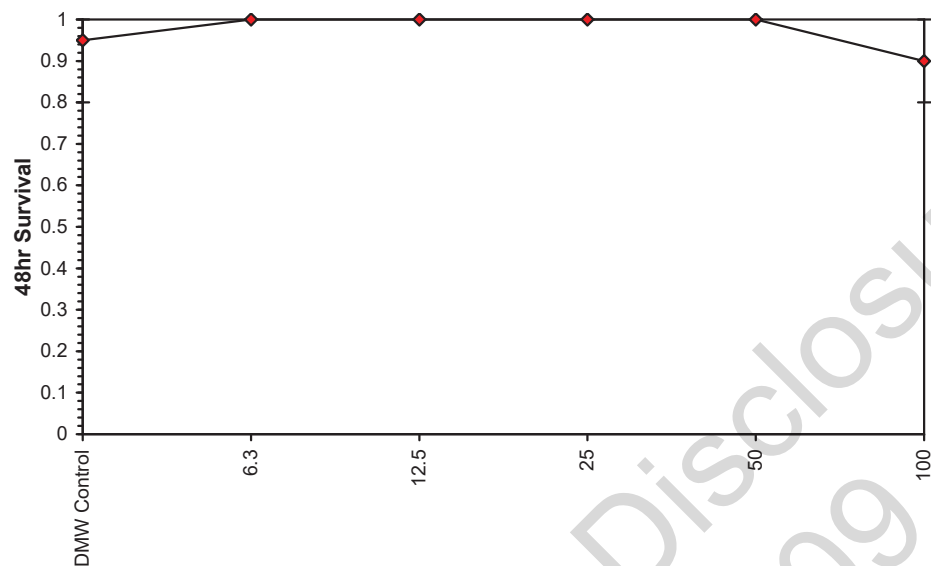
Point	%	SD	95% CL(Exp)	Skew
IC05	85.024			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



Chironomid Acute Toxicity Test-48hr Survival

Start Date:	26/08/2011 13:00	Test ID:	PR0787/03	Sample ID:	Content Pit
End Date:	28/08/2011 13:00	Lab ID:	4928	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:		Test Species:	CT-Chironomus tepperi
Comments:					

Dose-Response Plot



Chironomid Acute Toxicity Test-48hr Survival

Start Date: 26/08/2011 13:00 Test ID: PR0787/03 Sample ID: Content Pit
 End Date: 28/08/2011 13:00 Lab ID: 4928 Sample Type: AQ-Aqueous
 Sample Date: Protocol: Test Species: CT-Chironomus tepperi
 Comments:

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	% Survival	95.00	80.00	100.00	10.00	3.33	4
6.3		100.00	100.00	100.00	0.00	0.00	4
12.5		100.00	100.00	100.00	0.00	0.00	4
25		100.00	100.00	100.00	0.00	0.00	4
50		100.00	100.00	100.00	0.00	0.00	4
100		90.00	80.00	100.00	11.55	3.78	4
DMW Control	pH	8.00	8.00	8.00	0.00	0.00	1
6.3		7.90	7.90	7.90	0.00	0.00	1
12.5		7.80	7.80	7.80	0.00	0.00	1
25		7.70	7.70	7.70	0.00	0.00	1
50		7.40	7.40	7.40	0.00	0.00	1
100		4.30	4.30	4.30	0.00	0.00	1
DMW Control	Cond uS/cm	172.40	172.40	172.40	0.00	0.00	1
6.3		206.00	206.00	206.00	0.00	0.00	1
12.5		236.00	236.00	236.00	0.00	0.00	1
25		300.00	300.00	300.00	0.00	0.00	1
50		428.00	428.00	428.00	0.00	0.00	1
100		709.00	709.00	709.00	0.00	0.00	1
DMW Control	DO %	100.50	100.50	100.50	0.00	0.00	1
6.3		100.20	100.20	100.20	0.00	0.00	1
12.5		98.60	98.60	98.60	0.00	0.00	1
25		99.60	99.60	99.60	0.00	0.00	1
50		99.90	99.90	99.90	0.00	0.00	1
100		98.60	98.60	98.60	0.00	0.00	1

Statistical Printouts for the Freshwater Shrimp Tests

Freshwater Shrimp Acute Toxicity Test-96 hr Survival

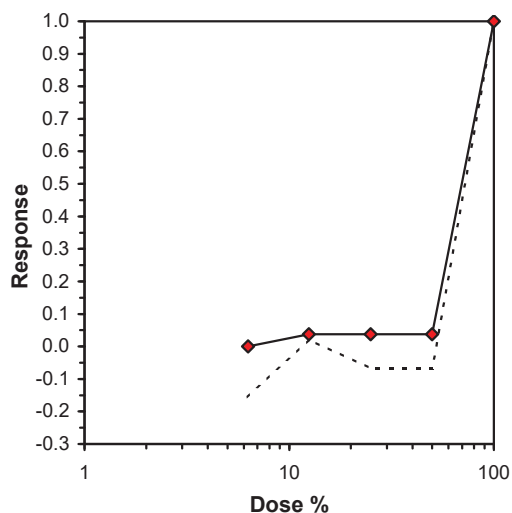
Start Date: 8/09/2011 15:00 Test ID: PR0787/10 Sample ID: Lady Isabella Pit
 End Date: 12/09/2011 15:00 Lab ID: 4927 Sample Type: AQ-Aqueous
 Sample Date: Protocol: ESA 107 Test Species: MD-Macrobrachium australiense
 Comments:

Conc-%	1	2	3	4
DMW Control	1.0000	0.6000	0.6000	0.8000
6.3	0.8000	1.0000	0.8000	
12.5	0.8000	0.8000	0.6000	
25	0.8000	0.8000	0.8000	
50	1.0000	0.8000	0.6000	
100	0.0000	0.0000	0.0000	

Conc-%	Mean	N-Mean	Transform: Arcsin Square Root				N	t-Stat	1-Tailed Critical	MSD	Number Resp	Total Number
			Mean	Min	Max	CV%						
DMW Control	0.7500	1.0000	1.0561	0.8861	1.3453	20.748	4				5	20
6.3	0.8667	1.1556	1.1865	1.1071	1.3453	11.587	3	-1.001	2.593	0.3378	2	15
12.5	0.7333	0.9778	1.0335	0.8861	1.1071	12.350	3	0.174	2.593	0.3378	4	15
25	0.8000	1.0667	1.1071	1.1071	1.1071	0.000	3	-0.392	2.593	0.3378	3	15
50	0.8000	1.0667	1.1128	0.8861	1.3453	20.637	3	-0.435	2.593	0.3378	3	15
100	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	3				15	15

Auxiliary Tests					Statistic	Critical	Skew	Kurt						
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)					0.961493	0.887	0.390541	-0.31868						
Equality of variance cannot be confirmed														
Hypothesis Test (1-tail, 0.05)					NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Bonferroni t Test					50	100	70.71068	2	0.324514	0.428283	0.010973	0.029084	0.820237	4, 11
Treatments vs DMW Control														

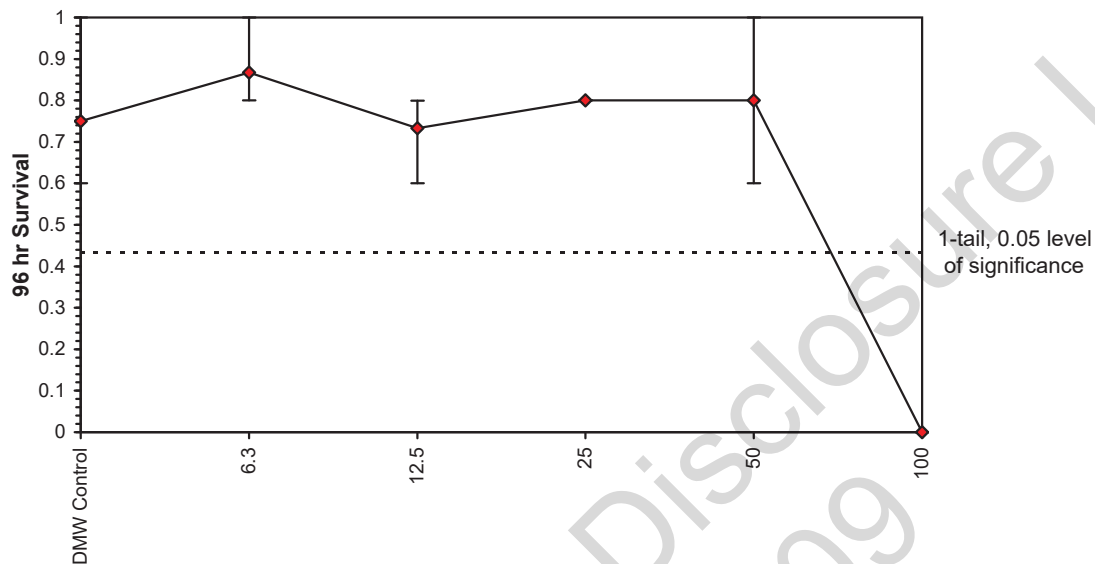
Trimmed Spearman-Kärber			
Trim Level	EC50	95% CL	
0.0%	65.375	58.098	73.564
5.0%	69.754	67.230	72.374
10.0%	69.754	67.230	72.374
20.0%	69.754	67.230	72.374
Auto-0.0%	65.375	58.098	73.564



Freshwater Shrimp Acute Toxicity Test-96 hr Survival

Start Date:	8/09/2011 15:00	Test ID:	PR0787/10	Sample ID:	Lady Isabella Pit
End Date:	12/09/2011 15:00	Lab ID:	4927	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 107	Test Species:	MD-Macrobrachium australiense
Comments:					

Dose-Response Plot



Freshwater Shrimp Acute Toxicity Test-96 hr Survival

Start Date:	8/09/2011 15:00	Test ID:	PR0787/10	Sample ID:	Lady Isabella Pit
End Date:	12/09/2011 15:00	Lab ID:	4927	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 107	Test Species:	MD-Macrobrachium australiense
Comments:					

		Auxiliary Data Summary					
Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	% Survival	75.00	60.00	100.00	19.15	5.83	4
6.3		86.67	80.00	100.00	11.55	3.92	3
12.5		73.33	60.00	80.00	11.55	4.63	3
25		80.00	80.00	80.00	0.00	0.00	3
50		80.00	60.00	100.00	20.00	5.59	3
100		0.00	0.00	0.00	0.00		3
DMW Control	pH	8.00	8.00	8.00	0.00	0.00	1
6.3		7.80	7.80	7.80	0.00	0.00	1
12.5		7.80	7.80	7.80	0.00	0.00	1
25		7.70	7.70	7.70	0.00	0.00	1
50		7.60	7.60	7.60	0.00	0.00	1
100		4.30	4.30	4.30	0.00	0.00	1
DMW Control	Cond uS/cm	0.17	0.17	0.17	0.00	0.00	1
6.3		191.20	191.20	191.20	0.00	0.00	1
12.5		211.00	211.00	211.00	0.00	0.00	1
25		251.00	251.00	251.00	0.00	0.00	1
50		336.00	336.00	336.00	0.00	0.00	1
100		525.00	525.00	525.00	0.00	0.00	1
DMW Control	DO %	101.30	101.30	101.30	0.00	0.00	1
6.3		117.50	117.50	117.50	0.00	0.00	1
12.5		118.20	118.20	118.20	0.00	0.00	1
25		118.90	118.90	118.90	0.00	0.00	1
50		119.30	119.30	119.30	0.00	0.00	1
100		121.00	121.00	121.00	0.00	0.00	1

Freshwater Shrimp Acute Toxicity Test-96 hr Survival

Start Date: 8/09/2011 15:00 Test ID: PR0787/10 Sample ID: Lady Isabella Pit
End Date: 12/09/2011 15:00 Lab ID: 4927 Sample Type: AQ-Aqueous
Sample Date: Protocol: ESA 107 Test Species: MD-Macrobrachium australiense
Comments:

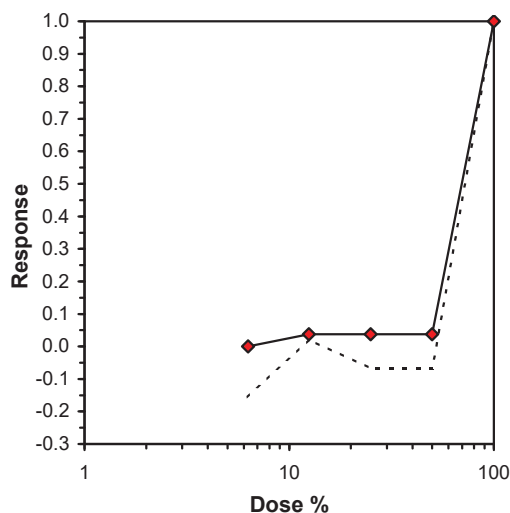
Conc-%	1	2	3	4
DMW Control	1.0000	0.6000	0.6000	0.8000
6.3	0.8000	1.0000	0.8000	
12.5	0.8000	0.8000	0.6000	
25	0.8000	0.8000	0.8000	
50	1.0000	0.8000	0.6000	
100	0.0000	0.0000	0.0000	

Conc-%	Mean	N-Mean	Transform: Arcsin Square Root					t-Stat	1-Tailed Critical	MSD	Isotonic	
			Mean	Min	Max	CV%	N				Mean	N-Mean
DMW Control	0.7500	1.0000	1.0561	0.8861	1.3453	20.748	4				0.8083	1.0000
6.3	0.8667	1.1556	1.1865	1.1071	1.3453	11.587	3	-1.001	2.593	0.3378	0.8083	1.0000
12.5	0.7333	0.9778	1.0335	0.8861	1.1071	12.350	3	0.174	2.593	0.3378	0.7778	0.9622
25	0.8000	1.0667	1.1071	1.1071	1.1071	0.000	3	-0.392	2.593	0.3378	0.7778	0.9622
50	0.8000	1.0667	1.1128	0.8861	1.3453	20.637	3	-0.435	2.593	0.3378	0.7778	0.9622
100	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	3				0.0000	0.0000

Auxiliary Tests					Statistic	Critical	Skew	Kurt						
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)					0.961493	0.887	0.390541	-0.31868						
Equality of variance cannot be confirmed														
Hypothesis Test (1-tail, 0.05)					NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Bonferroni t Test					50	100	70.71068	2	0.324514	0.428283	0.010973	0.029084	0.820237	4, 11
Treatments vs DMW Control														

Log-Logit Interpolation (200 Resamples)

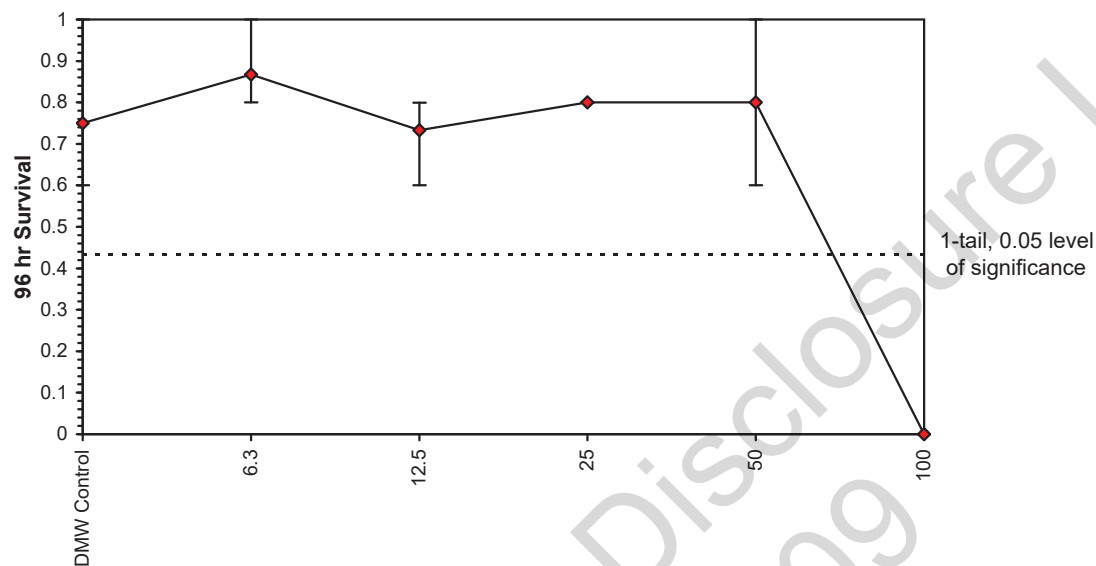
Point	%	SD	95% CL(Exp)		Skew
IC05	50.187	19.196	0.000	51.558	-0.4773
IC10	50.910	15.059	0.000	52.330	-1.4887
IC15	51.577	8.946	0.000	53.030	-3.2272
IC20	52.206	4.844	24.356	53.683	-6.3435
IC25	52.810	2.781	39.387	54.304	-6.9377
IC40	54.565	1.008	48.677	56.087	-1.1537
IC50	55.769	0.983	50.004	57.292	-1.1253



Freshwater Shrimp Acute Toxicity Test-96 hr Survival

Start Date:	8/09/2011 15:00	Test ID:	PR0787/10	Sample ID:	Lady Isabella Pit
End Date:	12/09/2011 15:00	Lab ID:	4927	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 107	Test Species:	MD-Macrobrachium australiense
Comments:					

Dose-Response Plot



Freshwater Shrimp Acute Toxicity Test-96 hr Survival

Start Date:	8/09/2011 15:00	Test ID:	PR0787/10	Sample ID:	Lady Isabella Pit
End Date:	12/09/2011 15:00	Lab ID:	4927	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 107	Test Species:	MD-Macrobrachium australiense
Comments:					

		Auxiliary Data Summary					
Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	% Survival	75.00	60.00	100.00	19.15	5.83	4
6.3		86.67	80.00	100.00	11.55	3.92	3
12.5		73.33	60.00	80.00	11.55	4.63	3
25		80.00	80.00	80.00	0.00	0.00	3
50		80.00	60.00	100.00	20.00	5.59	3
100		0.00	0.00	0.00	0.00		3
DMW Control	pH	8.00	8.00	8.00	0.00	0.00	1
6.3		7.80	7.80	7.80	0.00	0.00	1
12.5		7.80	7.80	7.80	0.00	0.00	1
25		7.70	7.70	7.70	0.00	0.00	1
50		7.60	7.60	7.60	0.00	0.00	1
100		4.30	4.30	4.30	0.00	0.00	1
DMW Control	Cond uS/cm	0.17	0.17	0.17	0.00	0.00	1
6.3		191.20	191.20	191.20	0.00	0.00	1
12.5		211.00	211.00	211.00	0.00	0.00	1
25		251.00	251.00	251.00	0.00	0.00	1
50		336.00	336.00	336.00	0.00	0.00	1
100		525.00	525.00	525.00	0.00	0.00	1
DMW Control	DO %	101.30	101.30	101.30	0.00	0.00	1
6.3		117.50	117.50	117.50	0.00	0.00	1
12.5		118.20	118.20	118.20	0.00	0.00	1
25		118.90	118.90	118.90	0.00	0.00	1
50		119.30	119.30	119.30	0.00	0.00	1
100		121.00	121.00	121.00	0.00	0.00	1

Freshwater Shrimp Acute Toxicity Test-96 hr Survival

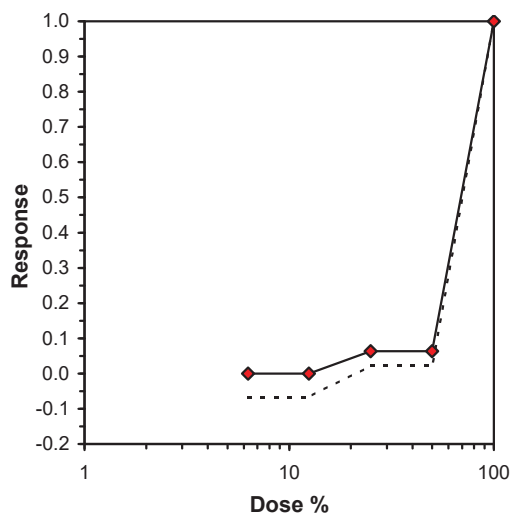
Start Date: 8/09/2011 15:00 Test ID: PR0787/11 Sample ID: Content Pit
End Date: 12/09/2011 15:00 Lab ID: 4928 Sample Type: AQ-Aqueous
Sample Date: Protocol: ESA 107 Test Species: MD-Macrobrachium australiense
Comments:

Conc-%	1	2	3	4
DMW Control	1.0000	0.6000	0.6000	0.8000
6.3	0.8000	0.8000	0.8000	
12.5	0.6000	1.0000		
25	0.8000	0.6000	0.8000	
50	0.8000	0.6000	0.8000	
100	0.0000	0.0000	0.0000	

Conc-%	Mean	N-Mean	Transform: Arcsin Square Root				N	t-Stat	1-Tailed Critical	MSD	Number Resp	Total Number
			Mean	Min	Max	CV%						
DMW Control	0.7500	1.0000	1.0561	0.8861	1.3453	20.748	4				5	20
6.3	0.8000	1.0667	1.1071	1.1071	1.1071	0.000	3	-0.376	2.634	0.3568	3	15
12.5	0.8000	1.0667	1.1157	0.8861	1.3453	29.104	2	-0.388	2.634	0.4046	2	10
25	0.7333	0.9778	1.0335	0.8861	1.1071	12.350	3	0.167	2.634	0.3568	4	15
50	0.7333	0.9778	1.0335	0.8861	1.1071	12.350	3	0.167	2.634	0.3568	4	15
100	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	3				15	15

Auxiliary Tests					Statistic		Critical		Skew		Kurt			
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)					0.927515		0.881		0.236404		-0.44311			
Equality of variance cannot be confirmed														
Hypothesis Test (1-tail, 0.05)					NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Bonferroni t Test					50	100	70.71068	2	0.343355	0.453149	0.004187	0.031465	0.966564	4, 10
Treatments vs DMW Control														

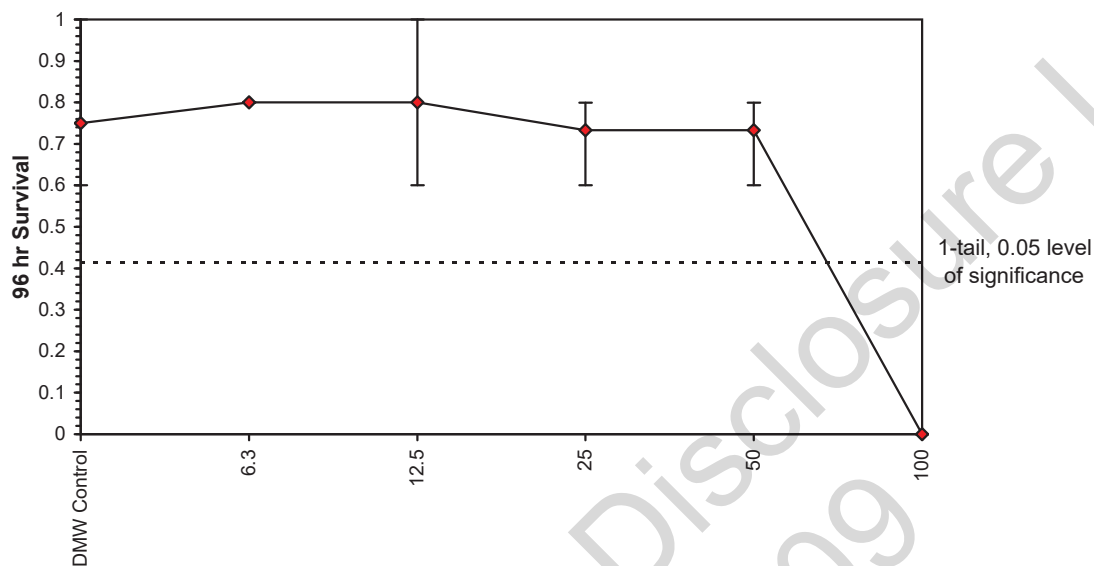
Trimmed Spearman-Kärber			
Trim Level	EC50	95% CL	
0.0%	64.723	57.189	73.248
5.0%	68.254	60.646	76.817
10.0%	69.059	65.697	72.594
20.0%	69.059	65.697	72.594
Auto-0.0%	64.723	57.189	73.248



Freshwater Shrimp Acute Toxicity Test-96 hr Survival

Start Date:	8/09/2011 15:00	Test ID:	PR0787/11	Sample ID:	Content Pit
End Date:	12/09/2011 15:00	Lab ID:	4928	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 107	Test Species:	MD-Macrobrachium australiense
Comments:					

Dose-Response Plot



Freshwater Shrimp Acute Toxicity Test-96 hr Survival

Start Date:	8/09/2011 15:00	Test ID:	PR0787/11	Sample ID:	Content Pit
End Date:	12/09/2011 15:00	Lab ID:	4928	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 107	Test Species:	MD-Macrobrachium australiense
Comments:					

		Auxiliary Data Summary					
Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	% Survival	75.00	60.00	100.00	19.15	5.83	4
6.3		80.00	80.00	80.00	0.00	0.00	3
12.5		80.00	60.00	100.00	28.28	6.65	2
25		73.33	60.00	80.00	11.55	4.63	3
50		73.33	60.00	80.00	11.55	4.63	3
100		0.00	0.00	0.00	0.00		3
DMW Control	pH	8.00	8.00	8.00	0.00	0.00	1
6.3		8.00	8.00	8.00	0.00	0.00	1
12.5		7.90	7.90	7.90	0.00	0.00	1
25		7.80	7.80	7.80	0.00	0.00	1
50		7.60	7.60	7.60	0.00	0.00	1
100		4.20	4.20	4.20	0.00	0.00	1
DMW Control	Cond uS/cm	0.17	0.17	0.17	0.00	0.00	1
6.3		215.00	215.00	215.00	0.00	0.00	1
12.5		245.00	245.00	245.00	0.00	0.00	1
25		318.00	318.00	318.00	0.00	0.00	1
50		439.00	439.00	439.00	0.00	0.00	1
100		712.00	712.00	712.00	0.00	0.00	1
DMW Control	DO %	101.30	101.30	101.30	0.00	0.00	1
6.3		114.30	114.30	114.30	0.00	0.00	1
12.5		115.80	115.80	115.80	0.00	0.00	1
25		115.50	115.50	115.50	0.00	0.00	1
50		118.10	118.10	118.10	0.00	0.00	1
100		118.90	118.90	118.90	0.00	0.00	1

Freshwater Shrimp Acute Toxicity Test-96 hr Survival

Start Date: 8/09/2011 15:00	Test ID: PR0787/11	Sample ID: Content Pit
End Date: 12/09/2011 15:00	Lab ID: 4928	Sample Type: AQ-Aqueous
Sample Date:	Protocol: ESA 107	Test Species: MD-Macrobrachium australiense

Comments:

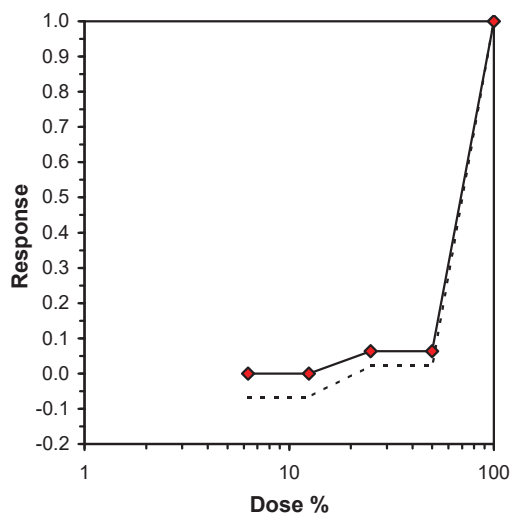
Conc-%	1	2	3	4
DMW Control	1.0000	0.6000	0.6000	0.8000
6.3	0.8000	0.8000	0.8000	
12.5	0.6000	1.0000		
25	0.8000	0.6000	0.8000	
50	0.8000	0.6000	0.8000	
100	0.0000	0.0000	0.0000	

Conc-%	Transform: Arcsin Square Root							t-Stat	1-Tailed Critical	MSD	Isotonic	
	Mean	N-Mean	Mean	Min	Max	CV%	N				Mean	N-Mean
DMW Control	0.7500	1.0000	1.0561	0.8861	1.3453	20.748	4				0.7833	1.0000
6.3	0.8000	1.0667	1.1071	1.1071	1.1071	0.000	3	-0.376	2.634	0.3568	0.7833	1.0000
12.5	0.8000	1.0667	1.1157	0.8861	1.3453	29.104	2	-0.388	2.634	0.4046	0.7833	1.0000
25	0.7333	0.9778	1.0335	0.8861	1.1071	12.350	3	0.167	2.634	0.3568	0.7333	0.9362
50	0.7333	0.9778	1.0335	0.8861	1.1071	12.350	3	0.167	2.634	0.3568	0.7333	0.9362
100	0.0000	0.0000	0.2255	0.2255	0.2255	0.000	3				0.0000	0.0000

Auxiliary Tests					Statistic	Critical	Skew	Kurt						
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)					0.927515	0.881	0.236404	-0.44311						
Equality of variance cannot be confirmed														
Hypothesis Test (1-tail, 0.05)					NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Bonferroni t Test					50	100	70.71068	2	0.343355	0.453149	0.004187	0.031465	0.966564	4, 10
Treatments vs DMW Control														

Log-Logit Interpolation (200 Resamples)

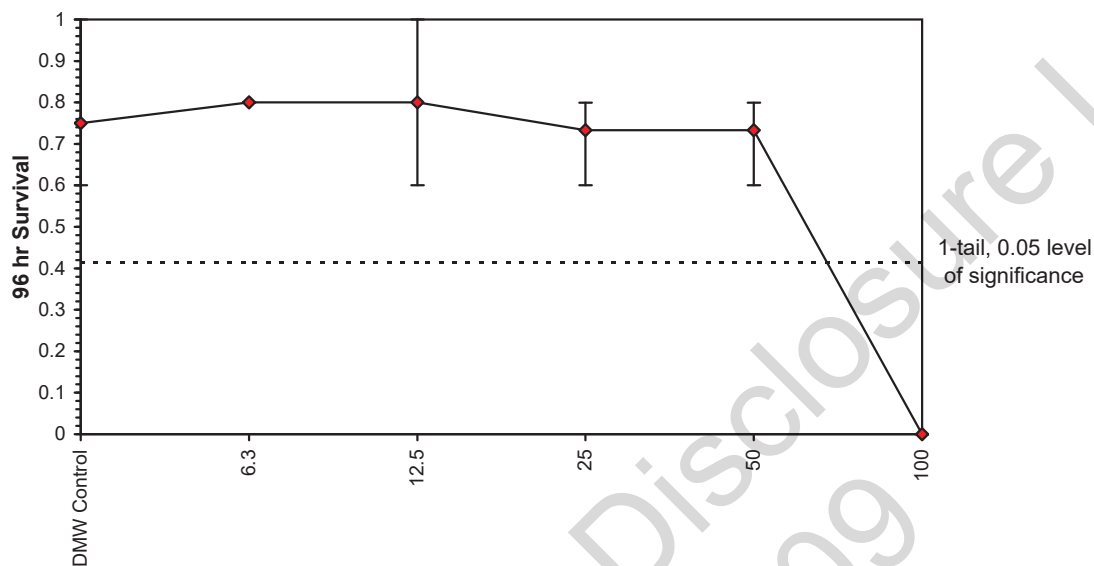
Point	%	SD	95% CL(Exp)	Skew
IC05	21.728	16.518	0.000	82.543
IC10	50.481	17.163	0.000	52.252
IC15	51.110	14.120	0.000	52.823
IC20	51.711	8.850	0.000	53.375
IC25	52.293	4.398	29.970	53.916
IC40	54.008	0.771	49.351	55.616
IC50	55.198	0.742	50.635	56.873



Freshwater Shrimp Acute Toxicity Test-96 hr Survival

Start Date:	8/09/2011 15:00	Test ID:	PR0787/11	Sample ID:	Content Pit
End Date:	12/09/2011 15:00	Lab ID:	4928	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 107	Test Species:	MD-Macrobrachium australiense
Comments:					

Dose-Response Plot



Freshwater Shrimp Acute Toxicity Test-96 hr Survival

Start Date:	8/09/2011 15:00	Test ID:	PR0787/11	Sample ID:	Content Pit
End Date:	12/09/2011 15:00	Lab ID:	4928	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 107	Test Species:	MD-Macrobrachium australiense
Comments:					

		Auxiliary Data Summary					
Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
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6.3		80.00	80.00	80.00	0.00	0.00	3
12.5		80.00	60.00	100.00	28.28	6.65	2
25		73.33	60.00	80.00	11.55	4.63	3
50		73.33	60.00	80.00	11.55	4.63	3
100		0.00	0.00	0.00	0.00		3
DMW Control	pH	8.00	8.00	8.00	0.00	0.00	1
6.3		8.00	8.00	8.00	0.00	0.00	1
12.5		7.90	7.90	7.90	0.00	0.00	1
25		7.80	7.80	7.80	0.00	0.00	1
50		7.60	7.60	7.60	0.00	0.00	1
100		4.20	4.20	4.20	0.00	0.00	1
DMW Control	Cond uS/cm	0.17	0.17	0.17	0.00	0.00	1
6.3		215.00	215.00	215.00	0.00	0.00	1
12.5		245.00	245.00	245.00	0.00	0.00	1
25		318.00	318.00	318.00	0.00	0.00	1
50		439.00	439.00	439.00	0.00	0.00	1
100		712.00	712.00	712.00	0.00	0.00	1
DMW Control	DO %	101.30	101.30	101.30	0.00	0.00	1
6.3		114.30	114.30	114.30	0.00	0.00	1
12.5		115.80	115.80	115.80	0.00	0.00	1
25		115.50	115.50	115.50	0.00	0.00	1
50		118.10	118.10	118.10	0.00	0.00	1
100		118.90	118.90	118.90	0.00	0.00	1

Croydon Mine Rehabilitation assessment, June 2013



Prepared for:

Barrick Gold Corporation (Australia)

Prepared by:

CTPI 49-Sch4

and

CTPI 49-Sch4

Vegetation Management Science

PO Box 32 Malanda Q. 4885

Summary

This report documents the third recent assessment of the rehabilitation at the Corydon mine. Live plant ground cover has been found to be similar between the mine rehabilitation sites compared with the combined analogue sites.

The 2012-13 summer was very dry and caused a decline in plant cover in all sites. Statistical analyses indicate that the rehabilitated sites did not suffer worse declines in plant ground cover than the analogues. That is, there is no significant difference in the resilience to the initial stages of drought between the rehabilitation and analogue vegetation.

However, the rehabilitated mined sites have a greater abundance of annual grasses and herbs than do the analogue sites, which have a greater proportion of perennials. This is likely to mean that, as the drought progresses, the rehabilitated sites may be less able to maintain ground cover than the analogue sites, because annuals require wet season rain to promote new plants each year, and annuals die off naturally in the middle of each year.

The decline in live plant cover was replaced mostly by increased bare ground, rather than leaf litter. This is in contrast to the Kidston rehabilitated sites, which are dominated by perennial grasses and where the decline in plant cover was replaced by leaf litter. The increase in bare ground at Croydon, rather than leaf litter, exposes the soil to potential erosion. There are existing erosion issues in the mine rehabilitated sites, especially the Golden Butterfly site.

There is some difference in the species of trees and shrubs dominating different sites. However, all of the trees are native to the Croydon area, so the differences should not be considered of enormous consequence.

It is recommended that grazing animals, particularly goats, be kept from the rehabilitation sites, to help grass growth. The promotion of perennial grasses should also be considered for the rehabilitated sites, to increase resilience to dry conditions. Sowing of the perennial grasses that have proven to be successful in the Croydon area, such as Spear grass or Buffel grass, with temporary irrigation if possible, will likely be the best way to successfully establish perennial grasses and improve ground cover on the Content Dump and Golden Butterfly rehabilitation sites. This establishment of palatable perennial grasses will help provide persistent cover that is useful for returning the sites to an end land use of grazing. It is also worth considering the incorporation of elements of the Queensland government's standard vegetation survey methodologies in future assessments, which may be useful in progressing towards mine site closure.

Background

Gold was discovered on Croydon Downs Station in 1885, with the peak of initial gold mining in the district focused between 1887 and 1906. The Croydon mining lease, now owned by Barrick Gold

Corporation (Australia), was closed and rehabilitated in the 1990's. It is located on the north-western outskirts of Croydon township, 18.192° South; 142.236° East (Figure 1).

The post-mining rehabilitation of vegetation was previously assessed in 2010 and 2012 by staff of Cedar Creek (Colorado, USA), Vegetation Management Science and Barrick Gold Corporation (Australia). These previous assessments suggested the mined rehabilitation had good potential for “adequate and diverse plant communities” (Cedar Creek Associates 2011). However, a key issue identified was the heavy grazing of the grasses especially by horses and goats.

This report documents the May 2013 assessment of the rehabilitation, with a view to summarising the condition and possible issues that can be addressed to progress towards finalisation.

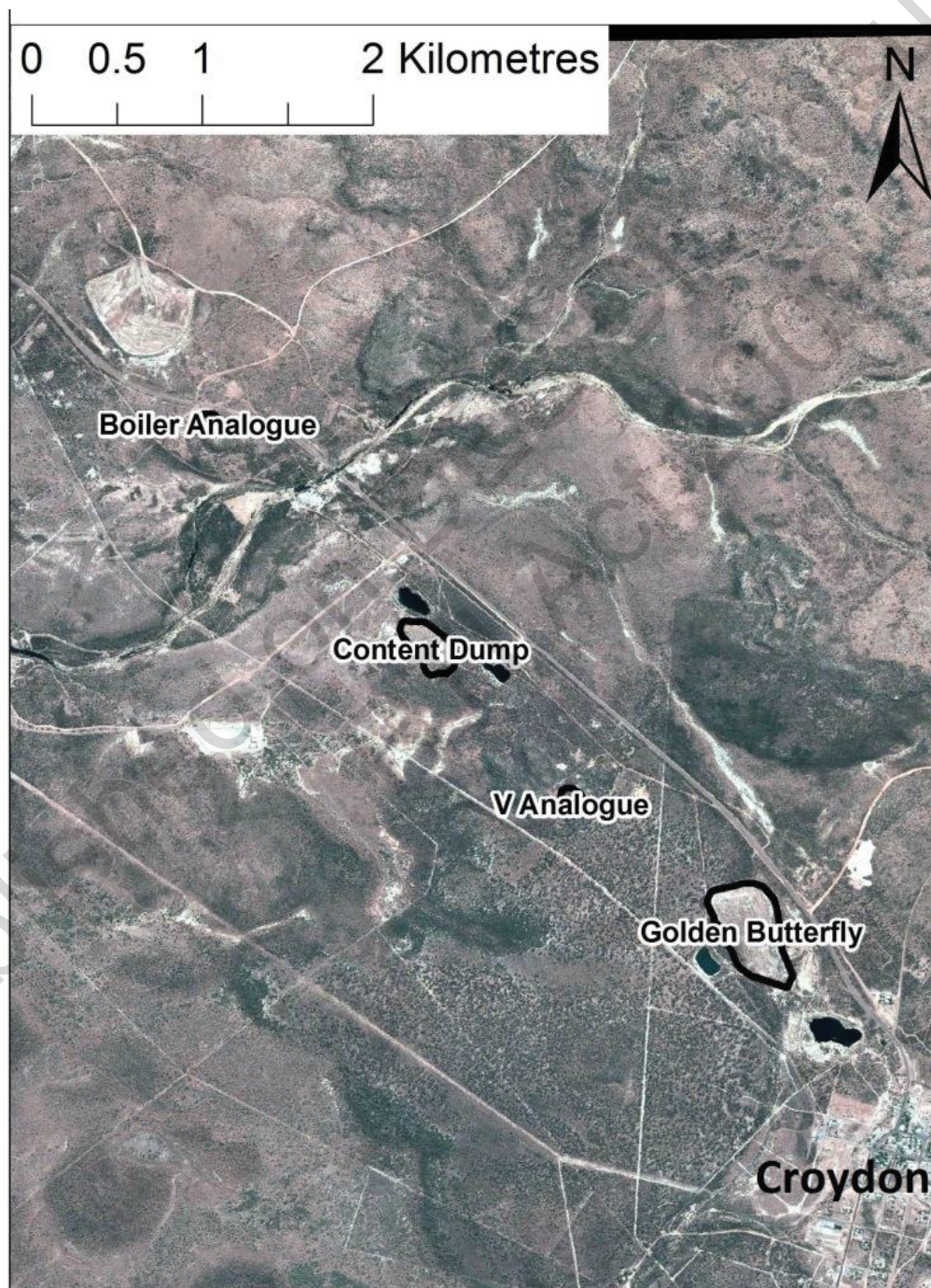


Figure 1. A map of the distribution of the mined rehabilitation sites (Content Dump and Golden Butterfly) and the two Analogue sites.

Methods

The 2013 survey followed the Barrick standard methodology used in the previous surveys (Cedar Creek Associates 2011). The sites were surveyed using a systematic grid format, where individual samples were taken at regular intervals across the sites, using a grid formation. This allows a thorough survey across each site. Each sample involved documenting the abundance, using the point cover method, of each plant species, rocks, bare ground and fallen leaf litter over a 10 m linear transect (e.g. Figure 2).



Figure 2. The laser method of sampling the point cover abundance of plants and bare ground etc (developed by Cedar Creek Associates, Colorado USA). The laser dots are circled in photo “b”.

To evaluate the comparative resilience of the mine site rehabilitation compared with the analogues in response to the drought, a statistical analysis, using a Repeated measures ANOVA, was performed on live plant ground cover, leaf litter and bare ground. This assesses the statistical significance of differences in plant cover, leaf litter and bare ground between sites and across years (hence it is a *repeated measures ANOVA*).

Results

The 2012-2013 wet season was very dry in Croydon, with monthly rainfall well below average, from December 2012 to May 2013 (Figure 2). This low rainfall had a considerable impact on the vegetation, with every site looking dry (Figures 3 to 6).

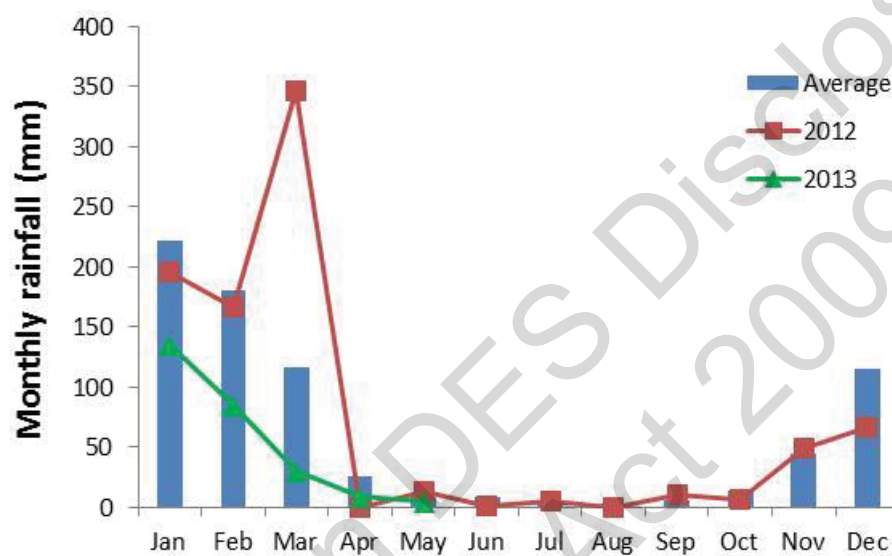


Figure 2. The average and recent monthly rainfall recorded in Croydon. Data are from the Bureau of Meteorology.



Figure 3. The Content Dump mined rehabilitation site, May 2013



Figure 4. The Golden Butterfly mined rehabilitation site, May 2013



Figure 5. The Boiler Analogue site, May 2013



Figure 6. The V Analogue site, May 2013

Live plant cover was highest for the combined mined sites compared with the combined analogue sites. The Content Dump had the highest individual plant ground cover, with Boiler Analogue site having the lowest (Figure 7 and Table 1). The average number of species per site was similar between the rehabilitated sites (average 20 species $\pm$ 0) compared with the analogue sites (18.5 species $\pm$ 1.5). This is slightly higher than that of the Kidston sites, where analogue sites averaged 16.5 species $\pm$ 1.5, and rehabilitated sites average 12.4 species $\pm$ 1.4.

Annual grasses and herbs were more abundant than perennials in the mine rehabilitation sites, with perennials more abundant than annuals in the analogue sites (Figure 7).

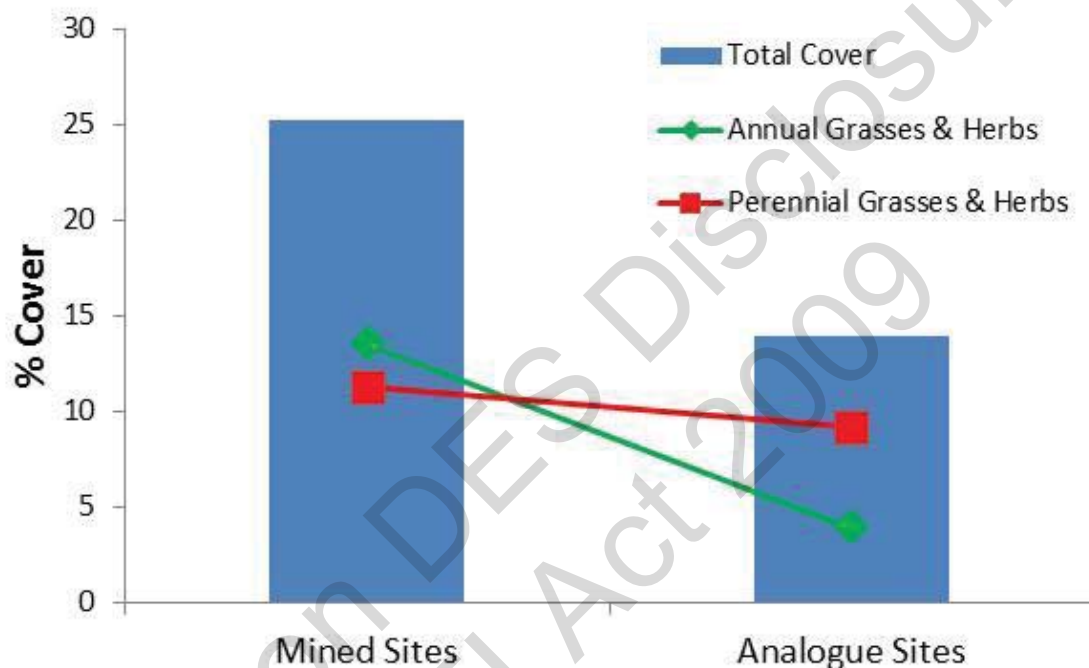


Figure 7. Comparison of the ground cover combined for the two mined and the two analogue sites, and the distinction between annual and perennial grasses and herbs.

The plants with the highest individual ground cover per site were: the perennial native grass *Aristida* sp in Content Dump and V Analogue; the annual native grass *Brachyachne convergens* in the Golden Butterfly site and the annual native grass *Mnesithea formosa* in the Boiler Analogue site (Table 1; Figure 8).

Table 1. The average percentage cover per site for all species, and bare ground, leaf litter and rock cover. A = annual native; P = perennial native; IA = introduced annual and IP = introduced perennial

Group	Species	Content Dump	Golden Butterfly	Boiler analogue	V Analogue
Grasses and Sedges					
P	<i>Aristida sp.</i>	3.4	0.35	0.15	7.25
A	<i>Brachyachne convergens</i>	0.65	2.9		
A	<i>Bulbostylis barbata</i>	0.65	0.1		
P	<i>Chrysopogon fallax</i>		0.2	0.05	
P	<i>Cymbopogon bombycinus</i>		1.5		0.1
P	<i>Cyperus conicus</i>	1.75			
A	<i>Dactyloctenium radulans</i>				
P	<i>Digitaria breviglumis</i>				0.55
IA	<i>Echinochloa colona</i>	0.05			
P	<i>Eragrostis sp.</i>	0.15	0.35		
A	<i>Eriachne armitii</i>	3.15		0.25	
A	<i>Eriachne ciliata</i>	2.45		0.15	0.1
IA	<i>Eriochloa sp</i>		0.05		
P	<i>Fimbristylis sp.</i>		0.05		
A	<i>Mnesithea formosa</i>		0.9	0.6	0.1
P	<i>Panicum decompositum</i>	0.5			
P	<i>Paspalidium rarum</i>	0.15			
P	<i>Pennisetum ciliare</i>		0.1		
P	<i>Schoenoplectus sp.</i>	2			
Herbaceous					
P	<i>Alysicarpus</i>		0.05		
P	<i>Anisomeles malabarica</i>	0.1		0.2	0.15
IA	<i>Bidens pilosa</i>			0.1	
A	<i>Bulbostylis barbata</i>			0.2	0.2
P	<i>Cheilanthes sp.</i>			0.2	0.15
A	<i>Cleome viscosa</i>			0.05	
A	<i>Crotalaria medicaginea</i>	0.05			
P	<i>Galactia tenuiflora</i>			0.05	
IA	<i>Hyptis suaveolens</i>	1.25	1.25	1.15	0.55
A	<i>Indigofera linifolia</i>			0.05	
A	<i>Ptilotus fusiformis</i>		0.05		
P	<i>Schoenoplectus</i>		0.2		
P	<i>Sida hackettiana</i>			0.35	
IP	<i>Stylosanthes scabra</i>		0.35		
A	<i>Tephrosia sp</i>			0.35	
P	<i>Waltheria indica</i>	0.1			

Table 1. cont.

Group	Species	Content Dump	Golden Butterfly	Boiler analogue	V Analogue
Shrubs and Trees					
P	<i>Acacia eleoantha</i>				
P	<i>Acacia holosericea</i>		0.05		
P	<i>Acacia leptostachya</i>				0.1
P	<i>Alphitonia excelsa</i>			0.5	
P	<i>Calytrix sp.</i>				0.2
P	<i>Corymbia pocillum</i>	0.1			
P	<i>Corymbia polycarpa</i>		0.05		
P	<i>Corymbia setosa</i>	0.15	0.05		
P	<i>Gardenia wilhelmii</i>				0.1
Overstory Hits					
P	<i>Acacia eleoantha</i>				
P	<i>Acacia holosericea</i>		0.05		
P	<i>Acacia julifera</i>	0.2		1.65	
P	<i>Acacia leptostachya</i>			0.35	9
P	<i>Acacia shirleyi</i>	0.9	0.7		
P	<i>Alphitonia excelsa</i>			0.25	0.65
P	<i>Corymbia confertiflora</i>			1.15	0.15
P	<i>Corymbia pocillum</i>	0.1	0.2		
P	<i>Corymbia polycarpa</i>	0.55	0.2		
P	<i>Corymbia setosa</i>	0.25	0.15		
P	<i>Erythrophleum chlorostachys</i>				4.15
P	<i>Eucalyptus chartaboma</i>				10.55
P	<i>Petalostigma pubescens</i>				1
P	<i>Terminalia aridicola</i>			0.05	
Understory Plant Cover		14.8	8.55	3.95	9.55
	Rock (> 5 mm)	19.1	20.2	26.35	18.9
	Litter	46.05	54.8	58.15	60.75
	Bare Ground	20.05	16.45	11.55	10.85
Overstory Plant Cover		2	1.3	3.45	25.5
Total Plant Cover		16.8	9.85	7.4	35.05
Native Annuals and Perennials Cover		15.5	7.95	4.7	34.15

The individual species covers, displayed in Figures 8 and 9, show the plants that contributed to the cover in the mined and analogue sites, and indicate the differences in annual versus perennial dominance. For example, the perennial grass *Aristida* is particularly abundant in the analogue sites and also common in the mined sites. *Brachyachne convergens*, *Eriachne armitii* and *Eriachne ciliata* are native annual grasses that are common in the mined sites. The annual exotic herb, *Hyptis suaveolens*, was abundant at both mined and analogue sites (Figure 9).

There was some difference between mine rehabilitation and analogue sites in the cover of the trees and shrubs (Figures 10 and 11). Figure 10 presents the ground cover (i.e. the abundance of the tree or shrub trunks that grow along the sample transects), whereas Figure 11 displays the canopy crown cover of the trees and shrubs. The differences between ground and crown cover estimates of trees (Figures 10 versus 11) are simply due to the randomness of whether an overhanging tree happens to have its trunk intercepted by one of the point samples on the ground.

Tree canopies have reached 4 to 8 metres in height on the mined rehabilitation, which is similar or only slightly lower than the trees in the analogue sites. The trees *Acacia leptostachya* and *Eucalyptus chartaboma* were more abundant in the analogue sites (the V Analogue in particular which had a high crown cover), while *Acacia shirleyi* and *Alphitonia excelsa* were more abundant in the mined sites. All of these trees are local to the Croydon area.

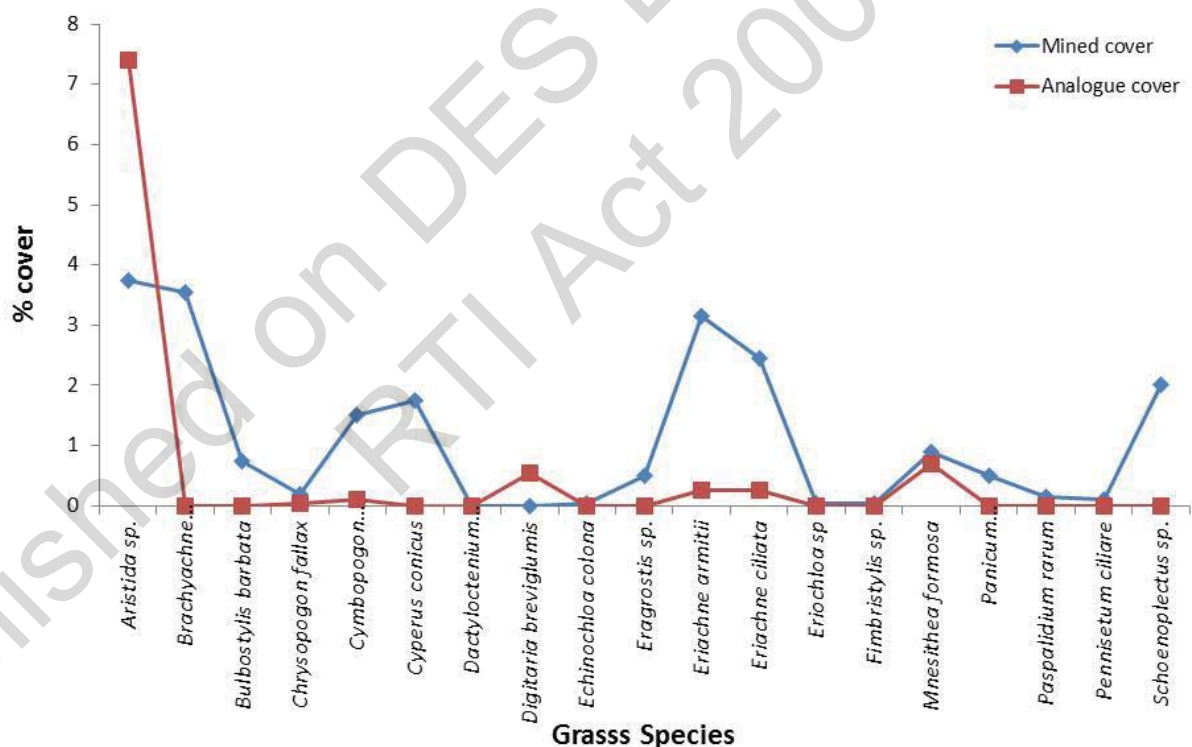


Figure 8. The percentage cover for each grass, combined for the two mined and the two analogue sites.

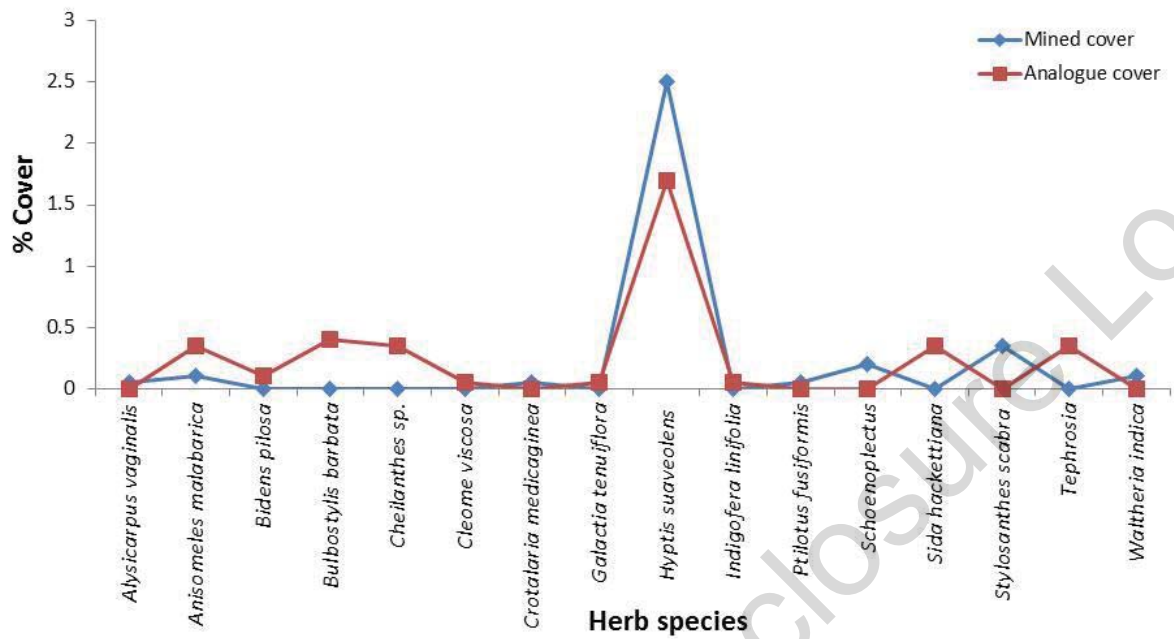


Figure 9. The percentage cover for each herb, combined for the two mined and the two analogue sites.

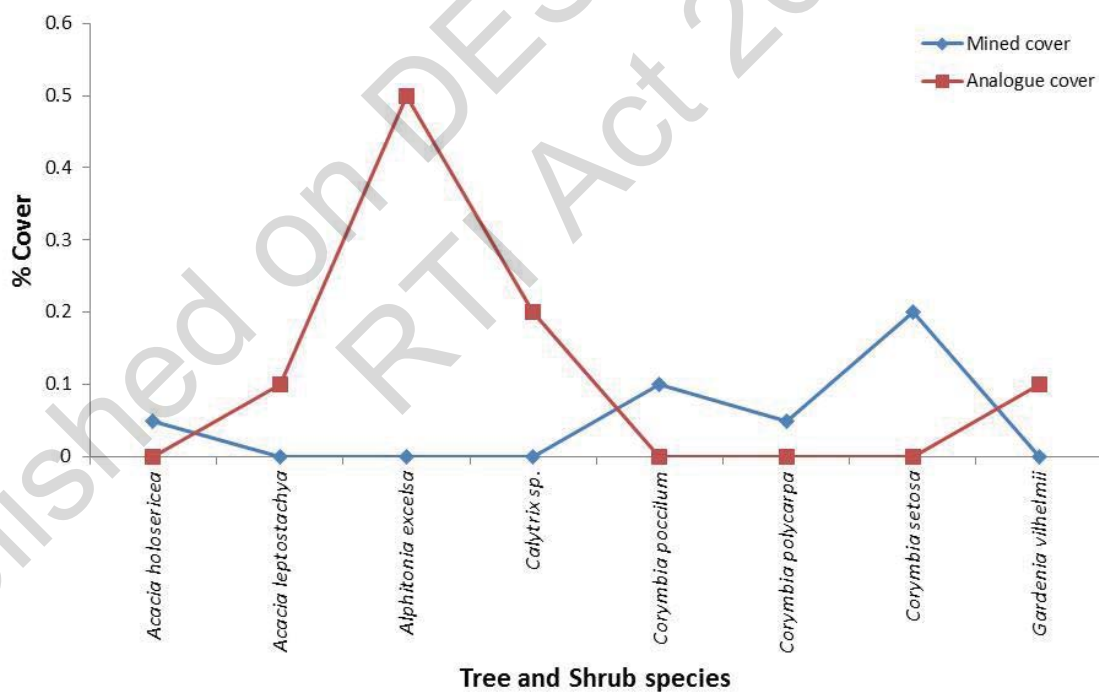


Figure 10. The percentage ground cover for each tree and shrub, combined for the two mined and the two analogue sites.

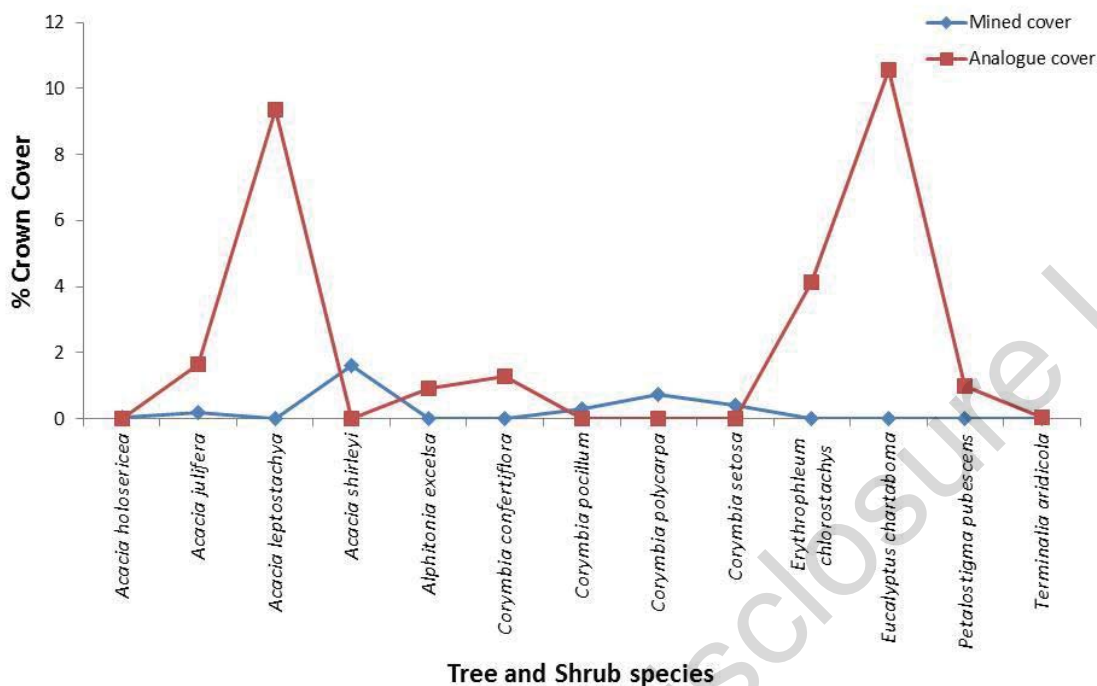


Figure 11. The percentage crown cover for each tree and shrub, combined for the two mined and the two analogue sites.

Comparisons of the live plant ground cover combined for the two mined and the two analogue sites show that annual grasses and herbs were more abundant than perennials in the mined rehabilitation sites. In contrast, perennial grasses, which provide long-term persistence, were more abundant in the analogue sites (Figure 7). A critical consideration is the resilience of the ground cover over time, especially during droughts such as experienced in 2013. A comparison of the understorey plant cover across the sites, between the initial 2010 and most recent 2013 surveys is displayed in Figure 12. The average plant cover declined over years in all sites, although the V Analogue site, dominated by the perennial *Aristida* grass, declined only slightly.

Statistical analyses

The statistical analysis (Repeated measures ANOVA) of the significance of differences in understorey plant cover between rehabilitated mined sites and comparative analogues, showed no significant difference between site type (mine rehabilitation versus analogue: $F = 1.82$; $P > 0.18$), indicating that the sites initially had similar ground cover levels. Neither was there a significant interaction in the change in cover over time between site types, which indicates neither type of site is more resilient to drought than the other ($F = 0.0698$; $P > 0.79$). There was, however, a significant difference between the years of survey ($F = 15.06$; $P < 0.001$), indicating that fall in plant cover in 2013 occurred consistently in rehabilitated mined sites and comparative analogue sites.

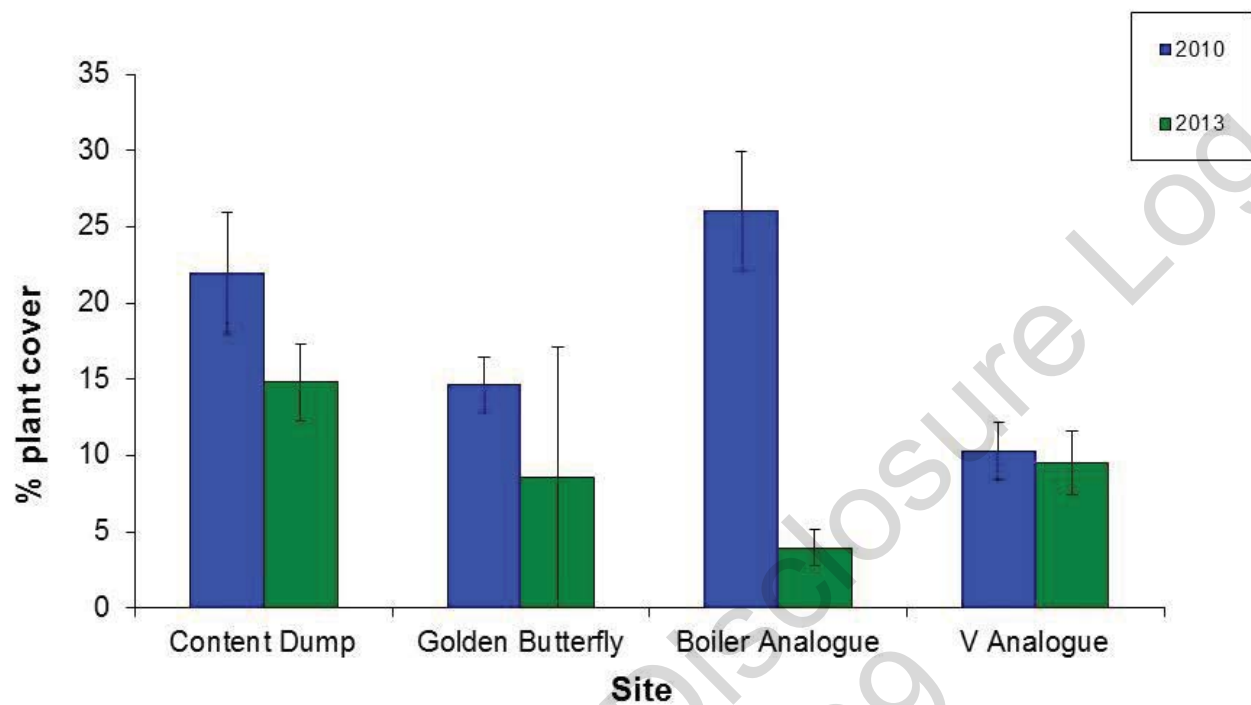


Figure 12. A comparison of the average understorey plant cover between sites from the initial 2010 survey and the current 2013 surveys. Error bars are 1 standard error and indicate the degree of fluctuations from the average by individual sample transects within each site.

The average percentage cover of leaf litter increased slightly in all sites (Figure 13). The statistical analysis (Repeated measures ANOVA) of leaf litter cover between rehabilitated mined sites and comparative analogues, showed a significant difference between site type (mine rehabilitation versus analogue: $F = 11.46$; $P < 0.01$), indicating that the sites have consistently had different leaf litter cover levels. However, there was no significant interaction in the change in leaf litter cover over time between site types, which would indicate a differing reaction to the drought by site type ($F = 0.38$; $P > 0.53$), nor was there a significantly big enough increase in leaf litter between 2010 and 2013 ($F = 1.18$; $P > 0.28$).

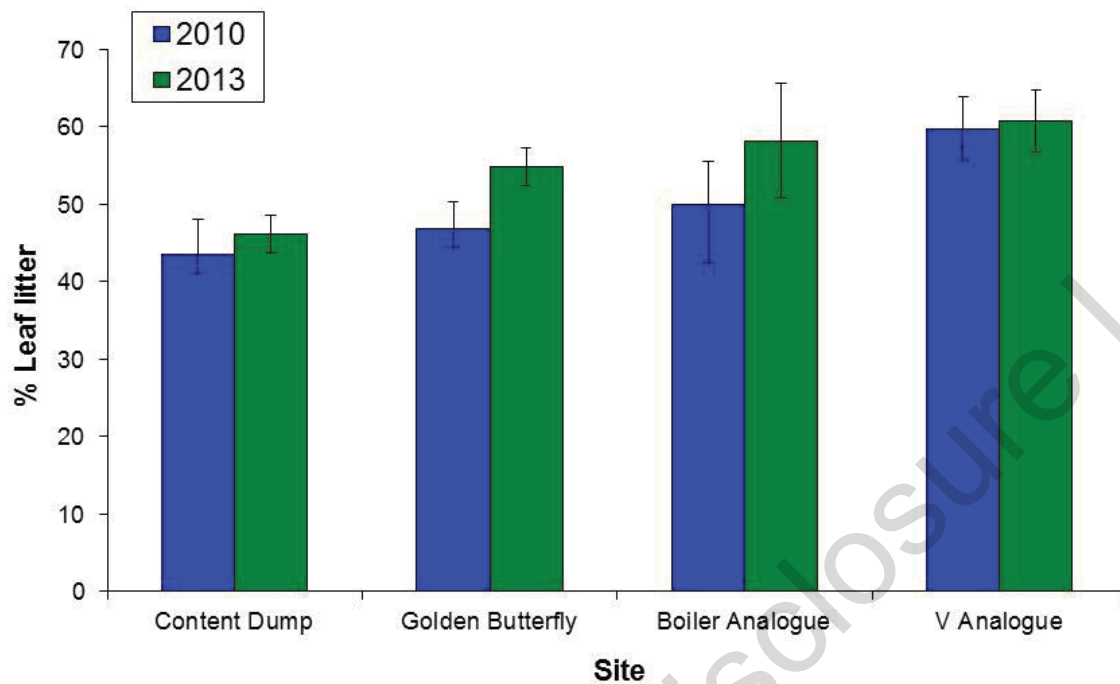


Figure 13. A comparison of the average leaf litter cover between sites from the initial 2010 survey and the current 2013 surveys. Error bars are 1 standard error and indicate the degree of fluctuations from the average by individual sample transects within each site.

The changes in bare ground mirrored the differences in live plant cover. The average percentage bare ground increased considerably in all sites (Figure 14). The statistical analysis (Repeated measures ANOVA) of bare ground between rehabilitated mined sites and comparative analogues, showed a significant difference between site type (mine rehabilitation versus analogue: $F = 13.85$; $P < 0.001$), indicating that the mine rehabilitation sites have consistently had higher bare ground levels. There was also a significant increase in bare ground between 2010 and 2013 ($F = 20.68$; $P < 0.0001$). However, there was no significant interaction in the change in bare ground over time between site types ($F = 0.46$; $P > 0.5$), which would indicate a different reaction to the drought – i.e. both site types increased in bare ground with the drought.

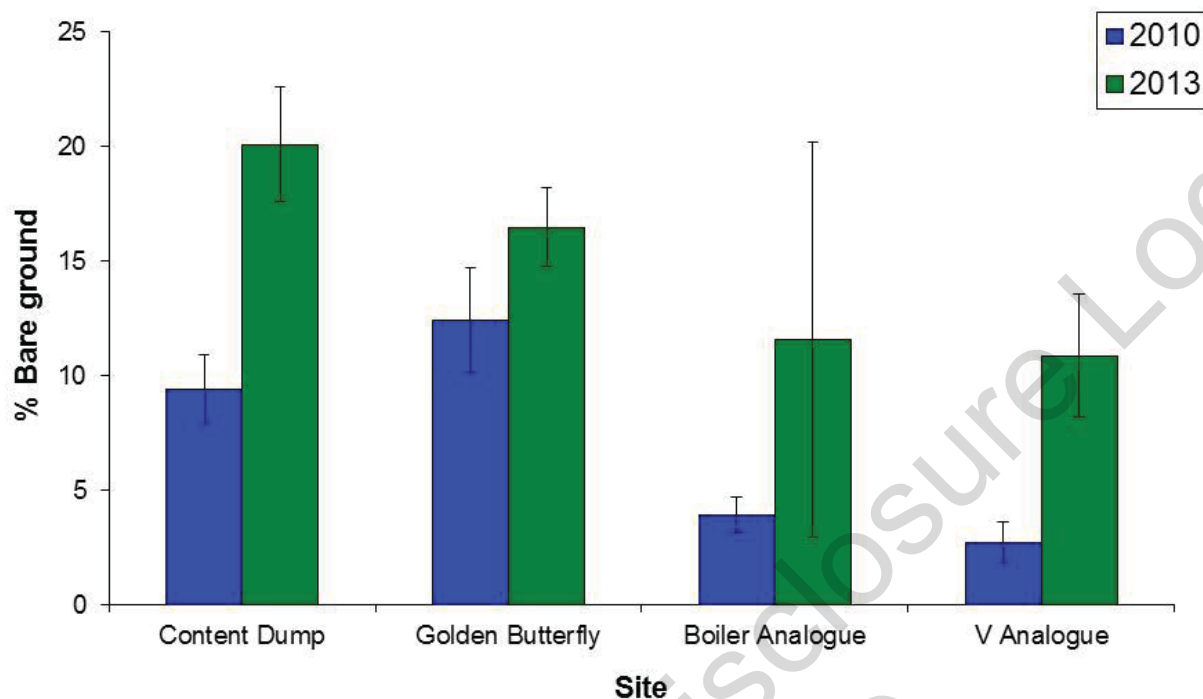


Figure 14. A comparison of the average percentage bare ground between sites from the initial 2010 survey and the current 2013 surveys. Error bars are 1 standard error and indicate the degree of fluctuations from the average by individual sample transects within each site.

Discussion

Live plant ground cover varied slightly between individual sites, but there was no statistically significant difference between the combined mined sites compared with the combined analogue sites.

While the current dry year has caused a decline in plant cover, it is useful in allowing a comparison of the resilience of the mined rehabilitation compared to analogue vegetation. Statistical analyses indicate that the rehabilitated sites did not suffer worse declines in plant ground cover than the analogues. In fact, the plant cover remained slightly higher for the mined rehabilitation than comparative analogues. That is, there is no significant difference in the resilience to the initial stages of drought between the rehabilitation and analogue vegetation.

However, the rehabilitated mined sites have a greater abundance of annual grasses and herbs than do the analogue sites, which have a greater proportion of perennials. This is likely to mean as the drought progresses, the rehabilitated sites may be less able to maintain ground cover than the analogue sites. This is due to the requirement of annual plants for sufficient wet season rainfall to germinate and establish seedlings each summer, and because annuals will naturally die off in the middle of the year.

The gaps left by the decline in live plant ground cover, were primarily replaced by a corresponding increase in bare ground, with only a slight increase in fallen leaf litter. This is in contrast to the Kidston rehabilitated sites, which are dominated by perennial grasses and where the decline in plant cover was mainly replaced by leaf litter. The increase in bare ground at Croydon, rather than leaf litter, will make the soil more exposed to potential erosion. There are existing erosion issues in the mine rehabilitated sites, especially the Golden Butterfly site.

There is some difference in the abundance of trees and shrubs, with *Acacia leptostachya* and *Eucalyptus chartaboma* more abundant in the analogue sites (the V Analogue in particular), while *Acacia shirleyi* and *Alphitonia excelsa* were more abundant in the mined sites. However, all of these trees are native to the Croydon area, so the differences should not be considered of enormous consequence.

Recommendations

The rehabilitated mined sites have shown similar resilience to the current drought to that of analogue sites. But a large proportion of the ground is bare, and this is at least partially due to prevalence of annual grasses and herbs and also the grazing by animals, especially goats. Therefore the ongoing resilience of the Croydon mine rehabilitation is likely to be improved by keeping grazing animals, particularly goats, from the rehabilitation sites. The sowing and promotion of some perennial grasses should also be considered. The establishment success and growth of perennial grasses would be enhanced with the use of the irrigation.

In regards to which perennial grasses to promote, native grasses, especially Black spear grass and Kangaroo grass would be ecologically beneficial. However, the existing surrounding landscape is dominated by Buffel grass and the end use is likely to be continued cattle grazing. Therefore, sowing of any of these palatable perennial grasses that have proven to be successful in the Croydon area would help improve the resilience of the rehabilitation.

The Queensland state government typically uses standard survey methodologies, such as “Biocondition” and regional ecosystem and regrowth mapping procedures to determine the condition and legal status of vegetation. These are used, for example, to determine whether regrowth vegetation has met the required 70% height and 50% cover of adjacent undisturbed remnant vegetation. It is worth considering whether elements of these standard methodologies be included in future assessments, as it may be useful in progressing towards mine site closure.

References

Cedar Creek Associates (2011) Croydon Mine 2010 Rehabilitation Evaluation.

1 August 2011

Queensland Government
Department of Environment and Resource Management
PO Box 2316
MT ISA QLD 4825

Attention: Alex Apostol

Dear Alex,

Subject: Croydon Gold Mine - Results of Water Quality Monitoring and Macroinvertebrate Survey Report

As you are aware, surface water outflows were recorded from the Content Pit at the Croydon Gold Mine at the end of March and early April 2011. Initial notification of the surface water outflows was provided by Barrick Australia Pacific Limited (Barrick) to the Department of Environment and Resource Management (DERM) on 30 March 2011. A detailed description of the background to the Content Pit outflow was provided in the follow-up written advice submitted by Barrick to the DERM on 14 April 2011.

In accordance with Condition A4-4 of the Croydon Gold Mine Environmental Authority (EA) No. MIN100401906, please find attached the following results of the monitoring performed in response to the Content Pit surface water outflow:

- analytical results from surface water quality monitoring undertaken at the relevant on-site and receiving water monitoring locations defined in Schedule F – Tables 7 and 1 respectively of the EA and at other relevant sites between 30 March to 2 May 2011 (Attachment A); and
- the *Croydon Gold Mine Macroinvertebrate Survey* (report prepared by frc environmental) undertaken in Belmore Creek (and relevant tributary downstream of ML 5248) on 4 to 6 April 2011 (Attachment B).

A description of the on-site and receiving water monitoring sites is provided in Table 1 and the locations are shown on Figure 1.

**Table 1
Description of On-site and Receiving Water Monitoring Sites**

Sample Site ¹	Sample Site Description
Content Pit	The point where water was flowing from the Content Pit.
SW5	The on-site surface water monitoring site located on the ML5248 boundary.
Mine Drainage	The defined channel draining the surface water outflows from the Content Pit. Other surrounding surface water flows also drain to this defined channel.
Confluence	The confluence of flow from the Mine Drainage channel with the separate channel draining the outflows from SW6. ²
Belmore Creek Upstream	Upstream of where the mine drainage channel enters Belmore Creek.
Belmore Creek Downstream	Downstream of where the mine drainage channel enters Belmore Creek.

¹ See Figure 1 for sample site locations.

² After the confluence of these two drainage channels, the combined streams flow within a drainage channel to enter Belmore Creek after approximately one kilometre.

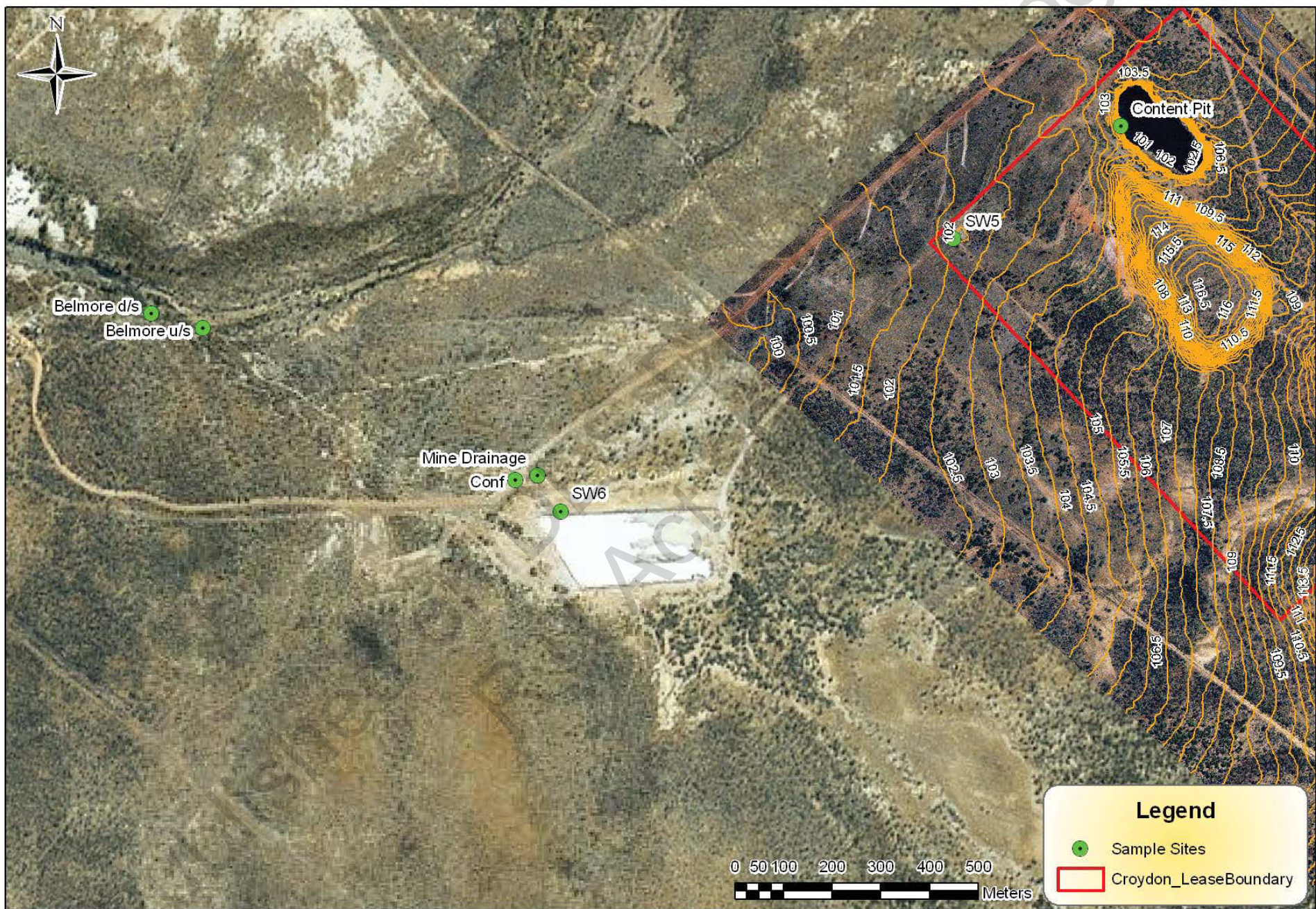


Figure 1: Sample Site Locations

A summary of the on-site water quality monitoring results from 30 March 2011 to 2 May 2011 compared with the on-site water contaminant limits defined in Schedule F – Table 8 of the EA is provided in Table 2 below.

Table 2
Summary of Analytical Results for Relevant On-site Water Monitoring Sites

Sample Site ¹	Analyte	Contaminant Limit	Number of Exceedances	Number of Samples	Minimum	Maximum	Mean
Content Pit	pH	4 - 9 pH units	3	9	3.91	4.20	4.08
SW5	pH	4 - 9 pH units	8	9	3.75	4.38	3.93
	Fluoride	2 mg/L	2	9	1.00	2.50	1.66
	Aluminium	5 mg/L	6	9	3.90	14.90	8.45
	Cadmium	0.01 mg/L	8	9	0.0091	0.0244	0.018

¹ Refer to Figure 1.

A summary of the receiving water quality monitoring results from 30 March 2011 to 2 May 2011 compared with the receiving water trigger levels and contaminant limits defined in Schedule F – Tables 2 and 3 respectively of the EA is provided in Table 3 below.

Table 3
Summary of Analytical Results for Relevant Receiving Water Monitoring Sites

Sample Site	Parameter	pH	EC (µS/cm)	F (mg/L)	Sulphate (mg/L)	Turbidity (NTU)	Al (mg/L)	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Co (mg/L)	Cu (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L)	Zn (mg/L)
SW7 (Belmore Creek EA upstream reference site)	Maximum	7.19	153	0.2	47	40	1.53	0.013	0.05	0.0001	0.002	0.001	0.002	0.0001	0.003	0.01	0.005
	Minimum	6.63	25	0.1	1	20	0.25	0.002	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	Average	6.92	83.43	0.14	17.29	29.10	0.87	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
	Median	6.93	102	0.1	20	25.1	0.85	0.004	0.05	0.0001	0.001	0.001	0.002	0.0001	0.002	0.01	0.005
	No. of samples.	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	Trigger Level Exceedance	-	-	-	-	Yes	Yes	-	-	-	-	-	-	-	-	-	-
	Contaminant Limit Exceedance	-	-	-	-	Yes	-	-	-	-	-	-	-	-	-	-	-
SW6 – Stock Water Dam (upstream of surface water outflow pathway)	Maximum	6.99	40	0.1	1	120	4.82	0.002	0.05	0.0001	0.002	0.001	0.002	0.0001	0.002	0.01	0.005
	Minimum	6.8	32	0.1	1	83.2	2.13	0.002	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	Average	6.90	36.00	0.10	1.00	101.60	3.48	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
	Median	6.895	36	0.1	1	101.6	3.475	0.002	0.05	0.0001	0.0015	0.001	0.0015	0.0001	0.0015	0.01	0.005
	No. of samples.	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	Trigger Level Exceedance	-	-	-	-	Yes	Yes	-	-	-	-	-	-	-	-	-	-
	Contaminant Limit Exceedance	-	-	-	-	Yes	-	-	-	-	-	-	-	-	-	-	-
Belmore Creek u/s (upstream of surface water outflow pathway confluence with Belmore Creek)	Maximum	7.21	65	0.2	8	29.7	1.28	0.016	0.05	0.0001	0.003	0.001	0.002	0.0001	0.002	0.01	0.007
	Minimum	6.73	33	0.1	2	9.7	0.04	0.004	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	Average	6.97	41.44	0.11	4.22	22.39	0.62	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
	Median	6.95	39	0.1	4	25	0.56	0.008	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	No. of samples	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
	Trigger Level Exceedance	-	-	-	-	Yes	-	Yes	-	-	-	-	-	-	-	-	-
	Contaminant Limit Exceedance	-	-	-	-	Yes	-	-	-	-	-	-	-	-	-	-	-
Trigger Level ¹		6 - 7.5	250	0.3	51.2	25.8	1.348	0.013	0.37	0.0002	0.005	0.0025	0.0046	0.0006	0.011	0.011	0.0092
Contaminant Limit ²		5 - 9	5970	2	1000	-	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

¹ Receiving Water Trigger Levels – EA Schedule F Table 2

² Receiving Water Contaminant Limits – EA Schedule F Table 3

Note: As per note 6 of Schedule F -Table 2 of the EA, comparison against trigger and contaminant limits is made to the maximum test values collected since a discharge event occurred.

Table 3 (Continued)
Summary of Analytical Results for Relevant Receiving Water Monitoring Sites

Sample Site	Parameter	pH	EC (µS/cm)	F (mg/L)	Sulphate (mg/L)	Turbidity (NTU)	Al (mg/L)	As (mg/L)	B (mg/L)	Cd (mg/L)	Cr (mg/L)	Co (mg/L)	Cu (mg/L)	Hg (mg/L)	Ni (mg/L)	Se (mg/L)	Zn (mg/L)
Mine Drainage	Maximum	6.88	354	0.8	130	110	1.74	0.003	0.05	0.0032	0.001	0.071	0.035	0.0001	0.047	0.01	0.158
	Minimum	4.9	71	0.3	17	1	0.37	0.002	0.05	0.0001	0.001	0.001	0.008	0.0001	0.003	0.01	0.005
	Average	5.40	237	0.57	84	19.8	0.90	0.0024	0.05	0.0024	0.001	0.0444	0.0263	0.0001	0.033	0.01	0.118
	Median	5.17	236	0.6	80	6	0.71	0.002	0.05	0.0028	0.001	0.041	0.029	0.0001	0.036	0.01	0.142
	No. of samples	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	Trigger Level Exceedance	Yes	Yes	Yes	Yes	Yes	Yes	-	-	Yes	-	Yes	Yes	-	Yes	-	Yes
	Contaminant Limit Exceedance	-	-	-	-	Yes	-	-	-	-	-	-	-	-	-	-	-
Confluence of surface water outflow pathway with tributary of Belmore Creek	Maximum	6.83	185	0.4	64	110	2.42	0.004	0.05	0.0007	0.002	0.018	0.02	0.0001	0.013	0.01	0.037
	Minimum	6.2	60	0.1	13	44.2	0.28	0.001	0.05	0.0001	0.001	0.001	0.004	0.0001	0.002	0.01	0.005
	Average	6.58	103.63	0.26	30.00	74.21	1.54	0.00	0.05	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.02
	Median	6.64	86	0.25	21.5	75	1.66	0.002	0.05	0.00055	0.001	0.008	0.008	0.0001	0.008	0.01	0.025
	No. of samples	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
	Trigger Level Exceedance	-	-	Yes	Yes	Yes	Yes	-	-	Yes	-	Yes	Yes	-	Yes	-	Yes
	Contaminant Limit Exceedance	-	-	-	-	Yes	-	-	-	-	-	-	-	-	-	-	-
Belmore Creek d/s (downstream of confluence of surface water outflow pathway with Belmore Creek)	Maximum	7.27	66	0.2	8	35	2.1	0.019	0.05	0.0003	0.002	0.002	0.004	0.0001	0.003	0.01	0.011
	Minimum	6.58	32	0.1	2	8.9	0.08	0.004	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	Average	6.93	42.44	0.12	4.33	22.36	0.71	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
	Median	6.97	39	0.1	4	22.3	0.45	0.006	0.05	0.0001	0.001	0.001	0.001	0.0001	0.001	0.01	0.005
	No. of samples	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
	Trigger Level Exceedance	-	-	-	-	Yes	Yes	Yes	-	Yes	-	-	-	-	-	-	Yes
	Contaminant Limit Exceedance	-	-	-	-	Yes	-	-	-	-	-	-	-	-	-	-	-
Trigger Level ¹		6 - 7.5	250	0.3	51.2	25.8	1.348	0.013	0.37	0.0002	0.005	0.0025	0.0046	0.0006	0.011	0.011	0.0092
Contaminant Limit ²		5 - 9	5970	2	1000	-	5	0.5	5	0.01	1	1	1	0.002	1	0.02	20

¹ Receiving Water Trigger Levels – EA Schedule F Table 2

² Receiving Water Contaminant Limits – EA Schedule F Table 3

Note: As per note 6 of Schedule F -Table 2 of the EA, comparison against trigger and contaminant limits is made to the maximum test values collected since a discharge event occurred.

Actions Taken

Based on the results of the surface water quality monitoring undertaken on-site and at receiving water sites located downstream of the recorded surface water outflows from the Content Pit (Attachment A), Barrick immediately commenced an investigation into the potential for environmental harm as a result of the Content Pit outflows.

The investigation is currently being completed and includes:

- a detailed description of the monitoring programme conducted in response to the outflows;
- results of all monitoring undertaken in response to the outflows; and
- an assessment of the monitoring results in accordance with the ANZECC and ARMCANZ (2000) risk-based decision framework to assess whether a stressor represents a low, possible or high risk to the aquatic ecosystem (this assessment includes a comparison of the monitoring data against ANZECC and ARMCANZ (2000) guideline trigger values and would identify the investigations conducted to determine whether or not a real risk to the ecosystem exists).

Barrick will submit the investigation including the components described above to the DERM by 31 October 2011.

Should you require any further information, please do not hesitate to contact me on 0417 989 036.

Yours sincerely

BARRICK (AUSTRALIA PACIFIC) LIMITED

CTPI 49-Sch4

CTPI 49-Sch4

Reclamation and Closure Manager

ATTACHMENT A
ANALYTICAL RESULTS OF SURFACE WATER QUALITY MONITORING

Attachment A: Analytical Results of Surface Water Monitoring during 30 March to 2 May 2011

Sample Site ¹	Sample Date	pH	EC μS/cm	Turbidity NTU	SO ₄ ²⁻ mg/L	Al mg/L	As mg/L	Cd mg/L	Co mg/L	Cu mg/L	Ni mg/L	Zn mg/L	B mg/L	Se Total mg/L	Hg mg/L	Cr ⁶⁺ mg/L	F mg/L
Relevant EA On-site Water Monitoring Sites																	
Content Pit	30/03/2011	3.91	782	0.8	300	1.37	0.004	0.0024	0.095	0.059	0.091	0.242	<0.05	<0.01	<0.0001	0.002	1.2
Content Pit	31/03/2011	3.96	740	0.8	303	1.36	0.004	0.0022	0.093	0.057	0.089	0.235	<0.05	<0.01	<0.0001	0.002	1.1
Content Pit	1/04/2011	3.98	737	1.2	301	1.38	0.005	0.0021	0.090	0.056	0.087	0.229	<0.05	<0.01	<0.0001	0.002	1.1
Content Pit	5/04/2011	4.11	781	2.1	304	1.62	0.009	0.0023	0.103	0.062	0.099	0.266	<0.05	<0.01	<0.0001	<0.001	1.3
Content Pit	6/04/2011	4.11	778	3.0	304	1.55	0.008	0.0023	0.104	0.061	0.1	0.27	<0.05	<0.01	<0.0001	<0.001	1.3
Content Pit	7/04/2011	4.19	783	5.8	309	1.51	0.006	0.0022	0.104	0.062	0.101	0.261	<0.05	<0.01	<0.0001	<0.001	1.5
Content Pit	13/04/2011	4.13	770	90	316	1.34	0.006	0.0021	0.101	0.057	0.096	0.244	<0.05	<0.01	<0.0001	<0.001	1.4
Content Pit	21/04/2011	4.2	784	4.3	310	1.31	0.007	0.0022	0.112	0.056	0.103	0.259	<0.05	<0.01	<0.0001	<0.001	1.4
Content Pit	2/05/2011	4.13	789	4.4	312	1.62	0.009	0.0025	0.101	0.061	0.097	0.279	<0.05	<0.01	<0.0001	0.002	1.4
SW5	30/03/2011	3.81	428	1.2	160	4.83	0.003	0.0137	0.089	0.278	0.093	0.492	<0.05	<0.01	<0.0001	0.001	1.0
SW5	31/03/2011	3.96	565	0.8	239	4.61	0.003	0.0113	0.106	0.232	0.103	0.478	<0.05	<0.01	<0.0001	0.002	1.2
SW5	1/04/2011	3.99	462	1.5	176	3.90	0.003	0.0091	0.089	0.195	0.082	0.385	<0.05	<0.01	<0.0001	0.002	1.0
SW5	5/04/2011	3.9	730	2	301	9.31	0.004	0.0167	0.156	0.425	0.152	0.692	<0.05	<0.01	<0.0001	0.001	1.7
SW5	6/04/2011	3.89	757	3.9	311	8.46	0.004	0.0156	0.16	0.396	0.148	0.654	<0.05	<0.01	<0.0001	0.001	1.7
SW5	7/04/2011	3.92	778	11	322	8.89	0.004	0.0154	0.164	0.395	0.157	0.662	<0.05	<0.01	<0.0001	0.001	1.7
SW5	13/04/2011	3.79	853	2	363	9.79	0.004	0.0164	0.179	0.433	0.177	0.688	<0.05	<0.01	<0.0001	0.001	2
SW5	21/04/2011	4.38	904	4.9	385	11.4	0.004	0.0192	0.202	0.534	0.19	0.771	<0.05	<0.01	<0.0001	0.001	2.1
SW5	2/05/2011	3.75	1130	3.7	491	14.9	0.004	0.0244	0.234	0.593	0.22	0.959	<0.05	<0.01	<0.0001	0.001	2.5
SW7	30/03/2011	6.93	102	37.3	24	1.23	0.004	<0.0001	0.001	0.002	0.002	<0.005	<0.05	<0.01	<0.0001	<0.001	0.2
SW7	31/03/2011	6.63	102	35.3	23	1.53	0.004	<0.0001	<0.001	0.002	0.002	<0.005	<0.05	<0.01	<0.0001	<0.001	0.2
SW7	1/04/2011	6.77	102	25.1	20	1.23	0.004	<0.0001	0.001	0.001	0.002	<0.005	<0.05	<0.01	<0.0001	0.002	0.1
SW7	6/04/2011	6.97	153	40	47	0.85	0.002	<0.0001	<0.001	0.002	0.003	0.005	0.05	0.01	<0.0001	0.001	0.2
SW7	13/04/2011	7.19	32	20	1	0.7	0.01	<0.0001	<0.001	0.002	0.003	0.005	0.05	0.01	<0.0001	0.001	0.1
SW7	21/04/2011	6.92	25	22	2	0.29	0.011	<0.0001	<0.001	0.002	0.003	0.005	0.05	0.01	<0.0001	0.001	0.1
SW7	2/05/2011	7.06	68	24	4	0.25	0.013	<0.0001	<0.001	<0.001	<0.001	0.005	0.05	0.01	<0.0001	0.001	0.1
SW6*	30/03/2011	6.99	40	83.2	<1	4.82	0.002	<0.0001	<0.001	0.002	0.001	<0.005	<0.05	<0.01	<0.0001	0.002	0.1
SW6*	5/04/2011	6.8	32	120	1	2.13	0.002	<0.0001	<0.001	<0.001	0.002	<0.005	<0.05	<0.01	<0.0001	0.001	0.1

¹ Refer to Figure 1.

Attachment A: Analytical Results of Surface Water Monitoring during 30 March to 2 May 2011 (Continued)

Sample Site ¹	Sample Date	pH	EC μS/cm	Turbidity NTU	SO ₄ ²⁻ mg/L	Al mg/L	As mg/L	Cd mg/L	Co mg/L	Cu mg/L	Ni mg/L	Zn mg/L	B mg/L	Se Total mg/L	Hg mg/L	Cr ⁶⁺ mg/L	F mg/L
Relevant Belmore Creek Upstream Reference Monitoring Sites																	
Belmore Creek u/s	30/03/2011	6.83	37	22.6	2	1.28	0.005	<0.0001	<0.001	0.001	0.001	<0.005	<0.05	<0.01	<0.0001	<0.001	<0.1
Belmore Creek u/s	31/03/2011	6.73	39	27.5	2	1.15	0.004	<0.0001	<0.001	0.001	0.001	<0.005	<0.05	<0.01	<0.0001	0.002	<0.1
Belmore Creek u/s	1/04/2011	6.95	40	29.7	4	1.14	0.005	<0.0001	0.001	0.002	0.002	0.007	<0.05	<0.01	<0.0001	<0.001	<0.1
Belmore Creek u/s	5/04/2011	7.02	39	26	4	0.64	0.008	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.1
Belmore Creek u/s	6/04/2011	6.94	39	25	4	0.56	0.008	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	0.003	0.1
Belmore Creek u/s	7/04/2011	6.94	39	25	3	0.52	0.008	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.1
Belmore Creek u/s	13/04/2011	7.11	42	21	4	0.16	0.016	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.1
Belmore Creek u/s	21/04/2011	7	33	15	7	0.04	0.011	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.2
Belmore Creek u/s	2/05/2011	7.21	65	9.7	8	0.08	0.011	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	0.002	0.1
Mine Drainage	30/03/2011	5.11	236	1.1	75	0.71	0.002	0.0032	0.041	0.030	0.036	0.142	<0.05	<0.01	<0.0001	0.001	0.6
Mine Drainage	31/03/2011	5.19	192	1.0	80	0.69	0.002	0.0032	0.040	0.029	0.035	0.143	<0.05	<0.01	<0.0001	0.001	0.5
Mine Drainage	1/04/2011	5.56	168	5.3	56	0.37	0.002	0.0028	0.029	0.025	0.027	0.115	<0.05	<0.01	<0.0001	0.001	0.4
Mine Drainage	5/04/2011	5.17	334	7.4	122	1.01	0.003	0.0026	0.066	0.034	0.047	0.158	<0.05	<0.01	<0.0001	0.001	0.8
Mine Drainage	6/04/2011	4.9	354	7.7	130	1.14	0.003	0.0028	0.071	0.035	0.047	0.152	<0.05	<0.01	<0.0001	0.001	0.8
Mine Drainage	7/04/2011	4.97	301	6	108	0.63	0.002	0.0019	0.063	0.023	0.036	0.111	<0.05	<0.01	<0.0001	0.001	0.6
Mine Drainage	13/04/2011	6.88	71	110	17	1.74	0.003	0.0001	0.001	0.008	0.003	0.005	<0.05	<0.01	<0.0001	0.001	0.3

¹ Refer to Figure 1.

* No further field sampling was conducted at site SW6 on 31 March 2011 and 1 April 2011 as the recorded surface water outflows from the Content Pit do not enter SW6. Site SW6 is located east of the defined Mine Drainage channel and outflows from SW6 are drained via a separate drainage channel (see Figure 1).

Attachment A: Analytical Results of Surface Water Monitoring during 30 March to 2 May 2011 (Continued)

Sample Site ¹	Sample Date	pH	EC μS/cm	Turbidity NTU	SO ₄ ²⁻ mg/L	Al mg/L	As mg/L	Cd mg/L	Co mg/L	Cu mg/L	Ni mg/L	Zn mg/L	B mg/L	Se Total mg/L	Hg mg/L	Cr ⁶⁺ mg/L	F mg/L
Relevant Receiving Water Monitoring Sites																	
Confluence	30/03/2011	6.82	88	44.2	20	2.02	0.002	0.0007	0.009	0.020	0.009	0.028	<0.05	<0.01	<0.0001	0.002	0.2
Confluence	31/03/2011	6.74	68	44.9	20	2.42	0.002	0.0006	0.009	0.008	0.009	0.029	<0.05	<0.01	<0.0001	0.001	0.2
Confluence	1/04/2011	6.83	60	54.6	13	2.24	0.002	0.0005	0.007	0.007	0.007	0.026	<0.05	<0.01	<0.0001	0.002	0.1
Confluence	5/04/2011	6.2	185	65	64	0.28	0.001	0.0007	0.018	0.008	0.013	0.037	<0.05	<0.01	<0.0001	0.001	0.4
Confluence	6/04/2011	6.34	156	90	48	0.99	0.002	0.0006	0.012	0.006	0.01	0.024	<0.05	<0.01	<0.0001	0.001	0.4
Confluence	7/04/2011	6.54	116	85	32	1.45	0.001	0.0003	0.006	0.004	0.005	0.01	<0.05	<0.01	<0.0001	0.001	0.3
Confluence	13/04/2011	6.78	84	100	23	1.87	0.002	0.0001	0.001	0.011	0.004	0.005	<0.05	<0.01	<0.0001	0.001	0.3
Confluence	21/04/2011	6.35	72	110	20	1.04	0.004	0.0001	0.001	0.01	0.002	0.005	<0.05	<0.01	<0.0001	0.001	0.2
Belmore Creek d/s	30/03/2011	7.05	38	22.3	2	1.24	0.004	<0.0001	<0.001	0.004	0.001	0.005	<0.05	<0.01	<0.0001	0.001	<0.1
Belmore Creek d/s	31/03/2011	6.58	38	22.0	2	1.51	0.005	<0.0001	0.001	0.002	0.001	0.005	<0.05	<0.01	<0.0001	<0.001	<0.1
Belmore Creek d/s	1/04/2011	6.77	50	35.0	7	2.10	0.004	0.0003	0.002	0.004	0.003	0.011	<0.05	<0.01	<0.0001	0.002	0.1
Belmore Creek d/s	5/04/2011	6.97	38	28	3	0.14	0.006	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.1
Belmore Creek d/s	6/04/2011	6.94	40	23	4	0.45	0.006	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.2
Belmore Creek d/s	7/04/2011	6.98	39	23	3	0.19	0.008	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.1
Belmore Creek d/s	13/04/2011	7.06	41	21	4	0.53	0.019	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.2
Belmore Creek d/s	21/04/2011	6.75	32	18	6	0.11	0.012	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.1
Belmore Creek d/s	2/05/2011	7.27	66	8.9	8	0.08	0.009	<0.0001	<0.001	<0.001	<0.001	0.005	<0.05	<0.01	<0.0001	<0.001	0.1

¹ Refer to Figure 1.

ATTACHMENT B
CROYDON GOLD MINE
MACROINVERTEBRATE SURVEY

Croydon Gold Mine

Macroinvertebrate Survey

April 2011

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Summary

Background

frc environmental was commissioned by Barrick Australia Pacific Limited, to complete a baseline macroinvertebrate survey in Belmore Creek and its tributaries in the vicinity of the decommissioned Croydon Gold Mine. Due to extensive rainfall in the region in late 2010 and early 2011, an increase in the water level in the Content Pit occurred. Water level monitoring of the Content Pit indicated that further heavy rainfall during the remainder of the wet season could lead to overtopping of the Content Pit. As a result of further heavy rainfall between 29 March 2011, when the survey was commissioned, and 4 April 2011, when the survey commenced, the Content Pit overtopped. This changed the focus of the survey from a baseline assessment to an investigation into the potential impacts due to the overtopping of the Content Pit.

This report presents the findings of the macroinvertebrate survey conducted in Belmore Creek and its tributaries upstream and downstream of the Croydon Gold Mine in April 2011 and assesses the potential impact of the outflows from the Content Pit on the macroinvertebrate communities.

Study Area

Croydon Gold Mine is located in northern Queensland, west of Cairns, approximately 200 km from the Gulf of Carpentaria. Rainfall is highly seasonal and all local waterways are ephemeral. The south-eastern section of the mining lease (i.e. the Golden Butterfly mining area) is located in the upper catchment of Slaughteryard Creek, and the north-western section of the mining lease (i.e. the Content and Lady Isabella mining areas) is located in the Belmore Creek catchment.

As the overtopping event occurred at the Content Pit (located in the Belmore Creek catchment) the survey focused on Belmore Creek. A total of ten sites were surveyed in Belmore Creek and its tributaries including five comparative (upstream) sites and five potentially impacted (downstream) sites.

Aquatic Habitat

In general, aquatic habitat condition was good at most survey sites, with cobble, pebble and gravel substrates suitable for macroinvertebrates and native vegetation was dominant in the riparian zones. The least suitable macroinvertebrate habitat was at comparative (upstream) sites SW7 and SW6. These sites had substrates dominated by fine sand and silt, poor riparian zones and low in-stream habitat diversity.

In Situ Water Quality

In situ water quality was within the ANZECC & ARMCANZ (2000) default trigger values for lowland streams¹ in tropical Australia (and the QWQG trigger value for electrical conductivity) except for turbidity. Turbidity exceeded the upper ANZECC & ARMCANZ (2000) trigger value at all sites except one, but this was likely caused by recent rainfall (and subsequent sediment-laden runoff) in the area.

The *in situ* water quality results provide no indication of potential impacts from the Content Pit overflow except for electrical conductivity. Electrical conductivity was similar at all sites, except comparative site SW7 and potentially impacted site DSDi, immediately downstream of the confluence between the Content Pit overflow and a tributary of Belmore Creek, where levels were higher. However, electrical conductivity levels were below the QWQG trigger value at all sites, including DSDi. The pH at all sites was within recommended guidelines and dissolved oxygen concentrations were only slightly below the trigger value range at two sites.

Macroinvertebrates

The overtopping of the Content Pit appears to have had a small impact on the macroinvertebrate communities at site DSDi, which is located approximately 30 m downstream of the confluence of the overflow pathway with the tributary of Belmore Creek (approximately 1.5 km from the Content Pit over land). The overflow from Content Pit appears to have affected the macroinvertebrate taxonomic richness, abundance and community composition at this site. However, the impact appears to be confined to a small spatial area, not extending to the first downstream site on Belmore Creek (BCDS1). As such sites downstream of site DSDi do not appear to have been impacted by overflows from the Content Pit.

¹ Streams that are at <150 m elevation.

A number of other factors such as habitat condition, land use and water quality also appear to be having an effect on macroinvertebrate communities. As a result the influence of the overtopping event from the Content Pit on the macroinvertebrate communities in the tributary to Belmore Creek is not able to be clearly defined.

Results and Recommendations

Water quality and macroinvertebrate results were spatially variable, and are expected to also vary temporally in response to seasonal and long-term climatic influences. As such, the results of this one-off survey are in-sufficient to fully characterise the impact of the overtopping event from the Content Pit, when compared with the influence of other factors.

Additional survey events or a long-term ecological monitoring program would provide the opportunity to:

- describe the natural variability of the macroinvertebrate communities in the survey area
- determine if the overtopping event from the Content Pit had a short or long term impact, or potentially no impact at all, and
- gather comprehensive background data from comparative sites.

1 Introduction

1.1 Background

frc environmental was commissioned by Barrick Australia Pacific Limited, to complete a baseline macroinvertebrate survey in Belmore Creek and its tributaries in the vicinity of the Croydon Gold Mine. The Croydon Gold Mine was a low-grade gold mine located west of Croydon, 560 kilometres west of Cairns. Operational mining ceased at the Croydon Gold Mine in 1990 and the mine was decommissioned in 1993. Since 1993, activities on the site have included maintenance, monitoring, investigations and reclamation works.

Mining related landforms on the site include waste rock dumps, open pits and infrastructure areas (i.e. abandonment bunds, hardstand areas, water management structures, and roads and tracks). The open pits and waste rock dumps include:

- Golden Butterfly Pit
- Golden Butterfly North Pit
- Golden Butterfly waste rock dump
- Content Pit
- Content waste rock dump, and
- Lady Isabella Pit.

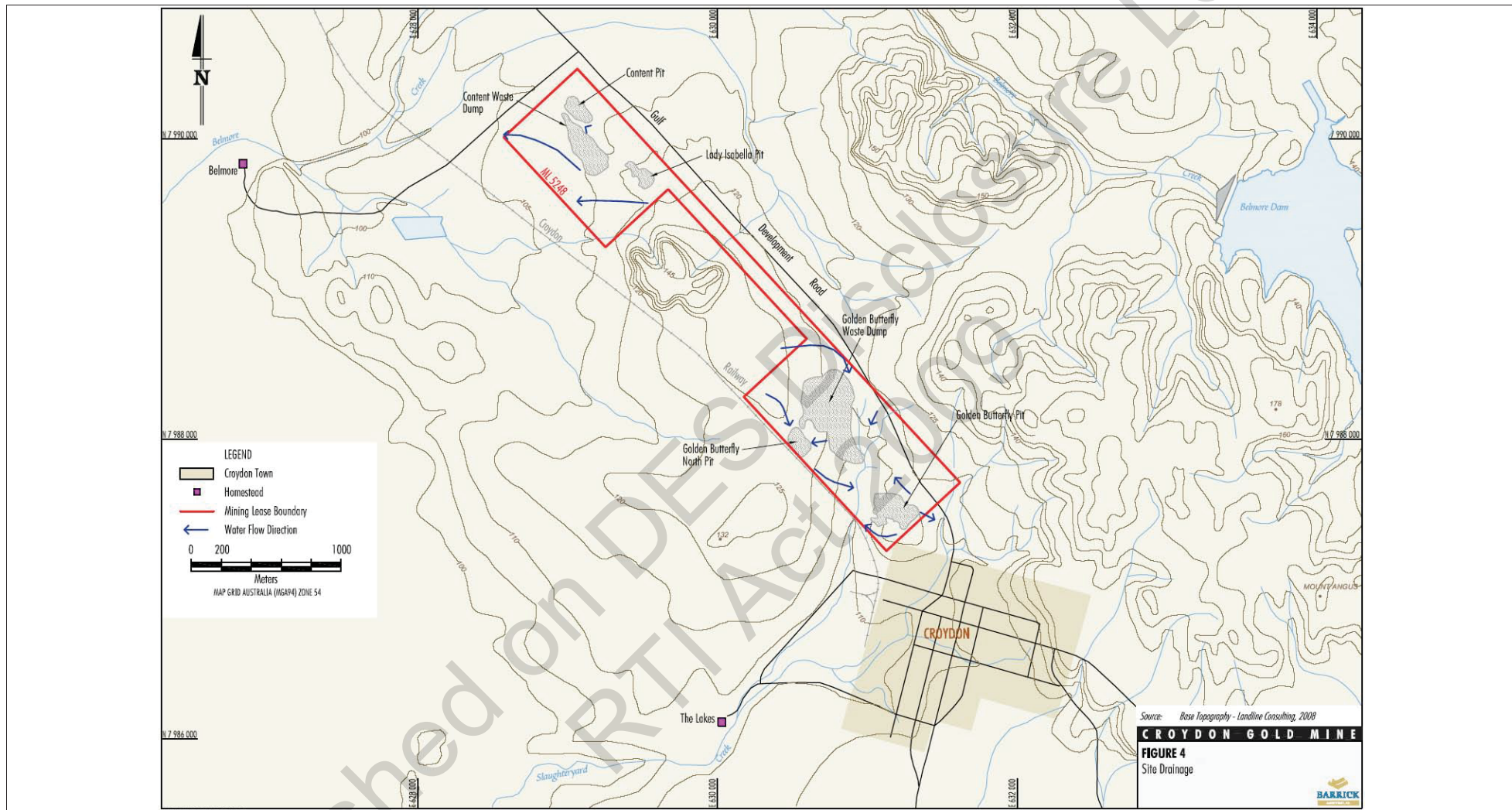
Extensive rainfall in the region in late 2010 and early 2011 led to an increase in the water level in the Content Pit at the Croydon Gold Mine. Water level monitoring indicated that further heavy rainfall during the remainder of the wet season could lead to overtopping of the Content Pit. In late March 2011 a baseline macroinvertebrate survey was commissioned to characterise the existing environment in order to assess the risk to macroinvertebrate communities in the receiving environment if the Content Pit overtopped. However, as a result of further heavy rainfall between 29 March 2011, when the survey was commissioned, and 4 April 2011, when the survey commenced, the Content Pit overtopped. This changed the focus of the survey from a baseline assessment to an investigation into the potential impacts due to the overtopping of the Content Pit.

This report presents the findings of the macroinvertebrate survey conducted in Belmore Creek and its tributaries upstream and downstream of the Croydon Gold Mine in April 2011 and assesses the potential impact of the outflows from the Content Pit on the macroinvertebrate communities.

1.2 Study Area

The Croydon Gold Mine is located in northern Queensland, west of Cairns, approximately 200 km from the Gulf of Carpentaria. Rainfall in the area is highly seasonal and all local waterways are ephemeral. The south-eastern section of the mining lease (i.e. the Golden Butterfly mining area) is located in the upper catchment of Slaughteryard Creek, and the north-western section of the mining lease (i.e. the Content and Lady Isabella mining areas) is located in the Belmore Creek catchment. There are no hydrological flow records for the mining lease, but it is believed that surface water runoff in local creeks ceases shortly after rainfall events and that sheet flow is dominant in the wet season.

As the overtopping event occurred at the Content Pit (located in the Belmore Creek catchment), the survey focused on Belmore Creek and its tributaries. A total of ten sites were surveyed on Belmore Creek and its tributaries, including five comparative (upstream) sites and five potentially impacted (downstream) sites (Figure 1.1).



Croydon Gold Mine Macroinvertebrate Survey

Figure 1.1 Croydon Gold Mine Location and Site Drainage.

Image supplied by Barrick Australia Pacific Ltd.

June 2011

2 Methods

2.1 Survey Design

Survey Timing

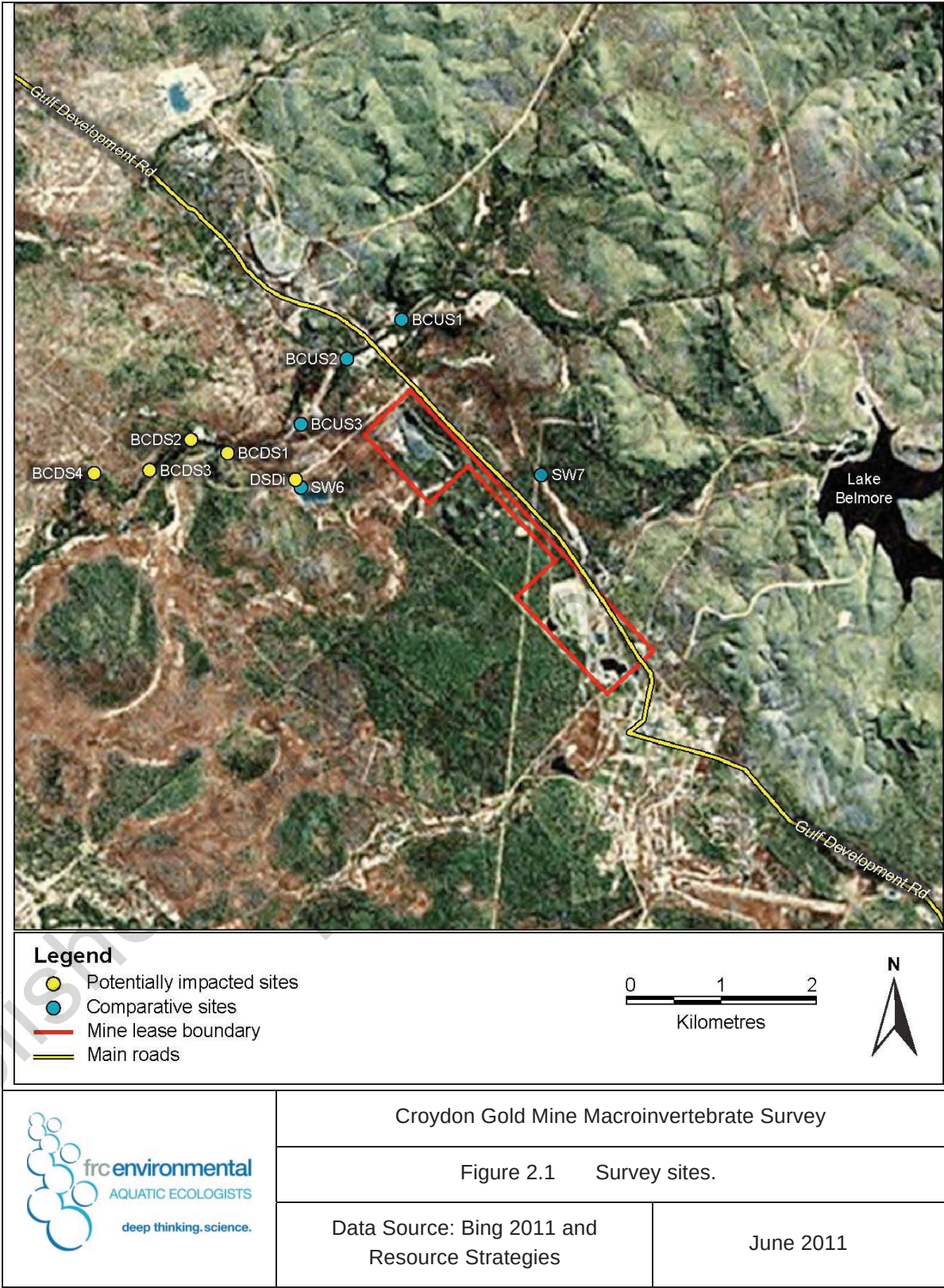
Aquatic habitat, water quality and macroinvertebrates were surveyed between 4 and 6 April 2011.

Weather was fine for the duration of the survey; there was dry track access and flowing water present in all creeks. The survey area experienced substantial rainfall in the months before the survey.

Site Details

A total of ten sites were surveyed in Belmore Creek and its tributaries by frc environmental (Figure 2.1):

- site SW7 – a comparative site, upstream of the mine, on a tributary of Belmore Creek, at a pre-existing water quality monitoring site
- sites BCUS1, BCUS2 and BCUS3 – three comparative sites on Belmore Creek, upstream of the mining lease
- site SW6 – a comparative site, upstream of the confluence between the Content Pit overflow and a tributary of Belmore Creek, at a pre-existing water quality monitoring site
- site DSDi – a potentially impacted site immediately downstream of the confluence between the Content Pit overflow and a tributary of Belmore Creek, and
- sites BCDS1, BCDS2, BCDS3 and BCDS4 – four potentially impacted sites on Belmore Creek, downstream of the confluence of the Content Pit overflow and a tributary of Belmore Creek.



With the exception of sites SW7 and SW6, comparative sites were chosen to represent the range of aquatic habitats in the area and to match potentially impacted sites, in terms of water body type (e.g. natural channel), stream order, and environmental conditions (e.g. erosion, vegetation and available habitat). Comparative site SW7 was selected because it was a pre-existing water quality monitoring site and because of its location upstream of the mine. Site SW6 was selected because it was a pre-existing water quality monitoring site and because of its location upstream of the Content Pit overflow. Site SW6 was located on the edge of a stock dam situated on a tributary of Belmore Creek. Sampling was conducted where the Belmore Creek tributary flowed out of the stock dam. The stock dam also receives flow from natural runoff.

Limitations

The waterways in the survey area are ephemeral, and of the sites surveyed, many are likely to be dry for part of the year. Aquatic faunal communities within ephemeral waterways are highly variable over time, with community structure strongly linked to flow conditions (Smith et al. 2004). The results of this study are based on a single field survey, completed during a very wet summer period. Additional surveys would be required to assess the natural variation of the macroinvertebrate communities.

2.2 Aquatic Habitat

Aquatic Habitat for Fauna

At each site, the condition of the surrounding and in-stream habitat was described based on the *Queensland AUSRIVAS Sampling and Processing Manual* (DNRM 2001), including an assessment of:

- reach environs (i.e. land directly adjacent to the riparian zone)
- type and condition of riparian vegetation
- availability of habitats (e.g. pools, riffles and runs)
- water depth, mean and maximum
- water velocity, mean and maximum
- bank erosion
- substrate composition
- channel diversity
- the presence of in-stream habitat (e.g. large woody debris), overhangs, undercuts, bars, and other forms of shelter, and
- physical barriers to water flow and fish passage.

Habitat Bioassessment Scores

The aquatic habitat descriptions were used to provide an assessment of the condition of habitat following the River Bioassessment Program scoring system. Based on these descriptions, each site was given a habitat assessment score following the River Bioassessment Program scoring system (DNRM 2001).

The habitat bioassessment score datasheets (DNRM 2001) were used to numerically score nine criteria, which were then allocated to one of four categories (excellent, good, moderate and poor). The sum of the numerical rating from each category produced an overall habitat assessment score (Table 2.1):

- Excellent >110
- Good 75 – 110,
- Moderate 39 – 74, and
- Poor ≤38.

Table 2.1 Habitat bioassessment scores used to derive overall condition of habitats.

Habitat Category	Category Score Range			
	Excellent	Good	Moderate	Poor
Bottom substrate / available cover	16 – 20	11 – 15	6 – 10	0 – 5
Embeddedness	16 – 20	11 – 15	6 – 10	0 – 5
Velocity / depth category	16 – 20	11 – 15	6 – 10	0 – 5
Channel alteration	12 – 15	8 – 11	4 – 7	0 – 3
Bottom scouring & deposition	12 – 15	8 – 11	4 – 7	0 – 3
Pool / riffle, run / bend ratio	12 – 15	8 – 11	4 – 7	0 – 3
Bank stability	9 – 10	6 – 8	3 – 5	0 – 2
Bank vegetative stability	9 – 10	6 – 8	3 – 5	0 – 2
Streamside cover	9 – 10	6 – 8	3 – 5	0 – 2
Total (Habitat Bioassessment Score for the Site)	111 – 135	75 – 110	39 – 74	0 – 38

Water Quality

Physical water quality measurements were collected *in situ* using a Hydrolab QUANTA water quality meter. The following variables were recorded:

- water temperature (°C)
- turbidity (NTU)
- dissolved oxygen (DO, % saturation)
- pH, and
- electrical conductivity (EC, µS/cm).

The water quality meter electrical conductivity probe failed to take readings during the survey; however, water quality samples collected by Barrick Australia Pacific Ltd at the same time as the survey were analysed for electrical conductivity and those results are presented in this report.

Data Analysis

There are no relevant guidelines for intermittent and ephemeral streams of this region in the Queensland Water Quality Guidelines (QWQG) (with the exception of a preliminary guideline value for conductivity), and the QWQG advises that the default ANZECC & ARMCANZ (2000) guidelines may not be appropriate (DERM 2009). Nevertheless, in the absence of any other guidelines, the results were compared with the ANZECC & ARMCANZ (2000) default trigger values for lowland streams² in tropical Australia and the preliminary QWQG trigger value for electrical conductivity (Table 2.2), to provide an overall indication of water quality. Results at the potentially impacted sites were also compared with the results at the comparative sites during the survey.

² Streams that are at <150 m elevation.

Table 2.2 ANZECC & ARMCANZ (2000) trigger values for physico-chemical water quality parameters in lowland freshwater systems in the survey area.

Parameter	Units	ANZECC & ARMCANZ (2000)
		Trigger Values
Dissolved oxygen ³	% saturation	90 – 120
pH	pH units	6.0 – 8.0
Electrical conductivity	µS/cm	500 ⁴
Turbidity ⁵	NTU	2 – 15.0

2.3 Aquatic Macroinvertebrates

Sample Collection

AUSRIVAS Samples

At each site, single samples from each of the edge, bed and riffle habitats (where present) were also collected. This sampling followed the methods in the Queensland AUSRIVAS sampling manual, and is designed to provide a broad description of macroinvertebrate communities, rather than a quantitative assessment (DNRM 2001). A standard triangular-framed, macroinvertebrate sampling net with 250 µm mesh was used to collect the samples. A 10 m section of stream bed or edge habitat was disturbed, and a sample collected by passing the net through the disturbed area.

Quantitative Samples

At each site, five macroinvertebrate samples were collected from edge habitat and five samples were collected from the bed habitat. At sites where a riffle habitat was present, five macroinvertebrate samples were also collected from the riffle habitat. The substrate and edge habitat for edge samples was disturbed within a 30 x 30 cm area for five seconds, and each sample was then collected by sweeping a standard triangular-framed, macroinvertebrate sampling net, with 250 µm mesh, through the disturbed area five times.

³ Dissolved oxygen values derived from daytime measurements, and may vary overnight and with depth.

⁴ Preliminary QWQG value for freshwaters in the Gulf region (75th percentile).

⁵ Low values for base flow conditions in Northern Territory rivers; Queensland turbidity values highly variable and dependent on catchment modification and seasonal rainfall runoff.

This quantitative sampling enabled a more rigorous analysis of the variability within and between sites to determine whether the overtopping from Content Pit impacted macroinvertebrate communities downstream.

Sample Processing

All samples were preserved in methylated spirits and returned to frc environmental's Brisbane laboratory, where they were sorted, counted and identified to the lowest practical taxonomic level (in most instances family), to comply with AUSRIVAS standards and those described by Chessman (2003).

Data Analysis

Data from the potentially impacted sites was compared to background data from the comparative sites for:

- taxonomic richness
- abundance
- PET richness
- dominant taxa
- community composition, and
- SIGNAL 2 / family bi-plots.

Calculation of Indices

Taxonomic richness, PET richness and SIGNAL 2 scores were calculated for each sample. These indices were used to indicate the current ecological health of surveyed waterways.

Taxonomic Richness

Taxonomic richness is the number of taxa (in this assessment, families) present in a sample. Taxonomic richness is a basic, unambiguous and effective diversity measure. It is however, affected by arbitrary choice of sample size. Where all samples are of equal size, taxonomic richness is a useful tool when used in conjunction with other indices. Richness does not take into account the relative abundance of each taxa, so rare and common taxa are considered equally.

Abundance

Abundance is the total number of macroinvertebrates present in a sample.

PET Richness

While some groups of macroinvertebrates are tolerant of pollution and environmental degradation, others are sensitive to these stressors (Chessman 2003). Plecoptera (stoneflies), Ephemeroptera (mayflies), and Trichoptera (caddisflies) are referred to as PET taxa, and are particularly sensitive to disturbance. There are typically more PET families within sites of good habitat and water quality than in degraded sites. PET taxa are often the first to disappear when water quality or environmental degradation occurs (EHMP 2007). The lower the PET score the greater the inferred degradation.

SIGNAL 2 Scores

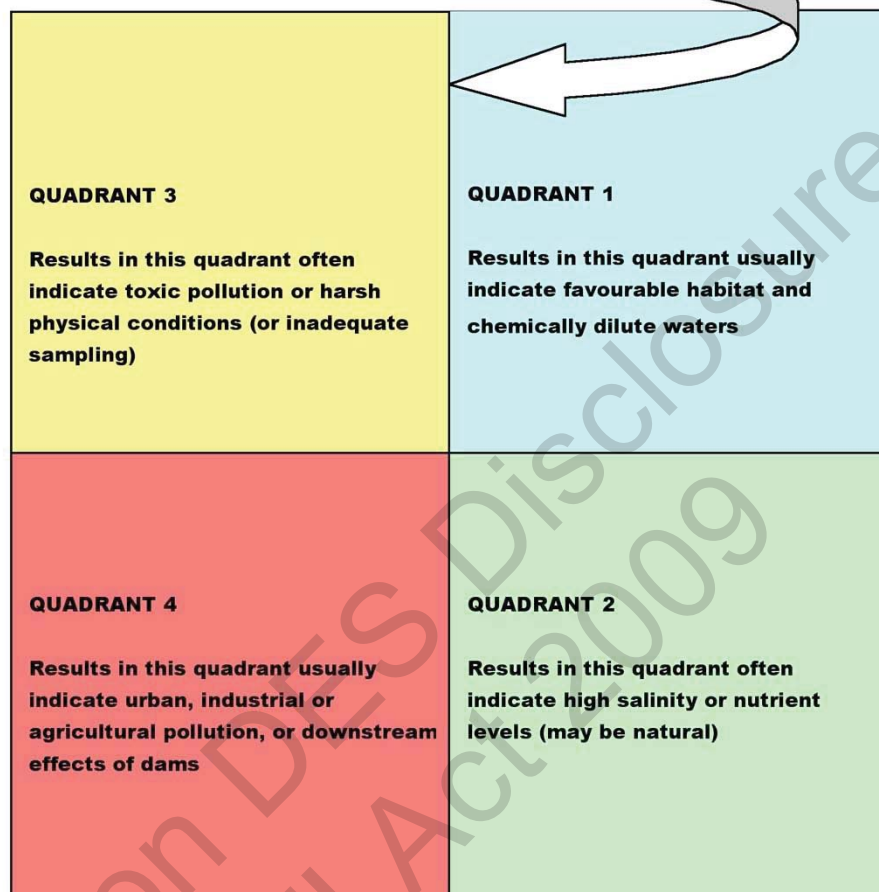
SIGNAL (**S**tream **I**nvertebrate **G**rade **N**umber — **A**verage **L**evel) scores are also based on the sensitivity of each macroinvertebrate family to pollution or habitat degradation. The SIGNAL system has been under continual development for over 10 years, with the current version known as SIGNAL 2. Each macroinvertebrate family has been assigned a grade number between 1 and 10 based on their sensitivity to various pollutants. A low number means that the macroinvertebrate is tolerant of a range of environmental conditions, including common forms of water pollution (e.g. suspended sediments and nutrient enrichment).

SIGNAL 2 scores are weighted for abundance. The scores take the relative abundance of tolerant or sensitive taxa into account (instead of only the presence / absence of these taxa). The overall SIGNAL 2 score for a site is based on:

- the total of the SIGNAL grade
- multiplied by the weight factor for each taxa, and
- divided by the total of the weight factors for each taxa.

SIGNAL 2 scores are interpreted in conjunction with the number of families found in the sample. This is achieved using a SIGNAL 2 / Family bi-plot (Chessman 2003). The plots are divided into quadrants, with each quadrant indicative of particular conditions (Figure 2.2). The quadrants used in this report are based on the default quadrant boundaries provided in Chessman (2001).

Borders between quadrants vary with geographic area,
sampling method and habitat type



Number of macro-invertebrate families

Figure 2.2 Quadrant diagram for SIGNAL 2 / Family Bi-plot.

Analyses of Quantitative Samples

Univariate

ANOVA (analysis of variance) is a statistical hypothesis testing procedure that compares the mean and variance around the mean within each test group (e.g. among replicates within a site) with that among each test group (e.g. sites). The null hypothesis is that this mean is the same for all groups. Generally, if the significance level of the F-test (p value) is below 0.05, the null hypothesis can be rejected.

A one-way ANOVA (analysis of variance) test was used for differences among sites. A significant difference ($p < 0.05$) at a potentially impacted site, relative to comparative sites,

may indicate an impact associated with the Content Pit overtopping. As macroinvertebrate richness is strongly linked to habitat type, differences in richness were therefore analysed separately for each habitat. Where an ANOVA test indicated significant differences among sites, a Student Newman-Keuls (SNK) test was used to determine which pairs of sites differed.

Multivariate

Multivariate analyses consider changes to the macroinvertebrate community structure as a whole, rather than to a single component of the community (e.g. indicator species) or single indices derived to represent the community (i.e. univariate analyses such as richness). Multivariate analyses provide a powerful tool to determine similarities or dissimilarities in community composition (i.e. type and abundance of each taxon) between pre-determined factors (e.g. sites and impacts).

To determine the extent of impact, differences in community composition within potentially impacted sites and comparative sites were examined using a one-way analysis of similarity (ANOSIM). Prior to analysis, community data were $\log_{x+1}$ transformed and converted to a Bray-Curtis similarity matrix. Community differences between sites were displayed visually, for each habitat at each site, using non-metric multi-dimensional scaling (MDS) ordinations. These were overlaid by lines indicating 40% or 50% similarity between sites, as determined using CLUSTER analysis (Clarke 1993). Individual taxa, that contributed to the differences between sites, were identified using the similarity percentages (SIMPER) species contributions routine (Clarke 1993).

To examine the relationships between macroinvertebrate communities and environmental variables (e.g. substrate composition, metal concentrations in sediments and water, pH levels and electrical conductivity), these were compared at the same sites using BIOENV.

The combination of environmental variable/s that best described the biological community pattern were ranked and analysed using a rank correlation coefficient test (Spearman's coefficient – Rho (ρ)). The combinations of environmental variables that best describe the macroinvertebrate communities typically have values of ρ closer to 1 than 0. Environmental variables were normalised and converted to a Euclidean Distance matrix for the analyses, and the most strongly correlated groups were visualised using MDS ordinations.

3 Results and Discussion

3.1 Aquatic Habitat

Aquatic Habitat for Fauna

Site Descriptions

In general, aquatic habitat was good at most survey sites, with cobble, pebble and gravel substrates suitable for macroinvertebrates and native vegetation dominant in the riparian zones. The least suitable macroinvertebrate habitat was at comparative (upstream) sites SW7 and SW6. These sites had substrates dominated by fine sand and silt, and poor riparian zones.

Figure 3.1

View downstream at site SW7 (comparative site).

The substrate was dominated by sand, with some gravel and silt. The riparian zone comprised mainly native vegetation, dominated by grass, with some small trees. Sand deposits were evident along the creek. There were no aquatic macrophytes. There was no evidence of cattle access.



Figure 3.2

View upstream at site BCUS1 (comparative site).

The substrate was dominated by cobbles, with some pebbles, gravel and sand. The riparian zone comprised mainly native vegetation, dominated by small trees and shrubs, with some grass. There were no sand deposits or aquatic macrophytes at this site. There was evidence of cattle access.



Figure 3.3

View downstream at site BCUS2 (comparative site).

The substrate was dominated by sand, with some pebbles, gravel and silt. The riparian zone comprised mainly native vegetation, dominated by small trees and shrubs. Sand deposits were evident on the creek bed. There were no aquatic macrophytes, but there was some filamentous algae. There was evidence of cattle access.



Figure 3.4

View upstream of right channel at site BCUS3 (comparative site).

The substrate was dominated by sand, gravel and pebbles, with some cobbles and silt. The riparian zone comprised mainly native vegetation, dominated by shrubs, with some grass and small trees. Sand deposits were evident on the creek bed. The submerged aquatic macrophyte water milfoil (*Myriophyllum* sp.) formed large beds. There was evidence of cattle access.

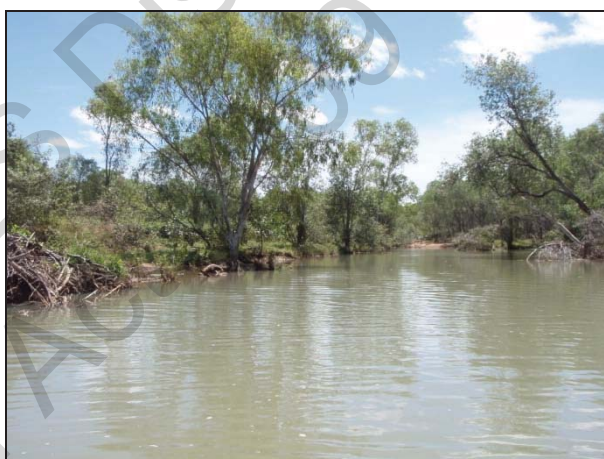


Figure 3.5

View of tributary outflow at site SW6 (comparative site).

This site was on the edge of a stock dam. The substrate was dominated by silt, with some sand and gravel. The riparian zone comprised sparse, mainly native vegetation and was dominated by grasses. There were no sand deposits or aquatic macrophytes. There were some filamentous algae along the edge. There was evidence of cattle access.



Figure 3.6

View upstream at site DSDi (potentially impacted site).

The substrate was dominated by sand, with some cobble, pebble, gravel and silt present. Sand deposits were evident on the creek bed. The riparian zone comprised mainly native vegetation dominated by grass. There were no aquatic macrophytes. There was evidence of cattle access.



Figure 3.7

View across stream at site BCDS1 (potentially impacted site).

The substrate was dominated by sand, with some bedrock, boulders, cobbles, pebbles, gravel and silt present. Sand deposits were evident on the creek bed. The riparian zone comprised dominated by small trees and shrubs. There was low coverage of the substrate by the aquatic macrophyte water milfoil (*Myriophyllum* sp.). There was evidence of cattle access.

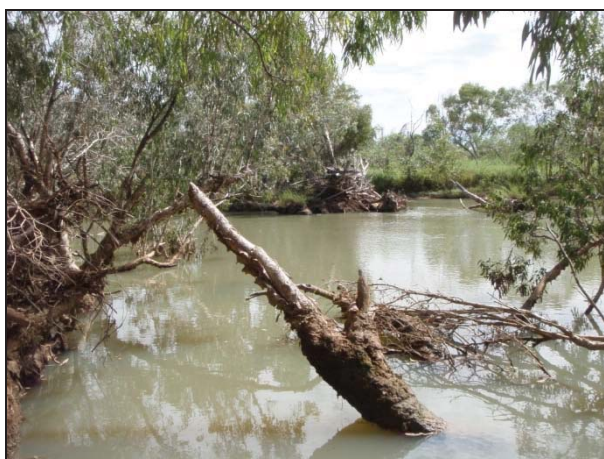


Figure 3.8

View upstream at site BCDS2 (potentially impacted site).

The substrate was dominated by sand, with cobbles, pebbles, gravel and silt also present. There were no sand deposits. The riparian zone comprised mainly native vegetation dominated by small trees and shrubs. There were no aquatic macrophytes. There was evidence of cattle access.



Figure 3.9

View upstream at site BCDS3 (potentially impacted site).

The substrate was dominated by sand and gravel, with some cobbles, pebbles and silt. Some sand deposits were evident on the creek bed. The riparian zone comprised mainly native vegetation dominated by grass, shrubs and small trees. There were no aquatic macrophytes. There was evidence of cattle access.



Figure 3.10

View upstream at site BCDS4 (potentially impacted site).

The substrate was dominated by sand, with some cobbles, pebbles, gravel and silt. The riparian zone comprised mainly native vegetation dominated by shrubs, with some grass and trees. There were no sand deposits or aquatic macrophytes. There was evidence of cattle access.



Bioassessment Scores

Habitat bioassessment scores ranged from moderate to good at all sites (Figure 3.11).

Comparative sites SW7 and SW6 had the lowest bioassessment scores. These scores were due to high embeddedness of the substrate (as it was dominated by fine sediments), as well as low diversity of in-stream habitat (i.e. there was only shallow pools and runs, with no deep pools or riffles present), and poor streamside cover. This indicates that these sites are likely to be less suitable for macroinvertebrates. Potentially impacted sites DSDi and BCDS1 also had relatively low bioassessment scores due to high embeddedness and poor in-stream habitat diversity.

There was a noticeable improvement in habitat condition between potentially impacted sites BCDS1 and BCDS2 (Figure 3.11). Along with comparative sites BCUS2 and BCUS3, potentially impacted sites BCDS2 and BCDS3 had the highest bioassessment scores, with each site classified as good. These sites had good in-stream habitat diversity, low embeddedness and high streamside cover.

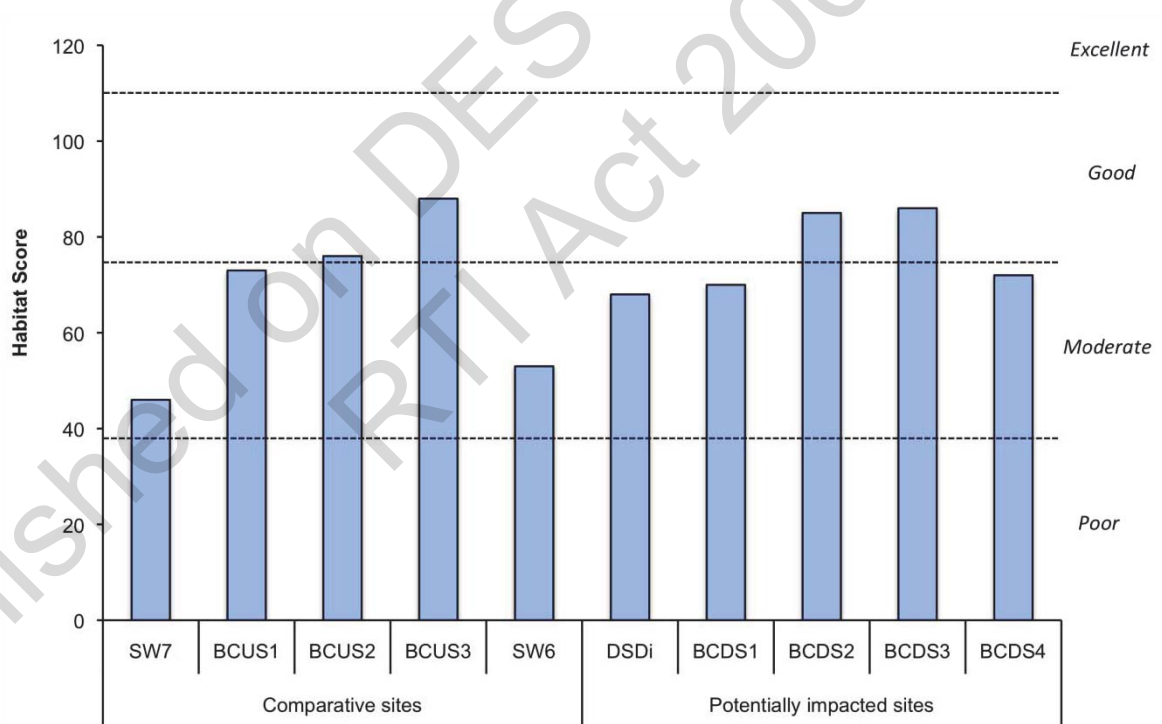


Figure 3.11 Habitat bioassessment scores at each site.

Water Quality

Water Temperature

Water temperature ranged from 24.1 °C – 31.4 °C. There are no ANZECC & ARMCANZ (2000) trigger values for water temperature. Temperature was similar across all sites however it was slightly lower at site DSDi, downstream of confluence of the Content Pit overflow and the Belmore Creek tributary. This is likely due to diurnal variation in temperature and the time of day it was measured.

Turbidity

Turbidity exceeded the upper and lower ANZECC & ARMCANZ (2000) trigger values at all sites, except site SW6 where it only exceeded the lower trigger value (Figure 3.12). Turbidity ranged from 14.2 – 52.6 NTU.

In general, turbidity was similar at all sites except comparative sites SW7 and BCUS3 (Figure 3.12). Turbidity at these sites was approximately double the turbidity at all other sites. The high turbidity recorded at all sites was likely due to the recent rainfall in the region and runoff carrying suspended sediments entering the creeks. Turbidity can have a negative impact on aquatic flora and fauna through a reduction in light penetration of the water and the siltation of interstitial spaces between cobbles and pebbles that provide habitat.

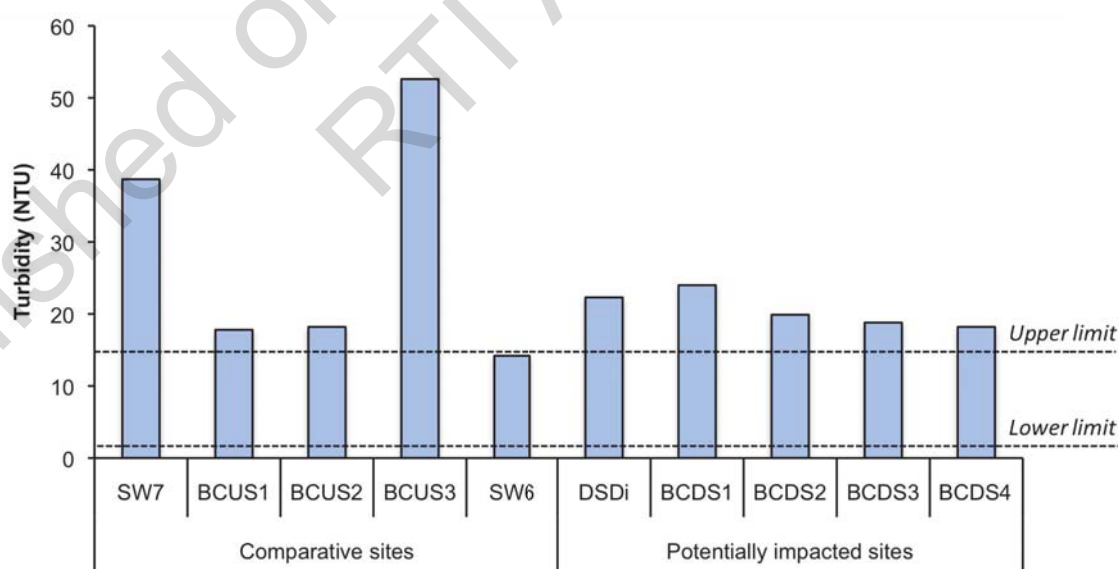


Figure 3.12 Turbidity at each site.

pH

The pH was within the ANZECC & ARMCANZ (2000) trigger value range at all sites, ranging from 6.6 to 7.59 (Figure 3.13). The pH was more alkaline downstream of the Content Pit overflow at DSDi, but the pH here was not substantially higher than at the other sites.

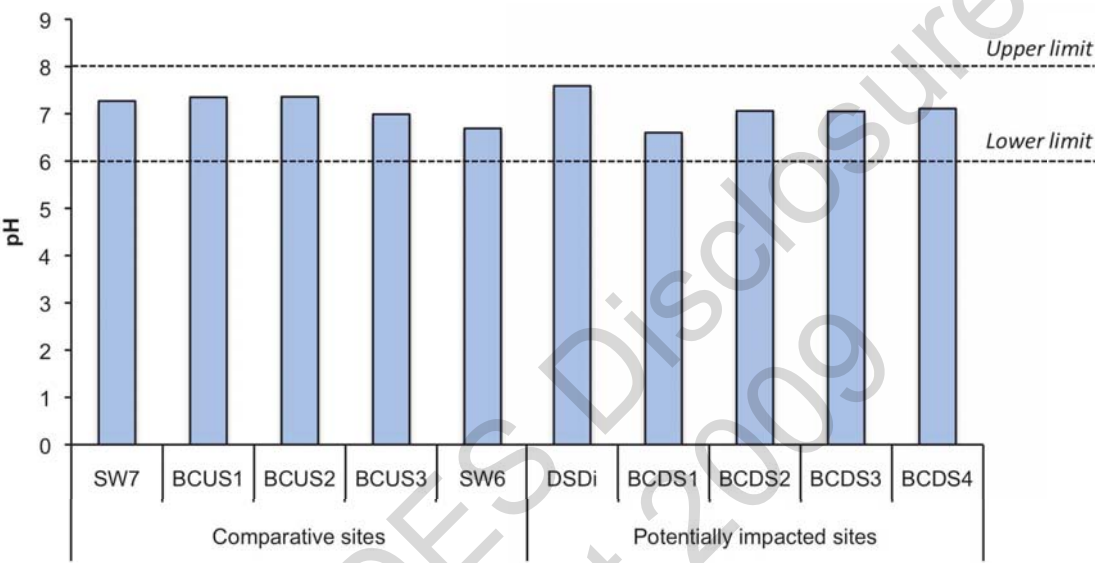


Figure 3.13 The pH at each site.

Electrical Conductivity

Electrical conductivity was below the QWQG trigger value at all sites (Figure 3.14). Conductivity was similar at all sites except comparative site SW7 and potentially impacted site DSDi. It is possible that the Content Pit overflow had an impact on conductivity at site DSDi, but the substantial decrease in conductivity between sites DSDi and BCDS1 (which are approximately 700 m apart) and the high value at comparative site SW7 suggest local variation may also be a factor. High conductivity can be directly toxic to macroinvertebrates and lead to reduced abundance and taxonomic richness; however the conductivity recorded at sites SW7 and DSDi is not considered to be 'high' in the context of the available water quality guidelines.

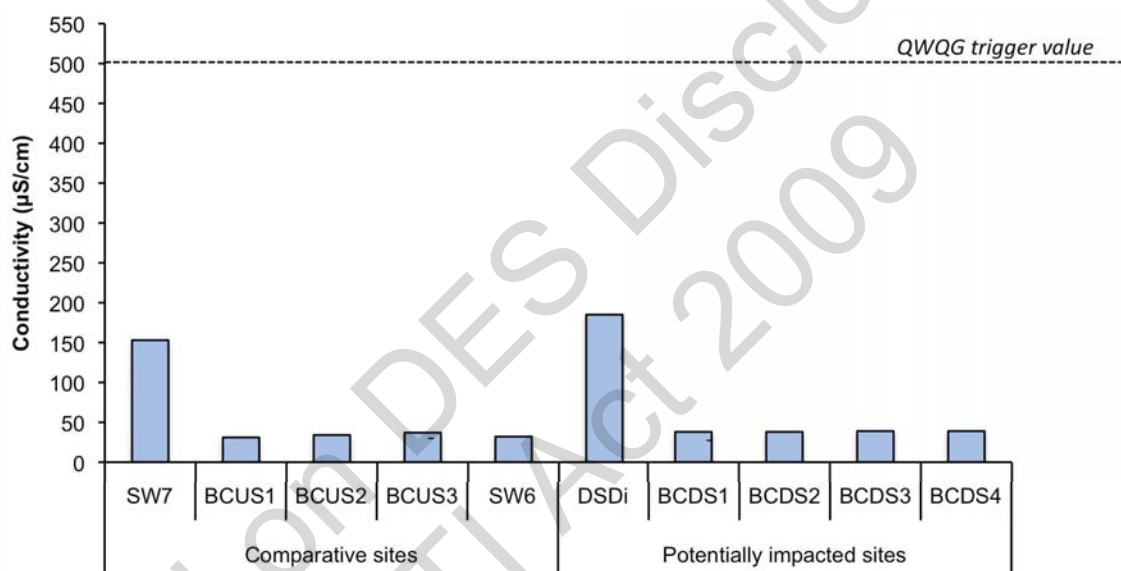


Figure 3.14 Electrical conductivity at each site.

Dissolved Oxygen

The percent saturation of dissolved oxygen (DO) was within the ANZECC & ARMCANZ (2000) trigger value range at all sites except comparative sites SW7 and SW6 (Figure 3.15). These sites had less flow than other survey sites, which may be a contributing factor to the lower dissolved oxygen. Dissolved oxygen was also slightly lower in potentially impacted sites than at comparative sites on Belmore Creek (although DO was within the trigger value range at all potentially impacted sites). This may indicate an impact from the Content Pit overflow; however, dissolved oxygen is highly variable throughout the day and should be measured over 24 hours to determine if any differences are real. Dissolved oxygen is essential to aquatic fauna survival and low dissolved oxygen can lead to a reduction in abundance and taxonomic richness.

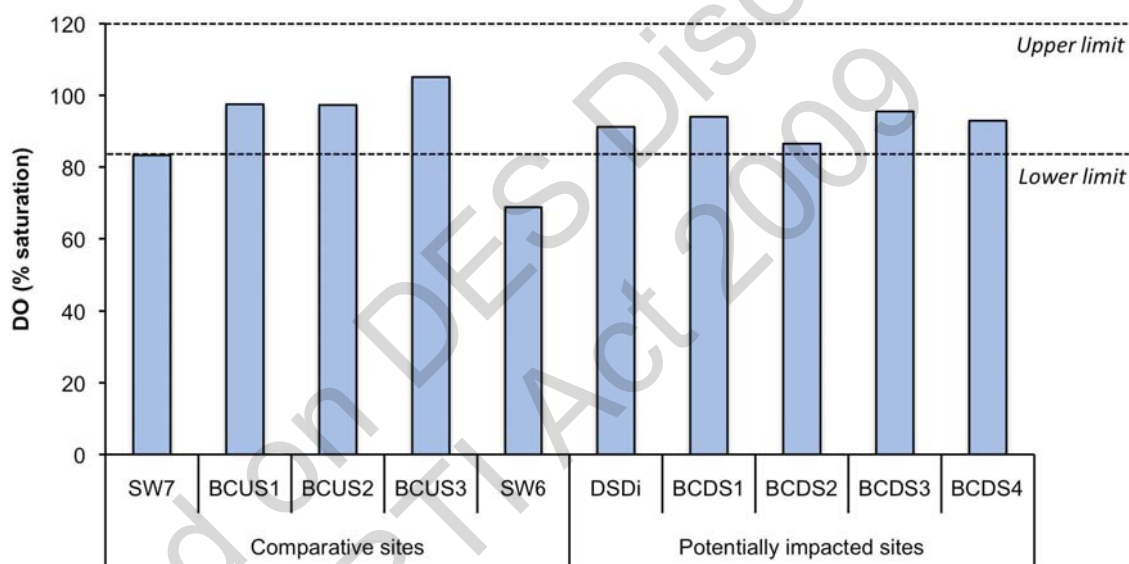


Figure 3.15 Dissolved oxygen at each site, and the ANZECC & ARMCANZ (2000) trigger level range.

3.2 Aquatic Macroinvertebrates

AUSRIVAS Assessment

Total Taxonomic Richness

Total taxonomic richness was generally low and variable across sites. It was typically higher in the edge and riffle habitats than in the bed habitat (Figure 3.16).

Macroinvertebrate taxonomic richness in the edge habitat was lowest at potentially impacted site BCDS1 and highest at potentially impacted site BCDS3 (Figure 3.16). Taxonomic richness was higher at site DSDi, downstream of the Content Pit overflow, than at comparative sites BCUS2 and SW6. This suggests that the overflow has not had a substantial impact on macroinvertebrates in edge habitat.

Total taxonomic richness in the bed habitat was variable, with similar results in the comparative and potentially impacted sites (Figure 3.16). No taxa were recorded for the site immediately downstream of the Content Pit overflow which suggests a potential impact on macroinvertebrates; however, only three taxa were found at sites BCUS2 and BCDS1 which indicates other factors (e.g. habitat or natural variability) may be influencing macroinvertebrates in the bed at site DSDi.

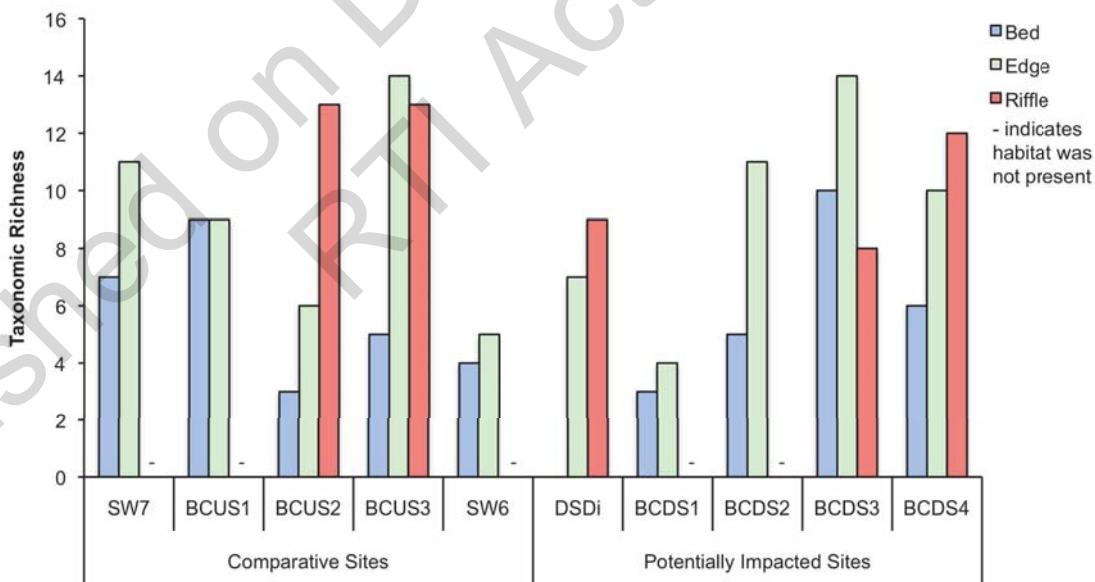


Figure 3.16 Total taxonomic richness for bed, edge and riffle habitats.

Total taxonomic richness in the riffle was generally lower at potentially impacted sites than at comparative sites. This is similar to the results for the quantitative samples and is likely to be the result of better riffle habitat (i.e. a greater percentage of cobble and pebble in the substrate; and shallow, fast flow) at these sites.

Variation in the results for the edge, bed and riffle habitats suggest that the Content Pit overflow did not have a substantial, or possibly any, effect on macroinvertebrate taxonomic richness.

PET Richness

PET richness was typically low across all habitats, but was higher in the edge and riffle habitats than in the bed habitat (Figure 3.17).

Potentially impacted site DSDi, immediately downstream of the Content Pit overflow, had the lowest PET richness for all habitats (with no taxa at all recorded in the bed) (Figure 3.17). This may indicate a potential impact from the Content Pit overflow; however, PET richness was low for the bed habitat at all comparative sites except site BCUS1, which suggests other factors (e.g. habitat) may also have been affecting PET taxa.

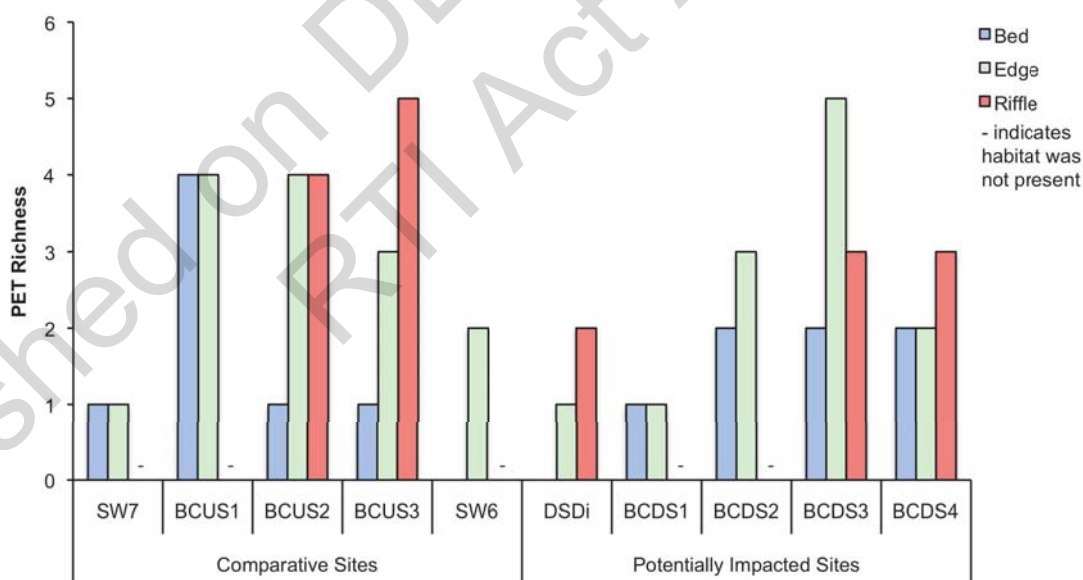


Figure 3.17 PET richness for edge, bed and riffle habitats.

SIGNAL 2

The lowest SIGNAL 2 scores for the edge habitat were recorded at comparative sites SW7 and BCUS3 (Figure 3.18). The lowest SIGNAL 2 score for the bed habitat was recorded at site SW7. The highest SIGNAL 2 scores for each habitat were recorded at comparative site BCUS2. SIGNAL 2 scores for all other sites were similar.

These results suggest there was no clear impact on pollution sensitive taxa from the Content Pit overflow. This is supported by the SIGNAL 2 / Family Bi-plot, which shows no distinction between comparative and potentially impacted sites, with all sites located in quadrants three and four (Figure 3.18). Quadrant three indicates toxic pollution or harsh physical conditions, while quadrant four indicates urban, agricultural or industrial pollution, or the downstream effects of dams. As the creeks in this region are ephemeral they are subject to naturally harsh conditions; and all sites are in an agricultural area, with most sites showing signs of cattle access. These conditions were likely to be affecting the macroinvertebrate communities.

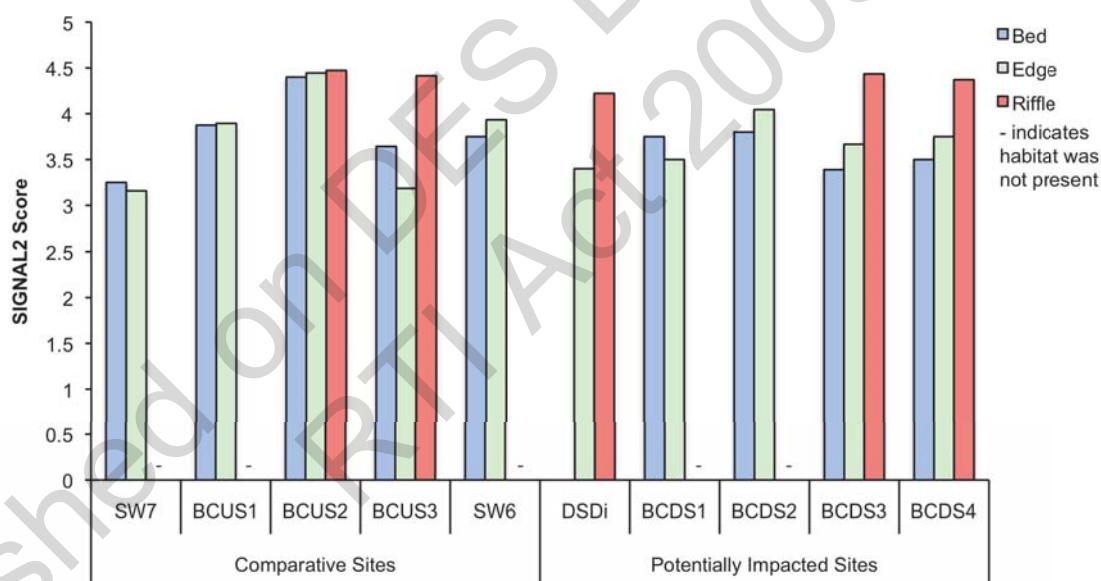


Figure 3.18 SIGNAL 2 scores for the edge, bed and riffle habitats.

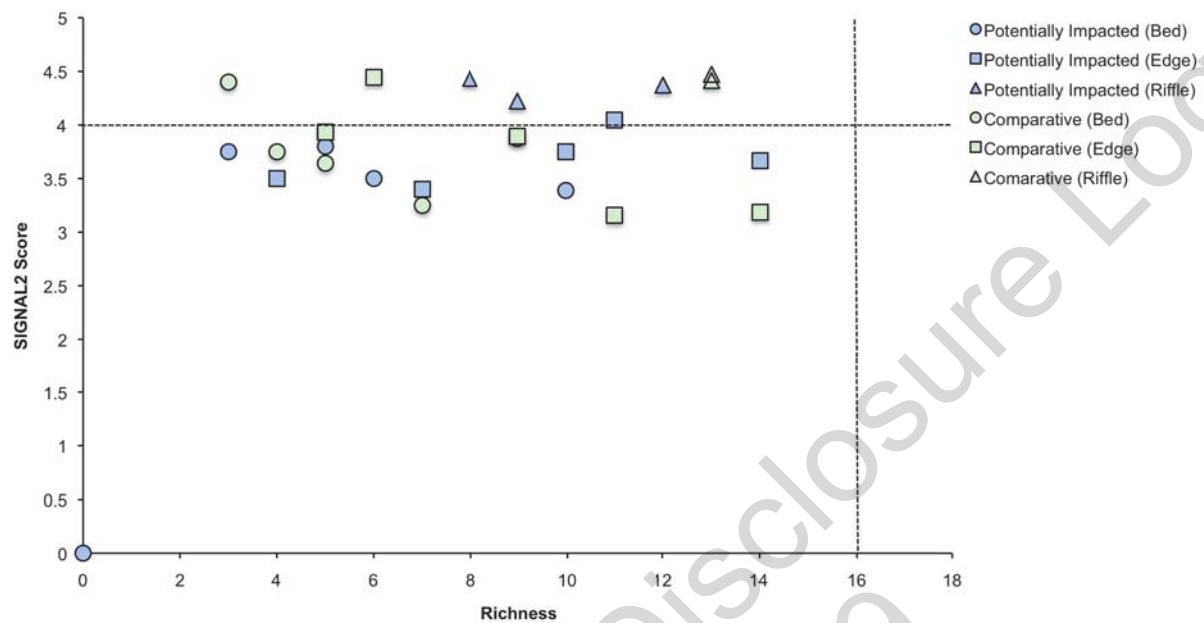


Figure 3.19 SIGNAL 2 / Family Bi-plot for edge, bed and riffle habitats.

Quantitative Impact Assessment

Mean Taxonomic Richness

Edge Habitat

Mean taxonomic richness in the edge habitat was highest at comparative site SW7 and lowest at comparative site SW6, where richness was significantly lower than all other sites (ANOVA SNK tests, $p < 0.05$) (Figure 3.20). This is likely due to the good and poor quality of the edge habitat present at these sites, respectively. Although the habitat bioassessment score at site SW7 was low, the presence of overhanging grasses at this site provided good edge habitat that was not affected by the embeddedness and low in-stream diversity.

In general, macroinvertebrate taxonomic richness was higher at the potentially impacted sites than at the comparative sites, except site DSDi (although richness here was only significantly lower than at site SW7; ANOVA SNK tests, $p < 0.05$) (Figure 3.20). This suggests that the Content Pit overflow did have an impact at site DSDi, but did not have an impact on the macroinvertebrate communities of the edge habitat further downstream in Belmore Creek.

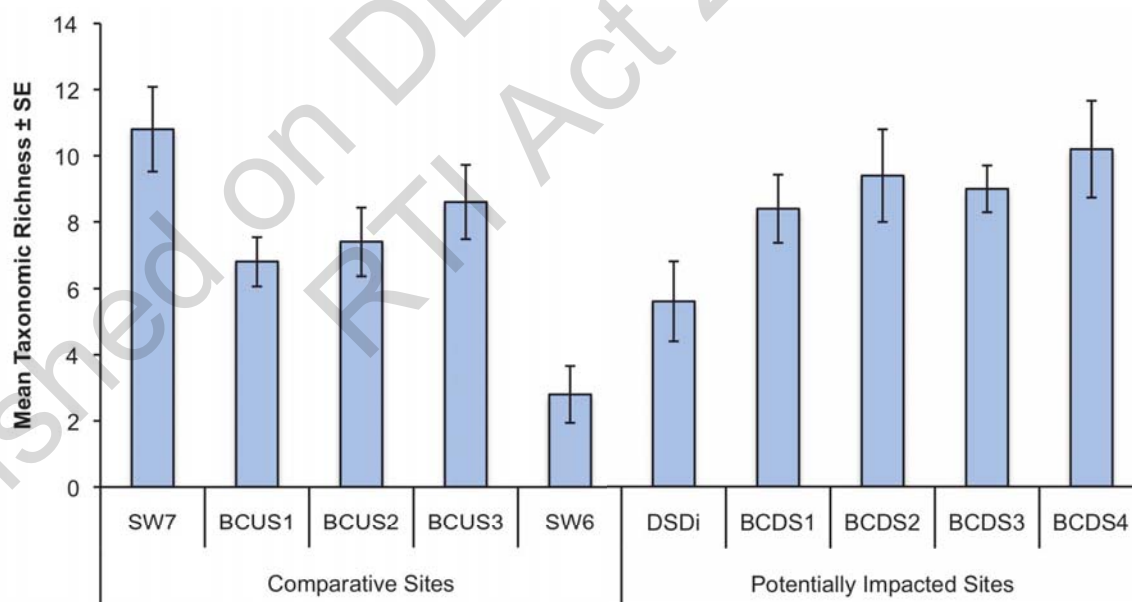


Figure 3.20 Mean taxonomic richness in edge habitat.

Bed Habitat

Mean taxonomic richness in the bed habitat was lowest at comparative site BCUS2 and potentially impacted sites DSDi and BCDS4 (Figure 3.21). It was highest at potentially impacted sites BCDS2 and BCDS3.

A decrease in taxonomic richness on the tributary of Belmore Creek from comparative site SW6 to potentially impacted site DSDi indicates a likely impact from the Content Pit overflow (Figure 3.21). However taxonomic richness increased from site DSDi to site BCDS1 and sites further downstream (with the difference in richness between site DSDi and BCDS2 being statistically significant; ANOVA SNK tests, $p < 0.05$), suggesting that any potential impact was limited in spatial extent. In addition, taxonomic richness in the bed was variable across sites, which may indicate that natural variability was also a factor in the low richness at site DSDi.

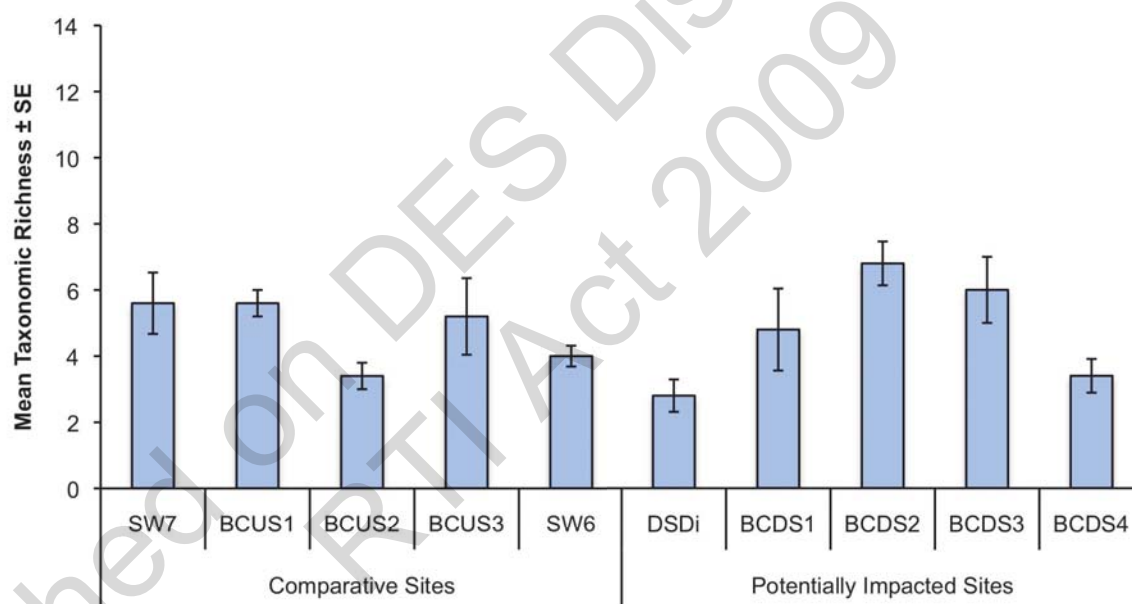


Figure 3.21 Mean taxonomic richness in bed habitat.

Riffle Habitat

Mean taxonomic richness in the riffle habitat was lower at the potentially impacted sites than at the comparative sites (Figure 3.22), although there were no significant differences in richness between sites (ANOVA SNK tests, $p > 0.05$). The taxonomic richness in the edge and bed habitats was relatively high at potentially impacted site BCDS3 and relatively high for the edge habitat at BCDS4; this difference may have been due to the Content Pit overflow, but is more likely to be related to habitat conditions or other factors.

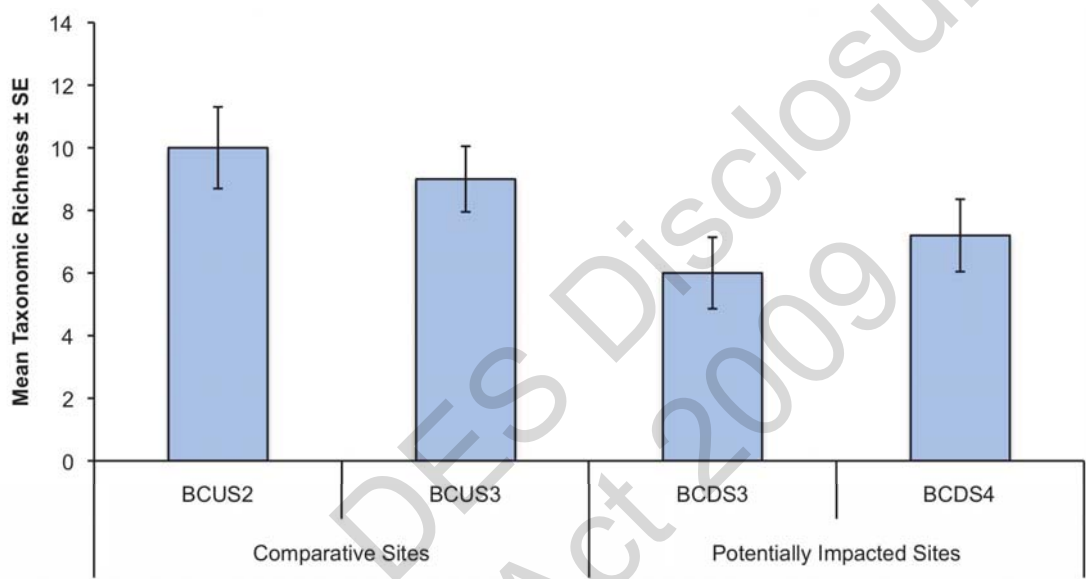


Figure 3.22 Mean taxonomic richness in riffle habitat.

Mean Abundance

Edge Habitat

Mean abundance in the edge habitat was lowest at potentially impacted site DSDi but was also low at comparative sites SW7 and SW6 (Figure 3.23); abundance at sites DSDi and SW6 was significantly lower than at most other sites (ANOVA SNK tests, $p < 0.05$). In general, mean abundance was higher at potentially impacted sites on Belmore Creek than at comparative sites, except for BCUS3.

Limited habitat availability at sites SW7 and SW6 is likely to have contributed to the low abundance at these sites, despite the presence of some good habitat at site SW7. It is possible that the Content Pit overflow had an impact in the tributary to Belmore Creek at site DSDi. Site DSDi had good edge habitat, therefore it is possible that the Content Pit overflow impacted macroinvertebrates communities at this site. Mean abundance increased between sites DSDi and BCDS1, suggesting that any potential impact was spatially limited.

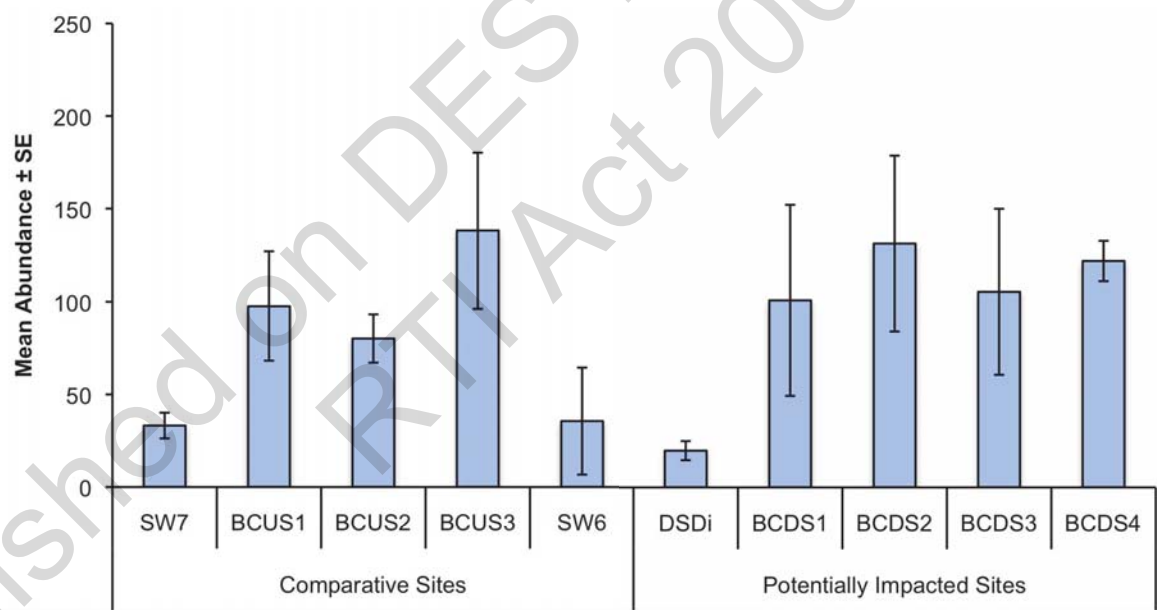


Figure 3.23 Mean abundance in the edge habitat.

Bed Habitat

Mean abundance in the bed habitat was low at all sites except sites BCUS3 and BCDS2, where abundance was significantly higher than at all other sites (ANOVA SNK tests, $p < 0.05$; Figure 3.24). The lowest abundances were at potentially impacted sites DSDi and BCDS4. A decrease in abundance between sites SW6 and DSDi indicates a possible impact on macroinvertebrates from the Content Pit overflow. However, the increase in abundance between sites DSDi and BCDS1, and the variability in abundance across sites, suggests any impact is limited or may be the result of natural variation.

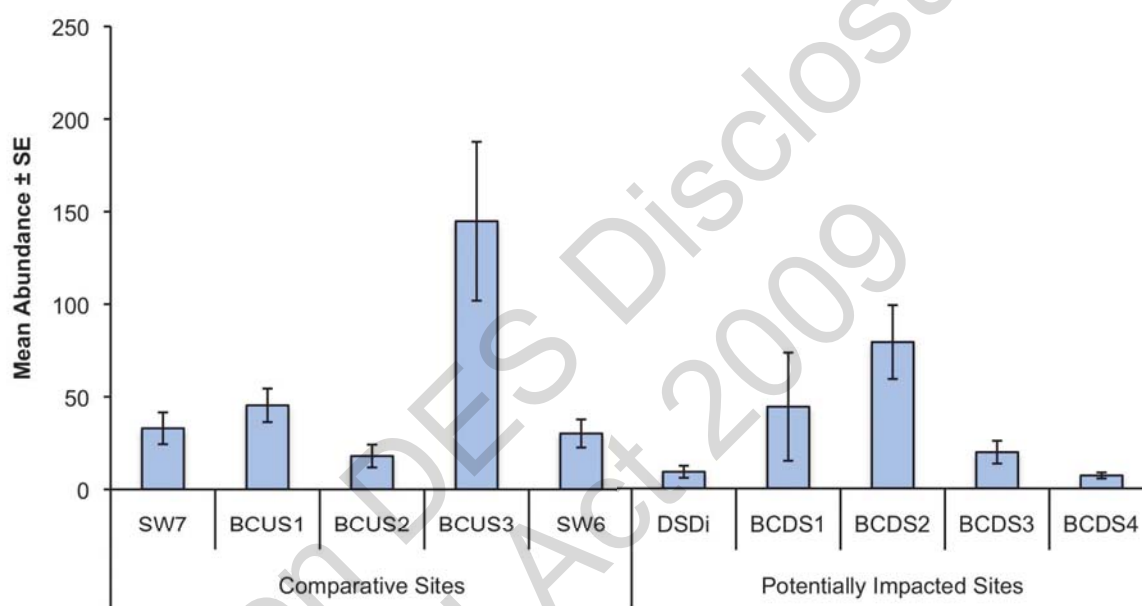


Figure 3.24 Mean abundance in the bed habitat.

Riffle Habitat

Mean abundance in the riffle habitat was higher at comparative sites than at potentially impacted sites (Figure 3.25), although there were no significant differences in richness between sites (ANOVA SNK tests, $p > 0.05$).

The abundance in the edge habitat at these potentially impacted sites was relatively high compared to the comparative sites, but was low for the bed habitat. This suggests that the difference in abundance between comparative and potentially impacted sites for the riffle habitat may not have been due to the Content Pit overflow, but was likely due to habitat conditions.

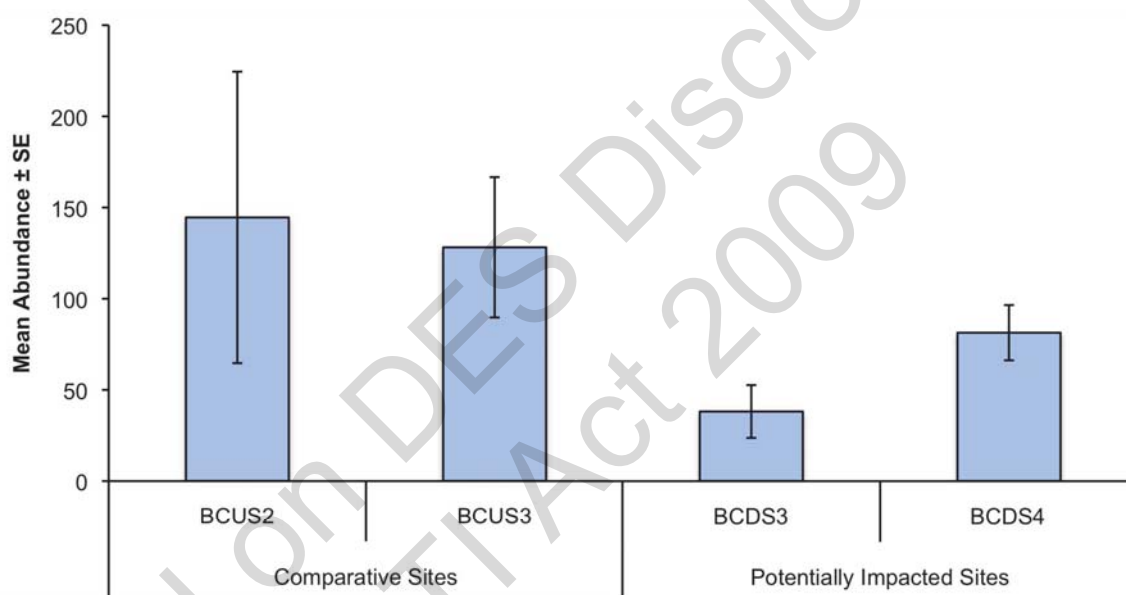


Figure 3.25 Mean abundance in the riffle habitat.

Community Composition

Edge Habitat

Macroinvertebrate community composition in the edge habitat was significantly different between sites; however, the differences were small (ANOSIM Global $R = 0.37$, $p = 0.001$). While communities between some sites were different from each other, there were no distinct groupings between communities at comparative and potentially impacted sites (Figure 3.26).

Communities at comparative site SW6 and potentially impacted site DSDi were the most distinct from communities at other sites (Figure 3.26). At potentially impacted site DSDi, this was mostly due to a decreased abundance or an absence of some taxa at this site compared with other sites, including both tolerant taxa such as non-biting midge larvae (sub-families Chironominae and Tanypodinae), and sensitive taxa such as caenid mayflies and leptocerid and ecnomid caddisflies (SIMPER). This may be indicative of an impact from the overtopping of the Content Pit, though it is important to note that abundances of other relatively sensitive taxa such as baetid mayflies and mites were similar to or higher than at other sites.

Communities at comparative site SW6 had low abundances of fairly tolerant taxa such as biting (family Ceratopogonidae) and non-biting midge larvae, and lacked a range of taxa that were relatively widespread across the study area, such as baetid and caenid mayflies, waterboatmen (family Corixidae), dragonfly larvae (family Libellulidae) and caddisflies (families Leptoceridae and Ecnomidae).

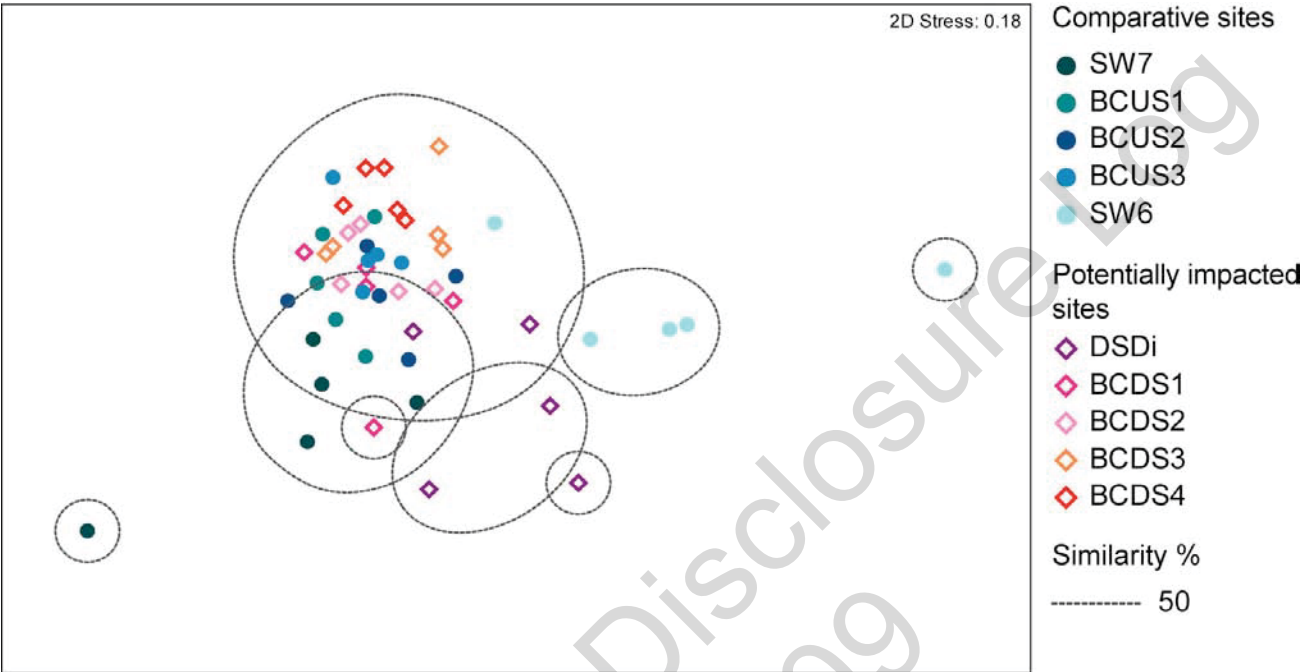


Figure 3.26 MDS ordination showing the differences between sites in macroinvertebrate community composition in edge habitat, and 50% similarity groupings based on CLUSTER analysis.

A comparison of environmental variables and macroinvertebrate community composition in the edge showed a significant correlation between community composition and a combination of turbidity, magnesium, arsenic, copper and total phosphorus concentrations (BIOENV Rho = 0.895, $p=0.04$). Comparative sites SW7 and SW6 and potentially impacted site DSDi were distinctly different from all other sites (Figure 3.27 and Figure 3.28), which suggest these water quality variables influenced macroinvertebrate communities at these sites.

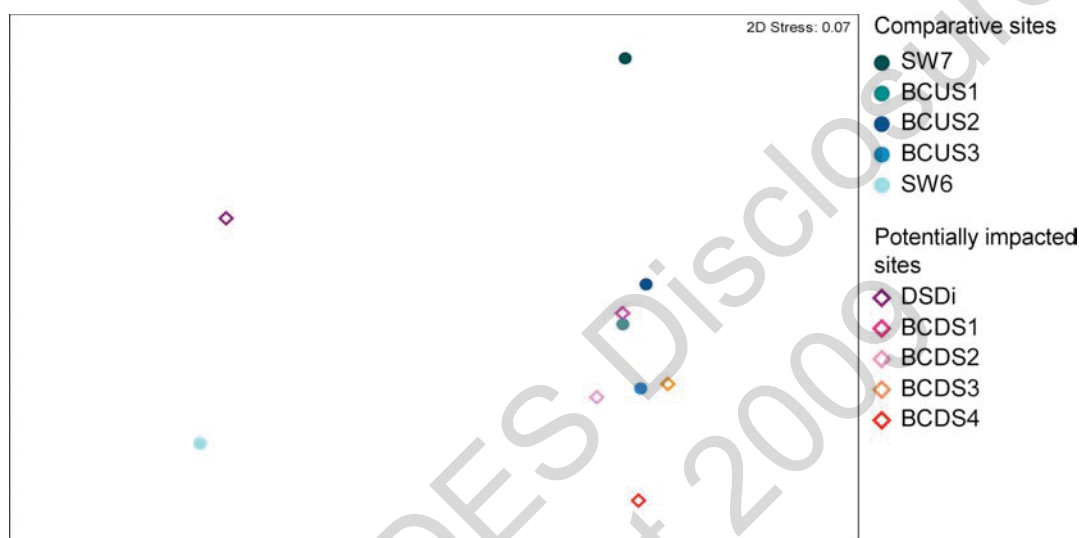


Figure 3.27 MDS ordination showing the differences between sites in macroinvertebrate community composition (averaged across replicates) in edge habitat.

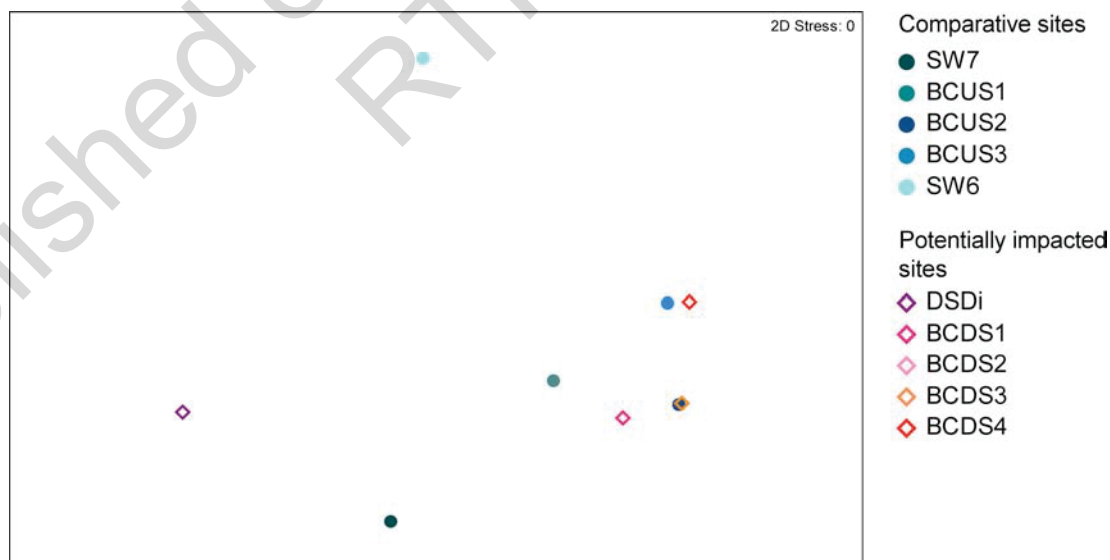


Figure 3.28 MDS ordination showing the differences between sites in water quality (turbidity, magnesium, arsenic, copper and total phosphorus).

Of these water quality variables, turbidity was higher at sites SW7, SW6 and DSDi than at the other sites surveyed; it is possible that elevated turbidity at site DSDi was related to overland flow from the overtopping Content Pit carrying suspended sediments to the tributary of Belmore Creek (though note that turbidity at site DSDi was similar to that at other sites during *in situ* sampling of turbidity). Magnesium concentrations were elevated at sites DSDi and SW7, and total phosphorus concentrations were elevated at sites DSDi and SW6; it is unclear whether this is related to the overtopping of Content Pit.

Arsenic concentrations were lower at sites SW7, SW6 and DSDi than at the other sites surveyed, which indicates that the overtopping of Content Pit did not have an adverse effect on macroinvertebrate communities due to toxicity of arsenic. Conversely, copper concentrations were elevated at these sites compared with the others surveyed: particularly at site DSDi, which may be a result of the overtopping of the Content Pit.

Bed Habitat

Macroinvertebrate community composition in the bed habitat was significantly different between sites, however the magnitude of this difference was small, and mostly indistinct at a 40% similarity level (ANOSIM global $R = 0.452$, $p = 0.01$; Figure 3.29).

Nevertheless, communities at site DSDi were different from those at other sites (Figure 3.29). This was mostly attributable to a low abundance of most taxa, including some sensitive taxa such as caddisflies (Ecnomidae and Leptoceridae), and an absence of taxa commonly found in the study area (caenid mayflies, mites and waterboatmen) (SIMPER). This may be indicative of an impact from the overtopping of the Content Pit.

A comparison of environmental variables, including water quality and sediment quality, and macroinvertebrate community composition in the bed showed no significant correlations.

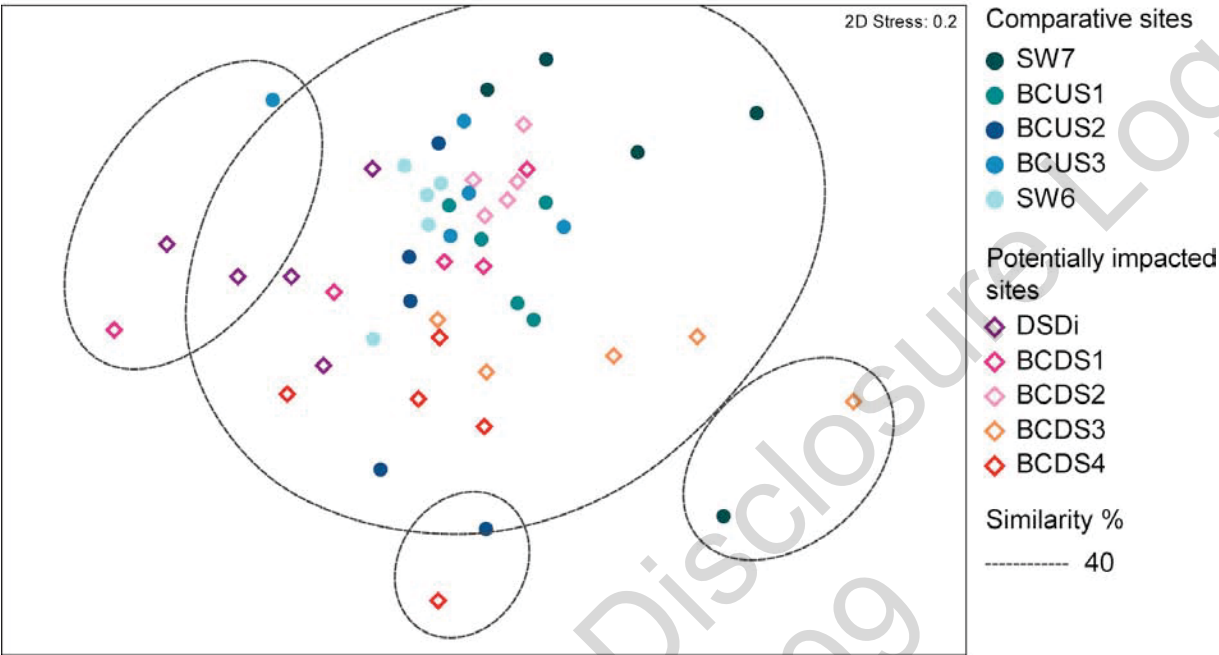


Figure 3.29 MDS ordination showing the differences between sites in macroinvertebrate community composition in bed habitat.

Riffle Habitat

There were distinct differences in macroinvertebrate community composition in the riffle habitat at comparative sites and the riffle habitat at potentially impacted sites (ANOSIM Global $R = 0.336$, $p = 0.01$); however communities at both the two comparative sites and the two potentially impacted sites were not significantly different from each other (ANOSIM pairwise tests $p > 0.05$, Figure 3.30). As discussed above, based on the results for other habitats, it is likely that these differences are related to riffle habitat quality upstream and downstream of the Content Pit, rather than the overtopping of the pit. A comparison of environmental variables, including water quality and sediment quality, and macroinvertebrate community composition in the riffle showed no significant correlations.

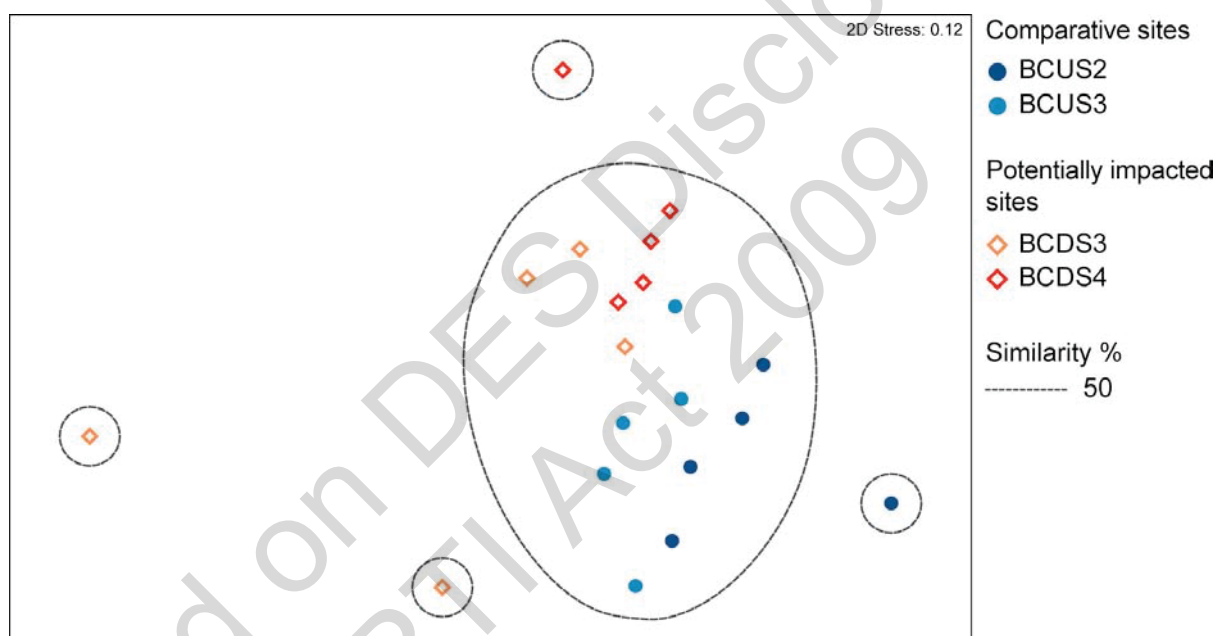


Figure 3.30 MDS ordination showing the differences between sites in macroinvertebrate community composition in riffle habitat.

4 Summary and Recommendations

4.1 Summary

The overtopping of the Content Pit appears to have had a small impact on the macroinvertebrate communities (i.e. on taxonomic richness, abundance and community composition) at site DSDi, which is approximately 30 m downstream of the confluence of the overflow pathway with the tributary of Belmore Creek (approximately 1.5 km from the Content Pit over land) (Figure 2.1). However, the impact appeared to be confined to a small spatial area, and did not extend to the first downstream site on Belmore Creek (i.e. BCDS1), which is approximately 700 m downstream of the confluence of the overflow pathway with the tributary of Belmore Creek (Figure 2.1). As such, the macroinvertebrate taxonomic richness, abundance and community composition at sites downstream of site DSDi do not appear to have been impacted by overflows from the Content Pit.

The *in situ* water quality results provide no indication of potential impacts from the Content Pit overflow except for electrical conductivity. Increased electrical conductivity was observed at site DSDi immediately downstream of the confluence of the overflow pathway with the tributary of Belmore Creek. Though electrical conductivity levels in the study area did not correlate highly to macroinvertebrate community structure, suggesting that electrical conductivity levels here may not have had a substantial influence on macroinvertebrate community structure.

A number of other factors (e.g. habitat condition, land use [i.e. cattle access] and water quality) also appear to have had an effect on macroinvertebrate communities. As a result, the influence of the overtopping event from the Content Pit on the macroinvertebrate communities in the tributary to Belmore Creek is not able to be clearly defined.

4.2 Recommendations

Water quality and macroinvertebrate results were spatially variable, and are expected to also vary temporally in response to seasonal and long-term climatic influences. As such, the results of this one-off survey are insufficient to fully characterise the impact from overtopping of the Content Pit, when compared with the influence of other factors. Additional surveys or a long-term ecological monitoring program would provide the opportunity to:

- describe the natural variability of the macroinvertebrate communities in the survey area

- determine if the overtopping event from the Content Pit had a short or long-term impact, or potentially no impact at all, and
- gather comprehensive background data from comparative sites.

4.3 Limitations

This macroinvertebrate survey was initially intended to provide baseline data for a survey in Belmore Creek and its tributaries in the vicinity of the Croydon Gold Mine, however due to heavy rainfall before sampling began, the Content Pit overtopped. Consequently, there is no baseline data from the area to which the survey results can be compared. The lack of baseline data limits the interpretation of the survey data, as it is not possible to assess whether the patterns in macroinvertebrate community structure existed before the overtopping occurred.

5 References

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10 November 2011

Queensland Government
Department of Environment and Resource Management
PO Box 2066
CAIRNS QLD 4870

Attention: Neil Maver

Project: Croydon Gold Mine

Subject: Environmental Investigation

Dear Neil,

Please find enclosed for your records the Barrick Australia Pacific (Barrick) *Croydon Gold Mine Environmental Investigation*. This report has been prepared to investigate the potential risk to Belmore Creek and its relevant tributaries in the vicinity of the Croydon Gold Mine as a result of the Content Pit surface water outflow on 30 March to 2 May 2011.

As described in Barrick's follow-up written advice submitted to the DERM on 1 August 2011, the assessments within the report have been conducted in accordance with the Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000) risk-based decision framework.

The assessments within the *Croydon Gold Mine Environmental Investigation* indicate that the Content Pit surface water outflow posed a low risk to the existing slightly to moderately disturbed condition of Belmore Creek and its relevant tributaries in the vicinity of the CGM. Therefore, in accordance with the ANZECC and ARMCANZ (2000) risk-based decision framework, no remediation measures are considered necessary.

Pit lake water level monitoring and observations during the 2011 dry season have indicated that the water level of the Content Pit has lowered, therefore increasing the storage capacity of the open pit. Notwithstanding, should average rainfall conditions occur during the 2011/2012 wet season, a reduction in the storage capacity of the Content Pit is likely and surface water outflows may occur.

Based on the conclusion of the *Croydon Gold Mine Environmental Investigation* and recent Content Pit lake water quality results (which demonstrates no deterioration of pit lake water quality during the 2011 dry season), should a surface water outflow occur from the Content Pit during the 2011/2012 wet season, Barrick expects the water quality of the outflow would be similar to that reported within the *Croydon Gold Mine Environmental Investigation* (i.e. with no receiving water contaminant limit exceedances of relevant metals). Therefore, Barrick would expect the outflow would pose a low risk to the existing slightly to moderately disturbed condition of Belmore Creek and its relevant tributaries in the vicinity of the CGM.

Notwithstanding, Barrick will continue to implement an additional monitoring programme during the 2011/2012 wet season. The monitoring programme would include surface water quality and stream sediment quality monitoring and a continuation of aquatic habitat and macroinvertebrate monitoring at locations in Belmore Creek upstream and downstream of the CGM.

Based on the above, Barrick intends to submit an application to amend the CGM Environmental Authority MIN100401906 to include the Content Pit and Lady Isabella Pit as licensed release points.

Please do not hesitate to call me on CTPI 49-Sch4 if you should have any queries regarding the above.

Yours sincerely

BARRICK AUSTRALIA PACIFIC LIMITED

CTPI 49-Sch4

CTPI 49-Sch4

Reclamation and Closure Manager

CC. Dean Sharpe