

# CAPABILITY STATEMENT



## C&R CONSULTING

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## COMPANY BACKGROUND

C&R Consulting Pty Ltd (C&R) is a Townsville-based, owned, and managed specialist environmental consulting company that has earned a reputation for delivering cost-effective solutions to complex environmental problems.

C&R is renowned for its ability to assess, evaluate and interpret environmental, climatological, geomorphological, hydrological, geochemical and mineralogical analytical data. C&R recognise that the correct advice, acquired at the preliminary stage of any project, reduces the potential for unexpected problems during both the development and operational period of a project.

C&R's expertise encompasses everything environmental, with our services including:

- **Geological:** Field mapping & drill logging, structural analysis, petrography, mineralogy and rock strength.
- **Hydrology:** Flooding, surface water and groundwater modelling, groundwater dewatering, assessment of contamination, water balance.
- **Chemical:** Hydrogeology/hydro-geochemistry, acid rock drainage, geochemical modelling, co-disposal systems, seepage associated with spoil dumps.
- **Ecological:** Terrestrial and aquatic ecological surveys, macroinvertebrate monitoring for river health, rehabilitation design, rehabilitation monitoring.
- **Geomorphology:** Landscape analysis, river channel stability, river and creek diversions, soil erosion and sediment control, sediment transport modelling.
- **Soils:** Acid sulphate soils (ASS), land suitability classification, soil characterisation and mapping, soil conservation, contamination investigations and remediation, rehabilitation design criteria.

C&R can provide a full project team or offer individual specialists depending upon client and project requirements. All staff members have managed environmental projects or have undertaken specialist investigations within fresh, estuarine and marine systems. Most projects have been long term, spanning approval and licensing stages, through operational phases, including monitoring and compliance reporting, to rehabilitation and final closure. Consequently, C&R understand the life of project requirements.



## OUR PEOPLE

### Staff member

### Position

### Specialties

#### Directors / Principal Scientists

Dr Christopher Cuff	Chemical mineralogist / Hydrogeochemist / Contaminated site assessor	Clay-water interactions / Spectral analyses / Hydrological & geochemical modelling / Contaminated water & soil remediation / Acid rock leaching / Groundwater movement
Dr Cecily Rasmussen	Fluvial & coastal geomorphologist	Geomorphological & palaeo-geomorphological interactions between & within terrestrial, coastal, estuarine & marine environments

#### Principal Scientists

Mr Ben Cuff	Botanist / Soils specialist	Environmental systems analysis / Contaminated soils assessment / Flora & fauna assessments / Rehabilitation inspection & design / GIS
Dr Jasmine Jaffrés	Numerical data analyst / Programmer / Hydroclimatologist	Modelling physical & chemical systems / Scripting / High-end statistical analysis / Extreme weather events / Big data
Ms Siân Kennare	Hydrogeologist / Mining environmental scientist	Coal mine environmental management / GIS / MODFLOW / Groundwater pumping & network design
Mr Matt Knott	Environmental scientist / Aquatic ecologist	Environmental analysis / Marine & freshwater ecology / Electrofishing / Macroinvertebrate assessment using AusRivAS methodology

#### Senior Scientists

Mr Dean Buchanan	Hydrologist / Chemical mineralogist / Water chemistry analyst	Nephelometer deployment / Monitoring design & implementation / Analytical evaluation & assessment / Water chemistry
Mr Mark Flintoft	Hydrogeologist	Aquifer test design, implementation & analysis / Contaminant transport modelling / MODFLOW / Groundwater & surface water monitoring
Mr Jason Schaffer	Aquatic & terrestrial ecologist / Environmental scientist	Aquatic & terrestrial ecology, fauna survey & assessment / Telemetry / Environmental management and analysis



## Staff member

## Position

## Specialties

### Scientists

**Mr Moe Maki**

Marine & aquatic ecologist / Spatial scientist / Cartographer

Ecological surveys / Environmental compliance / Mapping / GIS / Statistical analysis / Remote sensing

**Ms Kayla Polley**

Environmental monitoring scientist

Water & land management / Terrestrial fauna surveys

**Ms Rachel Rintoul**

Environmental compliance assessor / Aquatic ecologist

Environmental compliance / Ecological surveys

**Ms Julia Routh**

Mining environmental scientist

Groundwater & surface water monitoring / Coal mine environmental management / Terrestrial fauna surveys





## OUR SERVICES

### Approvals

- Development approvals
- EA amendments
- Transitional environmental programs (TEPs)
- Environmental evaluations (EEs)
- EM plans / Site-specific application documents
- Specialist environmental impact statement (EIS) studies

### Water

- Modelling water quality and geochemical interactions
- Release rate calculation and amendment
- REMP development, amendment and assessment
- Impact assessments
- Water balances
- Water management plans
- Water quality assessment
- Groundwater pumping and sampling
- Routine water quality monitoring (environmental and potable)
- Flood assessments and reviews (including forensic investigations)
- Hydraulic design
- Groundwater monitoring bore network review and design
- Groundwater contaminant modelling and plume migration
- Annual assessment/review of groundwater chemistry and level data
- Runoff quality predictions
- Irrigation and water disposal/treatment

### General Environmental Services

- Compliance audits
- Environmental officer secondment
- Environmental database management
- General environmental sampling

### Land / Geology

- Progressive rehabilitation and closure plans (PRCP) including environmental rehabilitation cost (ERC) calculator submissions
- Grounded and logical rehabilitation completion criteria
- Rehabilitation management plans
- Rehabilitation design
- Rehabilitation inspections
- Soil and land suitability assessments
- Erosion susceptibility
- Erosion and sediment control plans
- Soil loss modelling and measurement
- Residual void studies
- Acid metalliferous/mine drainage (AMD)
- Overburden and reject characterisation
- Contaminated land assessment and remediation
- Subsidence management plans and geomorphic assessment
- Field geological and stratigraphic expertise
- Mineralogical services (XRD/XRF interpretation)
- Clay evaluation for geotechnical concerns

### Biodiversity

- Vegetation mapping and ground-truthing
- Vegetation health assessments
- Aquatic and marine ecology assessments
- Electrofishing
- Biological indicator impact assessments

### Other Services

- Registered Research Service Provider (RSP)
- Underground coal gasification (UCG) site selection and assessment
- Specialist coal seam gas (CSG) advice and troubleshooting



## PROJECT EXAMPLES

### Surface and Groundwater Quality Monitoring

C&R regularly undertake routine (compliance) monitoring for extractive industries, commercial developments and government agencies throughout central and northern Queensland. Currently, C&R is undertaking routine monitoring for several mining companies and private developers that includes:

- Surface waters (fresh and marine);
- Groundwater;
- Potable waters;
- Dust monitoring; and
- Treated effluent.



As well as suitably qualified personnel to undertake the monitoring, C&R provide all the equipment necessary for safely and effectively monitoring watercourses and aquifers alike; including groundwater pumps, compressors, in-situ meters, sampling poles, etc.

### Ecological Impact Studies - Various Mines

C&R have undertaken detailed ecological studies as part of larger environmental impact studies in numerous greenfield locations across northern and central Australia for mining operations. These studies have encompassed both terrestrial and aquatic ecological values within the project sites that are often remote and/or on traditional land. Our projects are highly diverse and often multidisciplinary. One study investigated terrestrial fauna and groundwater conditions on a greenfield site adjacent to a RAMSAR protected wetland. Another project - an aquatic ecology study - examined surface and groundwater fauna of a proposed coal mine site in central Queensland. The associated area covered 18,000 ha, and encompassed four major watercourses and three defined aquifers immediately south of Moranbah. More recently, C&R senior scientists have undertaken freshwater and estuarine studies for a proposed bauxite project on the Cape York Peninsula.



### Rehabilitation Inspections for Various Mines

C&R have undertaken numerous rehabilitation inspections throughout central and north Queensland. C&R specialise in providing a rehabilitation inspection method to specifically address completion criteria and provide an insight to what processes are working (and which ones are not) on rehabilitation.

Inspections have been undertaken on rehabilitated spoil dumps, drains, subsided areas above longwall panels, streams, exploration holes and roads. C&R are adept at determining appropriate 'success criteria' for specific regions with the focus on returning the land to pre-mining condition.





## 2008 Central Queensland Flooding Investigations

One of the highest profile projects undertaken by C&R was a forensic flooding, engineering, geological and geomorphological investigation of the 2008 flood event in central Queensland.

C&R conducted a major investigation into the timing and magnitude of rainfall throughout the Nogoa catchment to derive the volume, velocity, height, timing and duration of waters moving through the catchment. The investigation highlighted major flaws in the application of standard rainfall-runoff processes in determining water movement through a multiple feed catchment in the seasonally arid tropics (SAT). These flaws had major implications for the stability of levees during flood events.

The investigation focused on the characteristics of rainfall in the SAT, where the timing, intensity, duration and periodicity of rainfall are notoriously erratic. The investigation noted the restrictions imposed by the need to create 1-in-100-year predictions of these same parameters based on models restricted to the use of observational data taken from gauging stations constrained by short operational periods at minimal locations.

The standard mathematical distributions recommended for use in Australia were unable to reflect the actual events of the SAT, and produced large, unacceptable uncertainties that underestimated the magnitude and timing of stream flows following intense rainfall throughout the region.



Helicopter based geo-referenced video mapping (GRV) was used as part of this investigation only days following the peak of the flood event over the majority of the Nogoa catchment. GRV mapping is a technology developed jointly by C&R and AME Surveys which allows video footage to be located spatially. This technique proved invaluable to verify and assess readings from flood gauges.

Geological engineering and stability properties of expansive and dispersive clays of central Queensland were tested for periods of immersion between 7 to 10 days. In general any extended period of inundation has the potential to cause significant weakening of the common clay rich materials typical of western Queensland.

## Independent Scientific Panel on Underground Coal Gasification (UCG)

Dr Chris Cuff was a member of the independent scientific panel charged with the assessment of UCG burns in Queensland. The three-person expert panel advised the Queensland Government on the likely risks associated with such developments and the best way forward to determine the future of the industry in Queensland. As a result of this involvement, a considerable expertise has grown within C&R associated with the design of exploration and hydrological assessment programmes associated with UCG and coal seam gas (CSG) throughout Australia and overseas.



## Ocean Terminal Development - Port of Townsville Ltd

C&R performed the marine ecology, sediment quality and water quality assessments of an EIS performed for the expansion of the ocean terminal at the Port of Townsville. This project had to determine the baseline environmental values of the area prior to dredging works associated with the development could begin. The project involved geochemical and physical modelling of tidal flushing within the marina basin, potential contaminant transfer along the coastline to seagrass beds and Mid Reef.

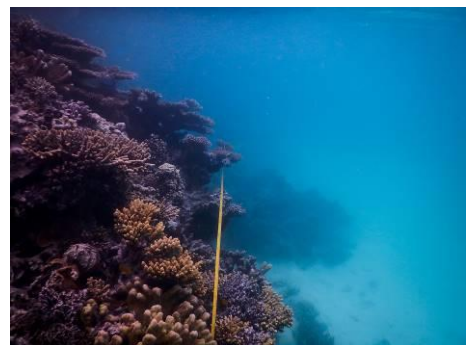


Extensive data was collected via visual underwater surveys and sediment core sampling. Environmental trigger levels based on sediment and water quality analysis were developed. The initial stages of the project also involved considerable discussions with the local indigenous communities, Great Barrier Reef Marine Park Authority (GBRMPA), environmental authorities (local, state and federal), and local advocacy groups. C&R were also commissioned to source sand and rock supplies from areas within 200 km of the Townsville region. The directive in this instance was material suited to the wetting and drying conditions of a marine environment. The outcome of the studies recommended innovative management techniques for mitigating impacts of the construction, dredging and operating processes of the marina. These were all incorporated into the final development.

## Reef Health Monitoring Plans and Assessment

C&R undertake continual health monitoring of the reef systems associated with Panforta's pontoon facility located within the Lady Musgrave Island lagoon. The facility has been operating within the lagoon for over 20 years. However, in 2015, the permit covering Panforta's tourism activities was amended to require the installation of a monitoring plan detailing ongoing monitoring requirements to ensure the protection of reef health. The project involved:

- The development of a reef health monitoring plan to assess the potential impacts from snorkelling activities to the surrounding reef system;
- Undertaking regular (twice yearly) monitoring trips to assess reef health by underwater surveys for visible impacts to hard corals, changes in coral composition, presence of disease or pest fauna/flora, water quality and sediment quality; and
- Preparing and submitting an annual report - detailing the results of the monitoring trips, including rigorous statistical analysis of collected data - to the GBRMPA for review.







## Water Management Plans & Erosion and Sediment Control Plans - Various Clients

One of the main areas where C&R use their hydrological expertise is the preparation of water management plans & erosion and sediment control plans for commercial, residential and industrial developments (particularly mining).

Water management plans involve inspection of the site and include the development of a comprehensive water balance taking catchment runoff, evaporation, groundwater seepage and pumping into consideration. Water balance models are constructed in Goldsim®. Typically a water quality model (using Geochemists Workbench Professional) is also constructed relevant to the water management criteria required by the site (mixing or discharge). On most occasions, identification and evaluation of the mineralogical and chemical components of the site is also required.

Once established, the baseline models can be varied according to the peculiarities and the requirements of the mine site to increase the efficiency of water management. Tailored applications and scenarios are created for each mine-site dependant on site specific circumstances and management objectives.

## Ben Lomond Project - Mega Uranium

C&R performed a detailed environmental impact assessment on a uranium mine site. This investigation was part of a feasibility study to re-open the mine. C&R commenced the collation of geological, mineralogical and hydrological data and assisted the client additionally with geological exploration input. The project also included:

- Baseline ecological surveys and assessments and geological evaluations (including petrographic examinations) to determine background information of factors likely to impact on or be impacted by the development of the mine;
- Aquatic ecology using electrofishing techniques, mega fauna and flora identification procedures, and frog call identification techniques;
- In-field flora evaluations using line transects and targeted sampling of specific areas; and
- GIS mapping of all sampling locations and results.





## Gulf & Mitchell Rivers, Calliope Water Resource Plans

Partnered with Hydrobiology Pty Ltd, C&R provided services in the geomorphological and geological assessment and water quality investigations of the Gulf and Mitchell rivers catchments and the Calliope catchments.



These projects involved detailed ecological and geomorphological investigations of the Gulf and Mitchell rivers catchment areas - as well as the Calliope catchment - that are known to contain a variety of unique ecosystems of national and international significance.

The project required a well-developed knowledge of aquatic, estuarine, coastal and near-shore ecology. An in-depth understanding of the environmental conditions was also crucial, including the continuation of the waters into the Gulf of Carpentaria - as well as links to sensitive sub-artesian and artesian basins.

A significant part of the project was to determine the location and dependence of groundwater ecosystems and. Extensive consultation with the community and relevant stakeholders - to identify issues associated with the allocation and sustainable management of water resources within catchments - was therefore conducted.

## Australian Catchment Classification

Undertaken for Australia's largest insurance company, C&R classified geomorphological, hydrological, geological, pedological, vegetation and climatic characteristics into regions to enable rainfall/runoff factors to be assessed in the context of flood risk to settled areas.

The classification system defined eight discrete zones in which the risk factors and responses relating to extreme rainfall events may be comparable. Applied techniques included multiple linear regression and fuzzy clustering in a range of software (e.g. R and GNU Octave), with the results published in peer-reviewed literature.

This classification study was expanded - using local and global climatic indicators - to the prediction of other major weather and climate risks (cyclones, droughts, floods, bushfires and storms) to enable the insurance company to decrease exposure prior to any event. The project used datasets that were regularly updated to maximise the ability to predict up to 2-3 months in advance.

