2 ENVIRONMENTAL ASSESSMENTS OF URANIUM MINES

2.1 Supervision process

The Supervising Scientist utilises a structured program of audits and inspections, in conjunction with the Northern Territory Government and the Northern Land Council, to supervise uranium mining operations in the Alligator Rivers Region (ARR). The outcomes of these activities are considered by the Supervising Scientist, together with environmental monitoring data and other information, to draw conclusions regarding the effectiveness of environmental management at uranium mining sites.

2.1.1 Minesite Technical Committees

Minesite Technical Committees (MTCs) have been established for Ranger, Jabiluka and Nabarlek. The MTC meetings provide an effective forum for stakeholders, including Supervising Scientist Division staff, to discuss technical environmental management issues, especially in connection with the assessment of applications and reports submitted by mining companies for approval under Northern Territory and Commonwealth legislation. Each MTC is made up of representatives from the Northern Territory Department of Resources (DoR – which provides the Chair), the Office of the Supervising Scientist (***oss***), the Northern Land Council (NLC) and the relevant mining company. A representative from the Gundjeihmi Aboriginal Corporation is invited to attend each Ranger and Jabiluka MTC meeting. Other organisations or experts may be co-opted from time to time as required to assist MTC members.

2.1.2 Audits and inspections

The Supervising Scientist, in consultation with the applicable MTC members, has developed and implemented a program of environmental audits and inspections at Ranger mine, Jabiluka project area and Nabarlek mine. ***oss*** staff also participate in audits of exploration operations throughout the ARR.

Routine Periodic Inspections (RPI) take place monthly at Ranger, being the only operating minesite in the region, and quarterly at Jabiluka, which is currently in long-term care and maintenance. The RPIs are intended to provide a snapshot of environmental management as well as an opportunity for the inspection team to discuss environmental management issues with staff on site. These discussions may include any unplanned events or reportable incidents and any associated follow-up actions. The inspection team is made up of representatives from ***oss***, DoR and the NLC.

The rehabilitated former abandoned minesites locations at South Alligator Valley are also routinely inspected at least once annually.

Environmental audits are conducted by a team of qualified audit staff from ***oss***, DoR and the NLC and are undertaken in general accordance with ISO Standard 19011:2003 (*Guidelines for quality and/or environmental management systems auditing*) and are consistent with current best practice in environmental assessments.

The annual environmental audits of Ranger and Jabiluka occur in April or May to assess each site under 'end of wet season' conditions. The final audit report is tabled at the following meeting of the Alligator Rivers Region Advisory Committee (ARRAC). Audit findings are followed-up as required through the RPI process. The Nabarlek program is slightly different in that an inspection is carried out early in the dry season and the annual environmental audit is conducted later in the year.

The audit outcomes are described later in this Annual Report.

2.1.3 Assessment of reports, plans and applications

The Authorisations for Ranger mine and the Jabiluka project area are issued under the Northern Territory *Mining Management Act 2001.* The Act provides for alterations to the Authorisation to be issued by the Northern Territory Government. The Authorisations require that ERA seeks approval for certain activities from the Northern Territory regulatory authority, through DoR, which then considers applications after ***oss*** and the NLC have assessed the proposal and provided feedback. This provides the primary mechanism for the Supervising Scientist's participation in the regulatory processes of the Northern Territory Government and is supported by section 34 of the Act which requires the Northern Territory Government to act in accordance with the advice of the Commonwealth Minister.

The main reports and plans assessed by the Supervising Scientist during 2009–10 included:

- Ranger Amended Plan of Rehabilitation No 35
- Ranger Mine Water Management Plan
- Ranger Mine and Jabiluka Project Annual Environmental Reports
- Ranger Mine and Jabiluka Project Wet Season Reports
- Ranger Mine Annual Tailings Dam Inspection Report
- Ranger Mine and Jabiluka Radiation Protection Monitoring Program quarterly and Annual Reports
- Jabiluka Project Plan of Rehabilitation No 13
- ERA weekly environmental monitoring data and quarterly reports submitted in accordance with the Authorisations
- Applications by the mining companies for amendments to their Authorisations

2.2 Ranger

2.2.1 Developments

Mining and milling of uranium ore at Ranger continued throughout 2009–10, with further development of the orebody in Pit 3. The Ranger mill produced 4222 tonnes of uranium oxide (U_3O_8) during 2009–10 from 2 282 670 tonnes of treated ore (Table 2.1). Production statistics for the milling of ore and the production of U_3O_8 at Ranger for the past five years are shown in Table 2.2.

TABLE 2.1 RANGER PRODUCTION ACTIVITY FOR 2009–2010 BY QUARTER

	1/07/2009 to 30/09/2009	1/10/2009 to 31/12/2009	1/01/2010 to 31/03/2010	1/04/2010 to 30/06/2010	Total
Production (drummed tonnes of U_3O_8)	1404.5	1100.2	887.5	829.7	4222
Ore treated ('000 tonnes)	532	583	564	604	2283

TABLE 2.2 RANGER PRODUCTION ACTIVITY FOR 2005–2006 TO 2009–2010

	2005–2006	2006–2007	2007–2008	2008–2009	2009–2010
Production (drummed tonnes of U_3O_8)	5184	5261	4926	5678	4222
Ore treated ('000 tonnes)	1960	2136	2001	2042	2283

2.2.1.1 On-site activities

Ranger Heap Leach Project

In March 2009 ERA submitted a referral under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) for the construction of a heap leach facility to treat low grade ore at Ranger. This referral was determined to be a controlled action and is to be assessed by an environmental impact statement (EIS) managed under a bilateral agreement by the Northern Territory Government. ERA is in the process of preparing an environmental impact statement in accordance with the guidelines prepared by the Northern Territory Government.

Ranger Exploration Decline Project

In April 2009 ERA submitted a referral for the proposed construction of an exploration decline to provide exploration access to mineralisation in the Ranger 3 deeps area. In May 2009 this proposal was deemed not to be a controlled action and will not require further assessment under the EPBC Act. This proposal will be submitted to the Minesite Technical Committee and will be assessed in accordance with the Working Arrangements between the Northern Territory and Commonwealth Governments.

Exploration

ERA is continuing to conduct exploration drilling within the Ranger Project Area. Recent exploration efforts have focussed on the Ranger orbit which includes Ranger 3 south east deeps, Ranger 1 deeps and Anomaly 8. ERA also plans to explore Ranger North and East in 2010.

Pilot covered evaporation tunnels and process water tunnel evaporators

ERA submitted a proposal to the MTC in July 2009 for the development of four covered tunnels to trial enhanced process water evaporation. The pilot tunnels were constructed in the Pit 1 catchment on a compacted clay base with designated bunded area equipped with a double liner and leak detection system. Laserlite roof sheeting allowed solar radiation to pass through to the water thus heating the interior of the tunnel. Evaporative rates achieved with the pilot program were consistently reported at ~8–10 mm/day. Based on the results of the pilot program, on 25 June 2010 ERA gained approval to construct up to 150 tunnels at a brownfield location on the project area.

Disposal of RP1 water to Magela Creek via MG001

In January 2010 ERA installed pipeline infrastructure to enable discharge of RP1 waters directly to Magela Creek at MG001. Discharging RP1 waters at MG001 under favourable conditions provides for greater mixing of released waters prior to the compliance and monitoring stations downstream of the confluence of Coonjimba Billabong and Magela Creek. Ceasing controlled discharge of waters directly to Coonjimba Billabong reduces the risk of potential negative impacts to Magela Creek when the billabong backflows under low flow conditions in Magela Creek. Discharge of RP1 water to MG001 is discussed further in Section 2.2.2.

Pit 3 modifications for bullnose failure

In June 2009 ERA became aware of geotechnical instability in Pit 3 below the old southern ramp. ERA undertook to install monitoring equipment in the area and found that movement measured during the monitoring period was directly related to routine blasting on the eastern side of the southern bullnose. On 31 October about 200 tonnes of material moved from the -55mRL batter to the floor of that batter in Pit 3. Safety restrictions were imposed in Pit 3 as ERA determined that ~3.4 Mt of material needed to be removed from the southern bullnose to maintain the integrity of Pit 3 in this area. ERA confirmed to stakeholders that there was no compromise to the integrity of the wall of RP2 as a result of the movement or remedial works. Works to remove the material from the southern bullnose have continued throughout this reporting period.

Jabiru East accommodation village

On 8 March 2010 ERA submitted a proposal to MTC members to construct a 1000 bed accommodation village at Jabiru East to service Ranger mine. It is proposed that the current

100-bed Ranger accommodation village will be removed once the Jabiru East village is completed. The Jabiru East village is proposed to be self contained with a variety of recreational facilities including a wet mess. Stakeholders are still considering the proposal and have requested additional information.

2.2.2 On-site environmental management

2.2.2.1 Water management

All water on site is managed in accordance with the Water Management Plan which is updated annually and subject to assessment by the Minesite Technical Committee (MTC) before approval. The 2009–10 Water Management Plan was submitted for approval by ERA on 30 September 2009. SSD endorsed the plan on 9 March 2010, however, final regulatory approval is still awaiting input from other stakeholders. Until this plan is approved, the existing 2008–09 plan remains in force. The plan describes the systems for routine and contingency management of the three categories of water on site, ie process, pond and potable.

Water management remains critical at Ranger mine. As shown in Figure 2.1, the 2009–10 wet season was close to average with a total of 1596 mm recorded at Jabiru Airport to 30 June 2010 compared with an annual average of 1584 mm. The pond water inventory has increased in comparison to this time last year while the process water inventory has decreased slightly.

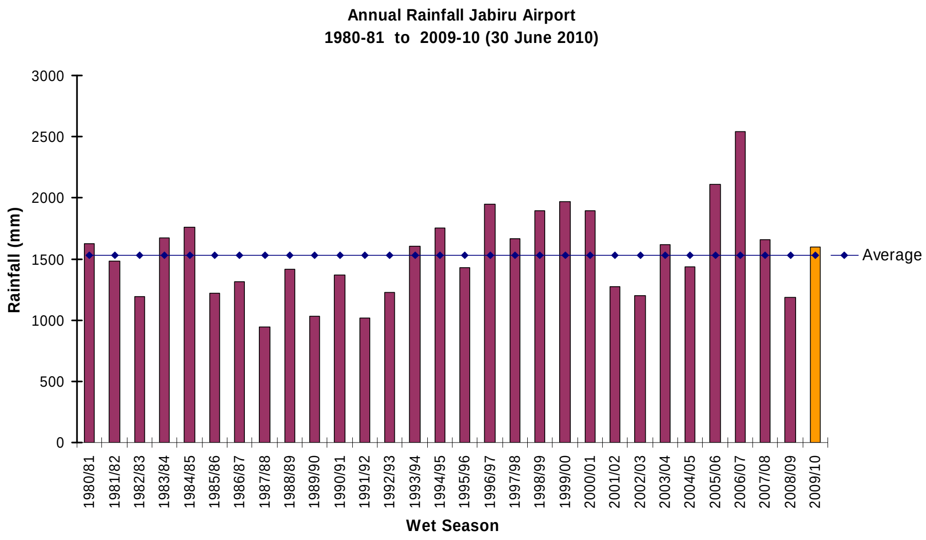


Figure 2.1 Annual rainfall Jabiru Airport 1980–81 to 2009–10 (data taken from Bureau of Meteorology)

Process water system

Under the Commonwealth Environmental Requirements, water that is in direct contact with uranium ore during processing (process water) must be maintained within a closed system. It may only be released by evaporation or after treatment in a manner and to a quality approved by the Supervising Scientist. Process water is currently stored in the Tailings Storage Facility (TSF) and in Pit 1. There were no releases of untreated process water to the surrounding environment during the reporting period.

The Process Water Treatment Plant was commissioned in late 2009 and commenced discharge of process water permeate to the Corridor Creek Wetland Filter on 9 October 2009 at a rate of approximately 0.7 ML per day until 28 December 2009. Further treatment capacity is expected to come on line late in 2010 with ERA being granted approval to construct 150 solar evaporation tunnels to the north of the TSF.

Following a lift of the TSF crest level to RL54m, on 18 December 2009 ERA was approved to raise the maximum operating level of the TSF to RL53m generating additional process water storage capacity in the dam.

At the end of the reporting period, the process water inventory was 9890 ML, of which 9680 ML is stored in the TSF. This represents a slight decrease over the previous years total of 9982 ML.

Pond water system

The pond water system contains water that has been in contact with stockpiled mineralised material and operational areas of the site other than those contained within the process water system. Water is managed within this system by quality. The pond water system consists primarily of Retention Pond 2 (RP2), Retention Pond 3 (RP3) and Pit 3. Water from RP2, RP3 and Pit 3 may not be released without prior treatment through wetland filtration and/or irrigation. At the end of the reporting period 1285 ML was contained within the system representing an increase of 393 ML over the previous year. The increased pond water inventory is due to unseasonably late rainfall in April 2010 combined with pumping of water from RP1 to RP2 as a result of poorer water quality in RP1.

Methods of disposal of pond water

Passive release water

Rainfall runoff discharges from the Ranger site during the wet season primarily via Corridor Creek and Coonjimba Creek with much lesser amounts via Gulungul Creek and minor amounts via overland flow direct to Magela Creek. RP1 and the Corridor Creek wetland filter act as sediment traps and solute polishing systems prior to outflow from the site. The Corridor Creek wetland filter receives runoff from specially prepared sheeted areas of low grade and waste rock stockpiles. The surfaces of these stockpile areas are compacted to minimise infiltration and hence contribution of additional water to the RP2 pond water system via seepage. RP1 receives sheeted runoff from the northern waste rock stockpiles and overflows passively via a constructed weir into Coonjimba Creek every wet season. Controlled discharge of RP1 via siphons/pumping over the weir occurred from January through to mid-April 2010 to assist with the removal of poorer quality water during periods of higher flow in Magela Creek. Passive release of water over the RP1 weir occurred intermittently from February through to mid-April 2010 and was managed by use of sluice gates on the weir. In Corridor Creek, passive release of waters retained upstream of GC2 occurred throughout the 2009–10 wet season. ERA also manually controls the discharge of runoff water via four sluice gates along the Ranger access road. Release from these gates occurred on several occasions from March through to mid-April 2010.

Pond water treatment

The two pond water treatment plants were in operation between January and May 2010. Treated permeate was discharged to the Corridor Creek wetland filter and from there passively released to Magela Creek via GCMBL and GC2.

RP1 Discharge to MG001

ERA was granted approval in January 2010 for the interim discharge of RP1 water to Magela Creek from the MG001 site. Discharge occurred at the end of January and again in April under high-flow conditions in Magela Creek. During both discharges ERA undertook studies to determine the rate of mixing and any potential effect on downstream water chemistry. Stakeholders are considering ERA’s application for approval to routinely release RP1 water at MG001, under high-flow conditions, in light of the data provided by the two previous discharge studies.

Stockpile sheeting

Runoff from sheeted stockpiles into the Corridor Creek wetland filter generated from the first 200 mm of rainfall continues to be diverted into the pond water system. This initial runoff generally contains higher levels of mine-derived solutes due to the leaching of solutes that occurs in the early stages of the wet season, from freshly mined rock.

Wetland filters and land application areas

Two wetland filter systems operated during 2009–10: the Corridor Creek system and the RP1 constructed wetland filter in the RP1 catchment.

Jabiru East and RP1 land application areas were operational during the 2009 dry season. Corridor Creek and RP1 land application areas are being utilised during the 2010 dry season. In keeping with ERA’s commitment that only treated or wetland polished water would be irrigated from 2009, there has been no direct irrigation of RP2 water in 2009 or 2010.

2.2.2.2 Tailings and waste management

Tailings

From August 1996 to December 2008 no process residue from the milling of ore was deposited into the TSF, with Pit 1 being the sole receptor. Over this period 20 Mm^3 of tailings were deposited in Pit 1 including 1.8 Mm^3 transferred from the TSF by dredging. Transfer of tailings into Pit 1 from the milling and processing of ore from Pit 3 ceased in December 2008 when tailings reached the maximum permitted level of RL12. Tailings are now discharged to the TSF via a floating discharge pipe that is moved regularly to achieve an even deposition of tailings across the footprint of the dam.

The average density of tailings in Pit 1 at June 2010 was 1.37 t/m^3, which exceeds the minimum target density of 1.2 t/m^3.

2.2.2.3 Audit and Routine Periodic Inspections (RPIs)

Eleven inspections and one audit were undertaken at Ranger during the 2009–10 reporting period. Findings from the May 2009 environmental audit were reviewed throughout the following RPIs until an acceptable outcome was achieved. An audit of the Ranger Radiation Management Plan was undertaken in May 2010. RPIs were carried out for each other month of the 2009–10 reporting year with the exception of May. Table 2.3 shows the focus areas for the audit and RPIs for the year.

TABLE 2.3 AUDIT AND RPI

Date	Foci
21 July 2009	Turbo burning yard, product packing, heavy equipment workshop, Ranger 3 deeps exploration
18 August 2009	Vehicle washdown bay, pilot covered evaporation pond construction, controlled area access signs to Pit 3, RP1 land application area
15 September 2009	Jabiru east land application area; potential heap leach facility sites and associated EIS works, trial landform, audit follow up
20 October 2009	Water treatment plant, Corridor Creek wetland filter, pilot covered evaporation ponds, bullnose cutback, tailings corridor, GCMBL
17 November 2009	Anomaly 4, bullnose cutback, Djalkmara sump
15 December 2009	TSF, v-notch drains, drainage lines, check dams, sumps, Sed2B, CB2, CB4, RP1, RP2, GCMBL, Djalkmara sump, access road culverts
20 January 2010	Sand filters, SW TSF sed sump, Sed2B, CB2, Corridor Creek wetland filter, GCMBL, Djalkmara sump, audit findings
17 February 2010	RP1 weir, MG001 discharge location, pilot covered evaporation tunnels, TSF wall and ring road water management
17 March 2010	Processing plant, turbo burning yard, TSF NW sump, trial landform
14 April 2010	TSF wet season inspection
17–19 May 2010	Audit: Ranger Radiation Management Plan
16 June 2010	Exploration decline box cut location, 100 man camp, confluence of Magela Creek and Coonjimba Billabong, Swift Creek, Djarr Djarr

Audit outcomes

Closeout of findings from the May 2009 environmental audit

The May 2009 audit delivered 7 significant findings, ranked:

- 1 x category 2 non-conformance
- 6 x conditional

These findings were followed up via the monthly RPI process with all corrective actions implemented.

May 2010 environmental audit

The 2009 environmental audit of Ranger mine was held on 17–18 May 2010. The audit team was made up of representatives from the NLC, DoR and ***oss***. The subject of the 2010 audit was the Ranger Radiation Management Plan.

Thirty commitments were audited against the ranking system shown in Table 2.4. Use of this ranking system ensures the outcomes of the Ranger auditing process are consistent with other mines in the Northern Territory.

TABLE 2.4 GRADING SYSTEM

Category 1 Non-Conformance (CAT 1)	A category 1 non-conformance refers to a situation where an identified activity is not in compliance with the Authorisation, approval document or applicable legislation and could result in a high risk or is a persistent Category 2 non-conformance.
Category 2 Non-Conformance (CAT 2)	A category 2 non-conformance relates to an isolated lapse of control or an identified activity that is not in compliance with the Authorisation, approval document or applicable legislation that could result in a low or moderate risk.
Conditional (C)	This includes items that have been identified during planning that meet the established criteria and have commenced but have yet to be completed.
Acceptable (A)	This includes items that have been identified during planning that meet the established criteria and have been completed.
Not Verified (NV)	This is where compliance with the item has not been assessed. This may also include items that have been identified during planning but have yet to commence.
Observation (O)	An area that has notably improved or has the potential to be improved, or is outside the scope of the audit but is notable.

The audit tested 30 commitments, and determined the following significant findings:

- 2 x category 2 non-conformances
- 6 x conditional

All other findings were ranked as acceptable or not verified.

The first of the category 2 non-conformances related to management of surface contamination whereby all workers are required to ensure that all plant, including vehicles, are cleaned of radioactive material before leaving a Controlled Area. It is also the responsibility of all workers to ensure that any vehicles that they are driving in Supervised Areas are not contaminated with radioactive material.

The audit randomly inspected two controlled area vehicles. One vehicle was without the rear vision mirror tag stating that the vehicle was a controlled area vehicle. This same vehicle had an internal 'controlled area' sticker, however, it was located under the driver's sun visor therefore not readily visible. The second vehicle inspected had a controlled area vehicle tag attached to the rear vision mirror (and an internal controlled vehicle label) that had expired in 2009. This criteria has been ranked as a category 2 non-conformance as it does not appear that the system for managing controlled area vehicles is appropriately executed to ensure that all workers are aware of the requirements for use of controlled area vehicles across the site.

The second of the two category 2 non-conformances related to staffing levels and expertise within the Radiation and Hygiene Management Section (RHMS). For ERA Ranger operations the radiation monitoring program is administered by members of the RHMS. The RHMS comprises 4 permanent positions in the ERA structure: a Specialist Radiation and Hygiene Advisor (team leader) and 3 radiation and hygiene advisors – there is also a casual position of laboratory technician. The RHMS is part of the Health and Safety Department (H&S). The Specialist Radiation and Hygiene Advisory reports directly to the Manager H&S, who in turn reports directly to the General Manager – Operations.

At the time of the audit, ERA advised that it does not currently employ a Specialist Radiation and Hygiene advisor (the previous incumbent left ERA in November 2009). ERA appointed a person to act in this position in December 2009. ERA also advised that current staff levels within the Radiation and Hygiene Team were reduced to a Superintendent (Radiation & Hygiene), two advisors and two full-time laboratory technicians. Of the advisors, one had already resigned and another would be finishing within 1 month of the audit. ERA advised that it has engaged the services of two radiation consultants to provide support to the Radiation and Hygiene Team. ERA advised that the process of recruiting to replace these positions had commenced. This criteria has been graded as a Category 2 non-conformance as ERA currently do not have the resources to completely implement the requirements of the radiation management plan.

The 6 conditional findings related to the following:

- Document control – the current version of the plan underwent minor revision in November 2009 but had not received signoff by the General Manager – Operations.
- Sealed sources storage – the current storage for no-longer-used sealed sources is in need of repair or a suitable replacement storage area needs to be found.
- Radiation signage – hazard signs adjacent to a sealed source gauge in the CCD area were not clearly visible.
- Controlled areas – the current version of the Radiation Management Plan has not been updated to include the following controlled areas; the laterite treatment plant, radiometric sorting plant and heavy vehicle wash down bay.
- Surface contamination checks – random checks of vehicles, change rooms and areas of the processing plant are to be undertaken monthly. The last recorded inspection in the register was dated 4 months prior to the audit in January 2010.
- Monitoring program – the Q4 2009 and Q1 2010 quarterly radiation and atmospheric monitoring reports noted a failure to undertake the full statutory monitoring program. This issue has been dealt with previously by the regulator outside of the audit process, however, it has been ranked conditional on the basis ERA resolve the outstanding resourcing issues.

oss will continue to follow up on the identified non-conformances and ensure the close-out of corrective actions through the RPI process.

2.2.2.4 Minesite Technical Committee

The Ranger Minesite Technical Committee met five times during 2009–10. Dates of meetings and issues discussed are shown in Table 2.5. Significant agenda items discussed at MTCs included updates from ERA on site activities, updates from the Ranger Closure Criteria Working Group, the Radiation Management Plan and a raise to the TSF maximum operating level. The Ranger Closure Criteria Working Group reconvened in June 2008. Terms of reference have been established for the group, which is working to develop and agree upon closure criteria for Ranger. Throughout 2009–10 the working group met following each Ranger and Jabiluka MTC.

TABLE 2.5 RANGER MINESITE TECHNICAL COMMITTEE MEETINGS

Date	Significant agenda items in addition to standing items
7 July 2009	Application to optimise the Radiation and Atmospheric Monitoring Program, groundwater monitoring around the TSF, Water Management Plan, application to raise the MOL of the TSF, Heap Leach referral, exploration decline referral, APR #34, exploration
November 2009	Radiation and atmospheric monitoring program, groundwater monitoring near the TSF, Water Management Plan, wet season report, TSF maximum operating level, exploration drilling rehabilitation, electromagnetic radiation survey, heap leach facility referral
February 2010	Expanded covered evaporation ponds program, RP1 release to MG001, 2010 exploration drilling program, expanded accommodation plans, bullnose cutback, mine closure, Information and Compliance Policies and Procedures
March 2010	Radiation and atmospheric monitoring program, Information and Compliance Policies and Procedures, water management plan, annual plan of rehabilitation #35, RP1 release to MG001, accommodation facilities
May 2010	Radiation and atmospheric monitoring program, information and compliance policies and procedures, covered evaporation ponds program, RP1 release to MG001, 250 bed extension to Ranger village.

2.2.2.5 Authorisations and approvals

The Ranger Authorisation 0108-10 was replaced with Authorisation 0108-11 on 16 November 2009 approving a cut back to the wall of Pit 3 outside of the previously approved ‘Shell 50’ design.

On 18 December 2009 Ranger Authorisation 0108-11 was replaced with 0108-12 approving a raise in the Maximum Operating Level of the TSF to RL53m and changing the submission date of Ranger Water Management Plan.

2.2.2.6 Incidents

Background to incident investigation

Since 2000, ERA has undertaken to provide stakeholders with a comprehensive list of environmental incidents reported at its Ranger and Jabiluka operations on a regular basis. The regular monthly environmental incident report is additional to reports made to meet the statutory requirements for incident reporting. This regime of reporting all recorded environmental incidents is undertaken voluntarily by ERA in response to concerns expressed by stakeholders about the establishment of suitable thresholds of incident severity for reporting.

Immediately upon receipt of notification of any incident, ***oss*** assesses the circumstances of the situation and a senior officer makes a decision on the appropriate level of response. Dependent on the assessment, this response will range from implementation of an immediate independent investigation, through seeking further information from the mine operator before making such a decision. In those cases where immediate action is not considered to be required, the situation is again reviewed on receipt of a formal incident investigation report from the operator.

Prior to each routine periodic inspection (see section 2.1.2), the inspection team reviews the previous month's environmental incident report summary (EIRS) and any open issues. Where incidents are considered to have any potential environmental significance or represent repetitions of a class of occurrences, an on-site review is scheduled as a part of the routine inspection protocol.

oss determined that no incidents that occurred during the reporting period were of a serious enough nature to warrant a separate independent investigation, however, the following incidents were followed up as part of the routine periodic inspections.

Pond water connection

On 5 August 2009, an ERA contractor was found using the wrong connection on a pond water line. The contractor was pressure washing in the CCD area and connected a garden hose to a pond water connection. The contractor responsible was stood down and ERA met with management of the contracting company and required the company's workers to go through another induction and training session. There was no impact to the surrounding environment.

Elevated EC in SMP4

On 19 November 2009 Ranger MTC stakeholders received notification of elevated EC levels in SMP4 from readings taken on 22 October. SMP4 is a bore monitoring the performance of the seepage limiting barrier constructed along the south-eastern wall of Pit 1. Data provided to SSD indicated that water quality continued to deteriorate after that date. ERA undertook weekly investigative sampling of SMP4 and found results showing further increases in EC within the bore. Further investigations are ongoing to determine the source and pathway of the contaminated water. ERA has informed stakeholders that a final report of the investigation is expected in July 2010.

Sand filter

On 24 December 2009 stakeholders were notified that approximately 500 L of pregnant liquor spilled onto the road behind the administration building and into a storm drain that drains into RP2. ERA determined the cause of this incident to be a corroded sand filter. The spill area was cleaned up and later cleared of any radiation contamination. Water was sampled at the RP2 entry point to monitor for any adverse impact on RP2 water. Having reviewed the data, SSD determined that the impact on RP2 water quality was negligible. Stakeholders inspected the area during subsequent RPIs and have noted the repair works and the maintenance works on the three other sand filters. ERA has advised it proposes to update the maintenance schedule for the sand filters to include a manual clean every 6 months and lining inspection every 2 years.

South west TSF runoff sump wall breach

A breach in the south west TSF runoff sump occurred on 29 December 2009 due to heavy rains. The sump collects sediment and runoff from the TSF walls. It contained approximately 6 ML when the breach occurred. ERA collected water samples at the tributary leading into Gulungul Creek as well as at Gulungul upstream and downstream monitoring points. Results showed no discernable increase in turbidity. This may be attributable to the incident occurring during the first significant rainfall and an associated flush of sediments through the catchment. ERA continued to collect and report water quality measurements for a number of weeks following the incident. ERA created a bund along the TSF road to divert water and sediment away from the sump and has committed to completing a wider catchment review of the area to model inputs into the sediment sump. SSD continues to monitor this progress through the RPI and MTC process.

2.2.3 Off-site environmental protection

2.2.3.1 Surface water quality

Under the Authorisation, ERA is required to monitor and report on water quality in Magela and Gulungul Creeks adjacent to Ranger mine. Specific water quality objectives must be achieved in Magela Creek.

The Authorisation specifies the sites, the frequency of sampling and the analytes to be reported. Each week during the wet season ERA reports the water quality at key sites, including Magela and Gulungul Creeks upstream and downstream of the mine, to the major stakeholders (the Supervising Scientist, DoR and NLC). A detailed interpretation of water quality across the site is provided at the end of each wet season in the ERA Ranger Annual Wet-season Report.

In addition to ERA's monitoring program, the Supervising Scientist conducts an independent surface water quality monitoring program that includes measurement of chemical and physical variables in Magela and Gulungul Creeks, and biological monitoring in Magela and Gulungul Creeks as well as other reference creeks and waterbodies in the region. Key results (including time-series charts of key variables of water quality) are reported by the Supervising Scientist through the wet season on the Internet at www.environment.gov.au/ssd/monitoring/index.html. The highlights of the monitoring results are summarised below.

Chemical and physical monitoring of Magela Creek

The Supervising Scientist Division (SSD) modified its wet season monitoring program in 2008–09 to enhance the ability of SSD to independently detect changes while reducing replication of monitoring activities that are already carried out by other agencies (see 2009 Annual Report, chapter 3, section 3.1).

From the 2008–09 wet season there has been close integration of the routine water chemistry weekly grab sampling monitoring program with continuous water quality monitoring and in situ toxicity monitoring programs. The weekly grab samples, as for previous seasons, are measured for key mine site analytes, including physicochemical parameters. Map 2 shows the location of the upstream and downstream monitoring sites and key features of the Ranger minesite.

Flow was first recorded for the 2009–10 wet season at the Magela Creek upstream monitoring station on 24 December 2009. At the downstream monitoring station flow started on 27 December 2009.

The first water chemistry grab samples for the Supervising Scientist's 2009–10 wet season surface water monitoring program were collected from Magela Creek on 30 December 2009. Weekly sampling continued throughout the wet season and was still underway as of 30 June 2010. The continuous monitoring of EC and turbidity was maintained at both the downstream and upstream sites throughout the wet season.

The increase in rainfall in the Magela Creek catchment in late December 2009 resulted in increased flow, with consequent decreased manganese concentration, electrical conductivity and pH, and increased turbidity at both the upstream and downstream sites. This behaviour is typical of first flush conditions.

During late January the continuous monitoring data showed there were a series of minor electrical conductivity events (Figure 2.2).

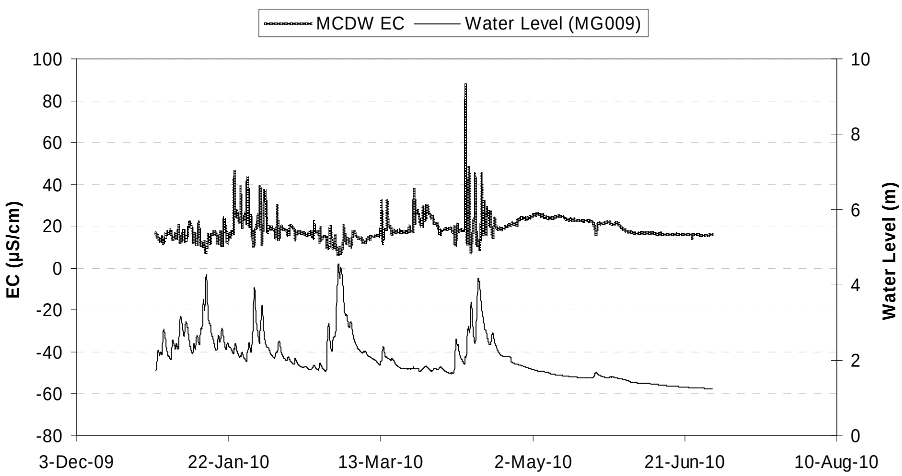


Figure 2.2 Electrical conductivity and discharge measurements in Magela Creek between December 2009 and July 2010 – continuous monitoring data

These are likely to be associated with the release of mine-derived solutes from Retention Pond 1 (RP1) to Coonjimba Billabong. These EC events lasted between 9 and 13 hours. During two of these events the EC remained above the EC guideline value of 43 µS/cm for periods of 2.25 and 0.83 hours.

On 3 February, uranium concentration peaked at approximately 3% of the limit and measured 0.175 µg/L at the SSD downstream site compared with 0.024 µg/L at the upstream site (Figure 2.3). This concentration is similar to uranium concentrations measured by the creekside field toxicity monitoring program on two occasions in 2002–2003 and once in the 2006–2007 wet season.

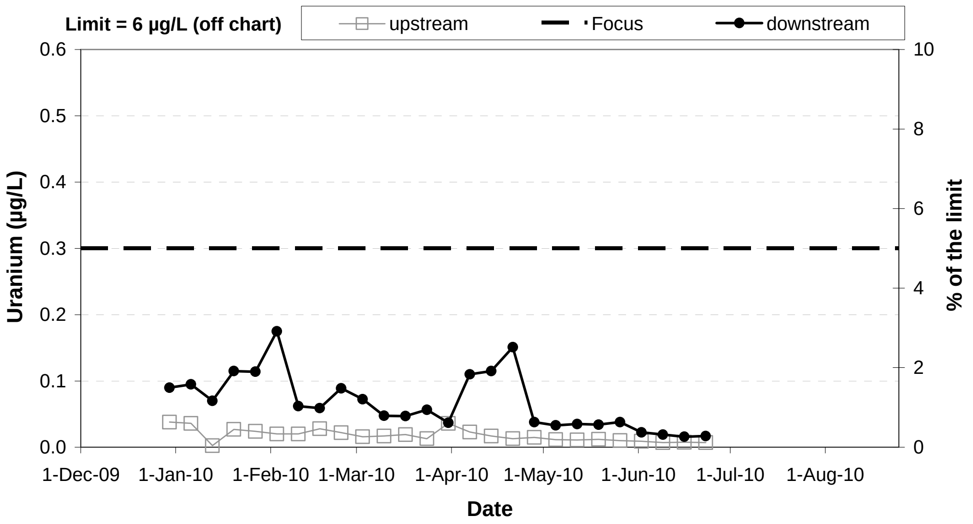


Figure 2.3 Uranium concentrations measured in Magela Creek by SSD between December 2009 and June 2010

Water levels within Magela Creek remained low during mid-February. High rainfall in late-February resulted in high creek levels from 26 February – 3 March 2010. Below average rainfall during March resulted in very low creek levels and increased values for electrical conductivity and pH and higher magnesium and sulfate concentrations. Heavy rainfall during mid-April resulted in seasonally low solute concentrations and increased turbidity due to high water flows (Figure 2.4).

Continuous monitoring data show several EC events during this period of high creek levels. These events coincided with increased discharge of water from Retention Pond 1 (RP1), with values of EC exceeding the EC guideline of 43 µS/cm for between 2.75 and 8.5 hours, with maximum conductivities from 48 to 90 µS/cm.

SSD considers these pulses of high conductivity water likely originated from RP1 (via Coonjimba Billabong). It is probable that an increase in flow (and water level) in Magela Creek had initially restricted flow from Coonjimba Billabong.

As the Magela Creek water level dropped, water held back in Coonjimba Billabong drained out causing the increase in EC at the downstream site (Figure 2.2) as a consequence of the reduced dilution. Ecotoxicological research conducted by SSD suggests that no detrimental environmental impacts would have resulted from these short-lived EC events.

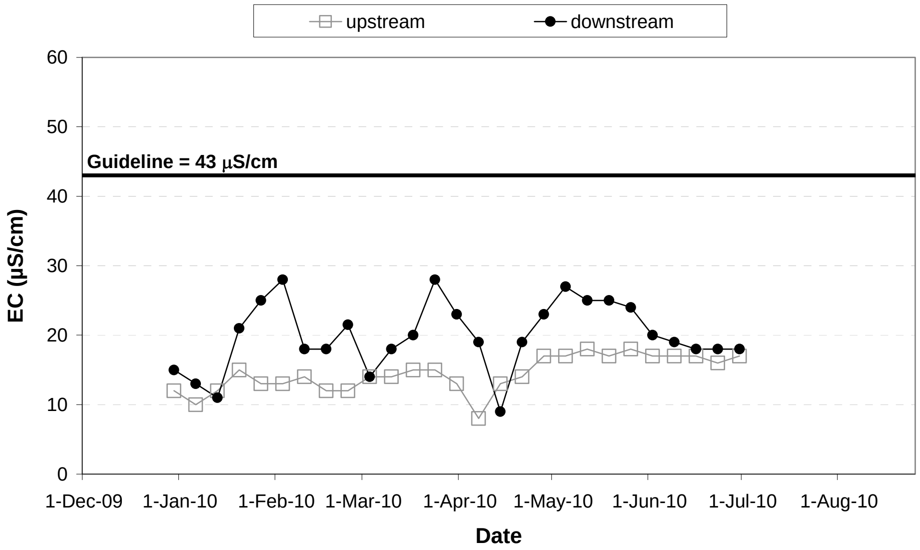


Figure 2.4 Electrical conductivity measurements in Magela Creek (SSD data) between December 2009 and June 2010 – grab sample data

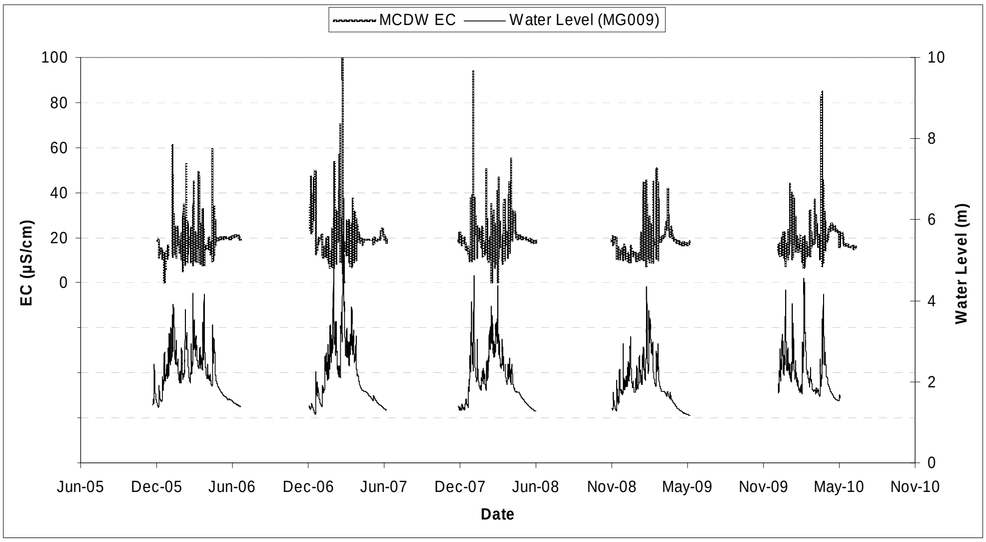
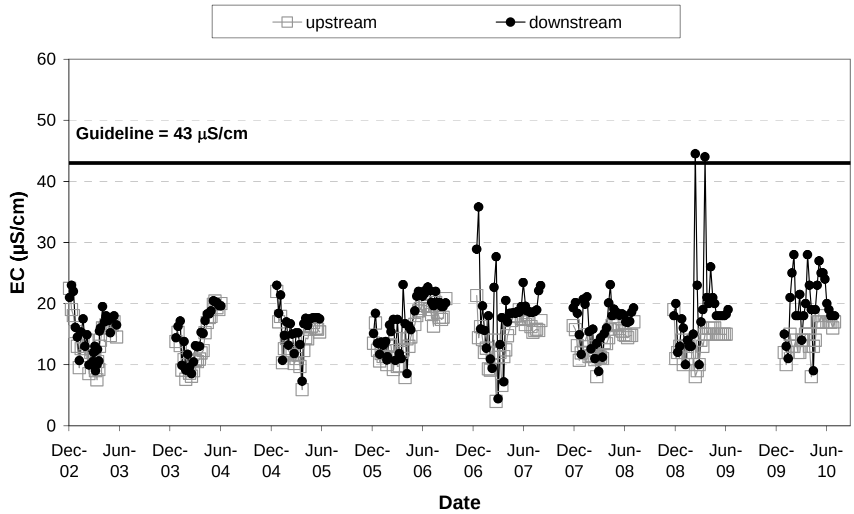


Figure 2.5 Electrical conductivity measurements and water level (lower trace) in Magela Creek (SSD data) between December 2005 and July 2010 – continuous monitoring data

From late-April, typical end of wet-season trends were apparent as the water level decreased. Manganese concentrations at the downstream site increased as groundwater influences started to dominate, and electrical conductivity between the upstream and downstream sites became similar as minesite influences decreased.

Overall, the data from the continuous monitoring and grab sample monitoring programs indicate that water quality in Magela Creek was comparable with previous seasons for the west channel (Figures 2.5 & 2.6). Figure 2.7 shows that uranium concentrations measured during the 2009–2010 wet season are comparable with previous seasons for the downstream west channel of Magela Creek.



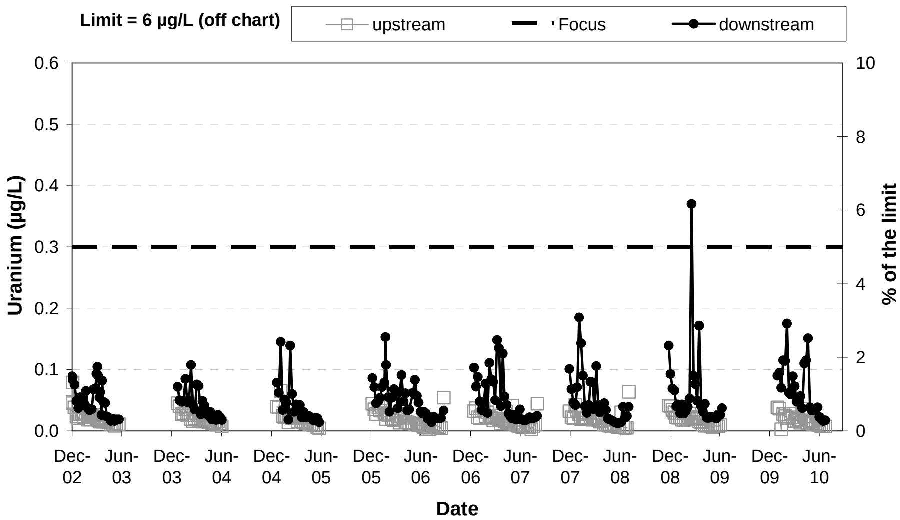


Figure 2.6 (top) Electrical conductivity measurements in Magela Creek (SSD data) between December 2002 and July 2010 – grab sample data. **Figure 2.7** (bottom) Uranium concentrations in Magela Creek since the 2002–03 wet season – grab sample data.

Radium in Magela Creek

Radium-226 (^{226}Ra) results for the 2009–10 wet season can be compared with previous wet season data from 2001-02 (Figure 2.8). The data from sample composites (weekly collected samples were combined from 2006–07 onwards to give monthly averages) show that the levels of ^{226}Ra are very low in Magela Creek, including downstream of Ranger mine. The anomalous ^{226}Ra activity concentration of 8.8 mBq/L in a sample collected from the control site upstream of Ranger in 2005 was probably due to a higher contribution of ^{226}Ra-rich soil or finer sediments that are present naturally in Magela Creek. This result has previously been explained in the 2004–05 Supervising Scientist Annual Report.

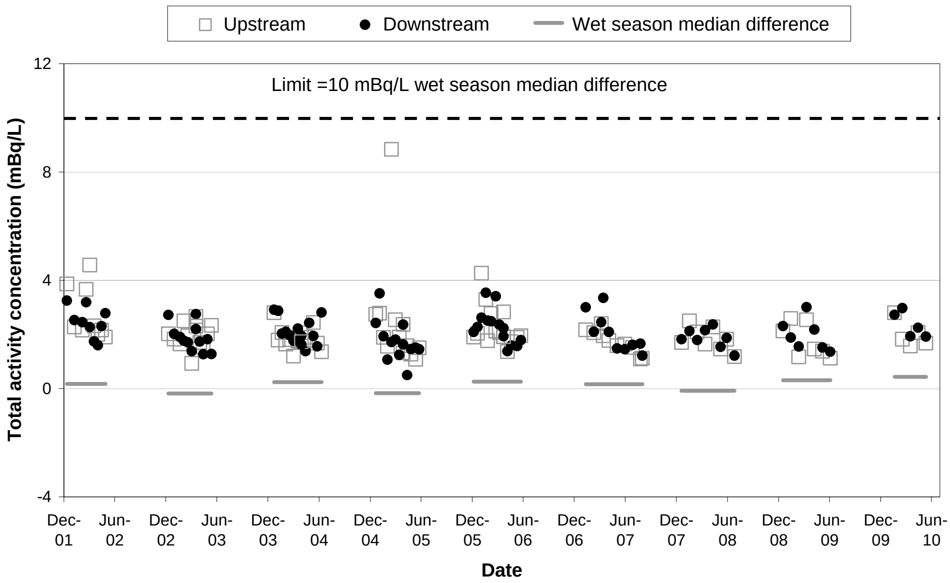


Figure 2.8 Radium-226 in Magela Creek 2001–2010 (SSD data)

The limit for total ^{226}Ra activity concentration has been defined for human radiological protection purposes. The medians of all ^{226}Ra data collected over the 2009–10 wet season are calculated for both the upstream and the downstream sites. The median of the upstream data is then subtracted from the median of the downstream data. This difference value, called the 'wet season median difference', should not exceed 10 mBq/L.

All wet season median differences (shown by the grey solid line in the graphs) from 2001 to 2010 are close to zero, indicating that ^{226}Ra levels at both sites in Magela Creek are due to the natural occurrence of radium in the environment. Thus, it is concluded that there is no significant input of ^{226}Ra from the Ranger minesite into Magela Creek.

Chemical and physical monitoring of Gulungul Creek

Weekly grab sampling for routine analysis of water chemistry variables was discontinued at the upstream site from the commencement of the 2008–09 wet season, as this site does not represent a useful reference site (ie water chemistry measured at this site may show upstream (natural) catchment influences that compromise its effectiveness for assessing downstream impacts from the mine). However, during the 2009–10 wet season grab samples were taken at the upstream site corresponding to the period of trial deployment of the in situ toxicity tests using the freshwater snail reproduction methodology. Weekly monitoring was continued at the downstream site. The continuous monitoring of EC and turbidity has been maintained at both the downstream and upstream sites.

The first water chemistry samples for the SSD 2009–10 wet season surface water monitoring program were collected from Gulungul Creek on 30 December 2009. Weekly sampling from the downstream site continued throughout the season while the creek was flowing until 24 June when MTC stakeholders agreed that surface flow had ceased in Gulungul Creek.

All weekly grab sample data show electrical conductivity measurements (EC) below the Magela Creek guideline value of 43 µS/cm (Figure 2.9). However, continuous monitoring data (Figure 2.10) shows two exceedances of this guideline during the peak of EC events on 26 January and 24 March 2010. These events lasted 14 and 21.5 hours respectively, during which time the EC remained above the guideline value for 3 hours during the January EC event and 1.25 hours during the March event.

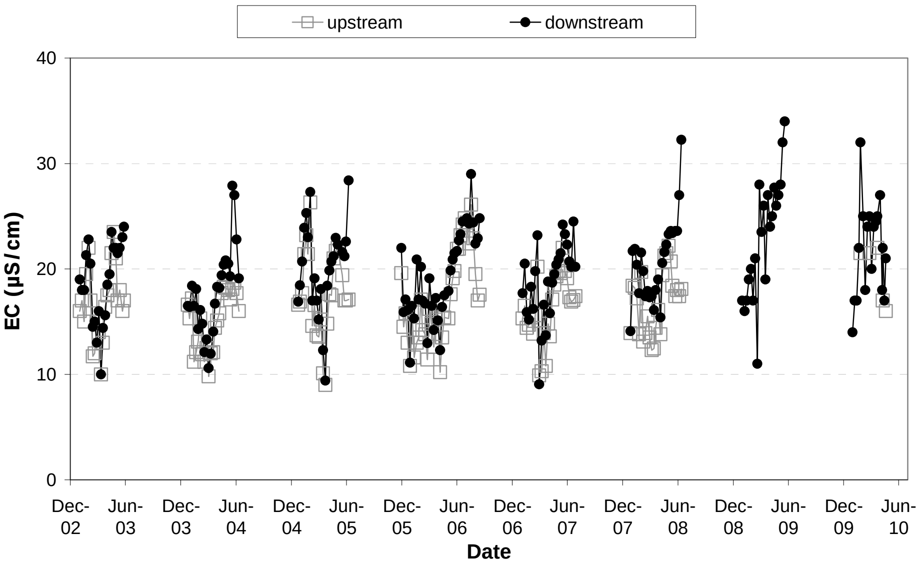


Figure 2.9 Electrical conductivity measurements in Gulungul Creek (SSD data) between December 2002 and June 2010 – grab sample measurements

The increased electrical conductivity and concentrations of magnesium and sulfate measured by both SSD and ERA were proposed to have originated from surface water runoff from an area of material used in the construction of the road at the base of the TSF. This runoff appears confined to the NW area of the TSF. ERA constructed a sump to collect the surface runoff and redirect it to the pond water circuit if of unacceptable quality, or allow it to overflow naturally across a rock-lined spillway if of appropriate quality. ERA will undertake a program of investigative works over the dry season to remove any problematic material.

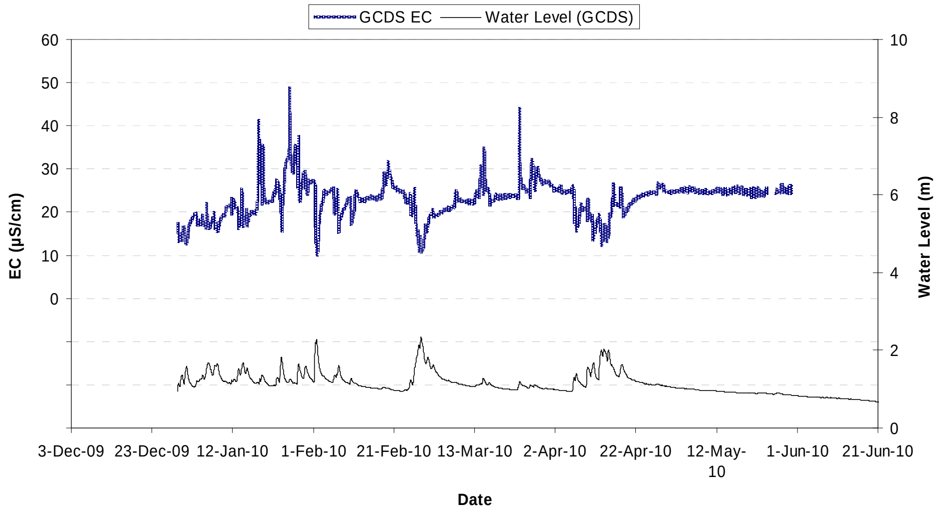


Figure 2.10 Electrical conductivity measurements in Gulungul Creek between December 2009 and June 2010 – continuous monitoring data

Figure 2.11 displays uranium concentrations measured by SSD at the downstream Gulungul Creek monitoring site for the 2009–10 wet season. Figure 2.12 shows the uranium data acquired by SSD for the 2002–03 to 2009–10 wet seasons to provide context. On 6 January 2010, uranium was 0.32 µg/L at the downstream site (<6% of the Magela Creek limit). This did not coincide with elevated EC, magnesium or sulfate concentrations, which were 17 µS/cm, 0.8 mg/L and 1.1 mg/L respectively at this time.

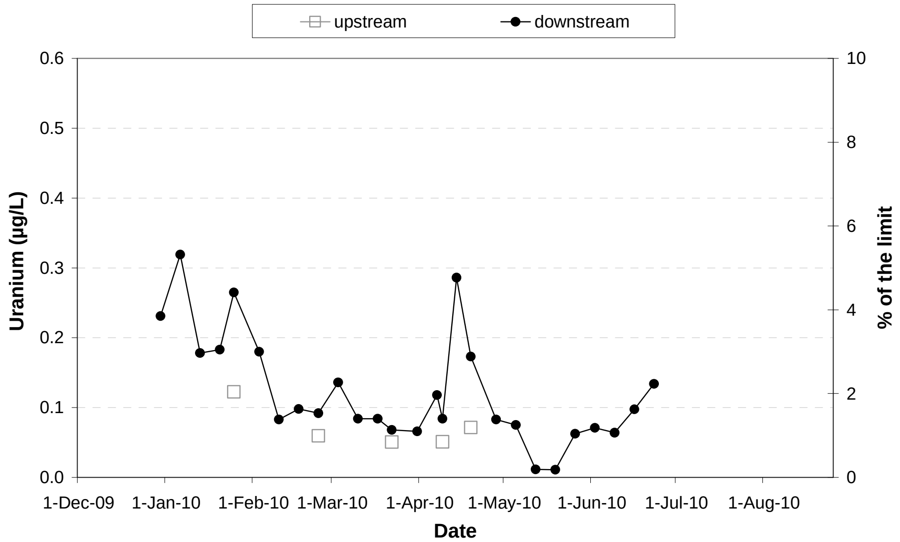


Figure 2.11 Uranium concentrations measured in Gulungul Creek by SSD between December 2009 and June 2010 – grab sample measurements.

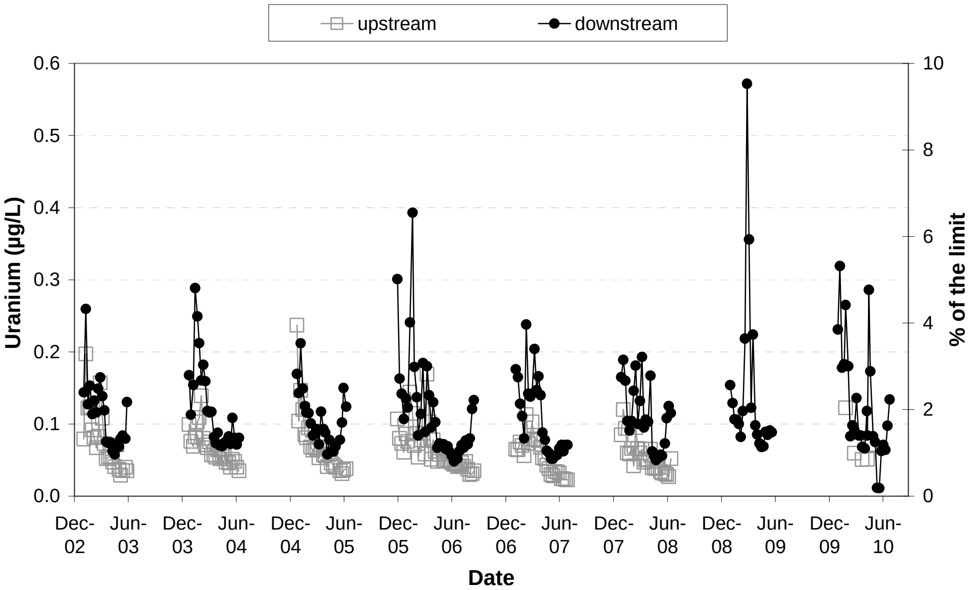


Figure 2.12 Uranium concentrations measured in Gulungul Creek by SSD between December 2002 and June 2010 – grab sample measurements.

On 25 January 2010 uranium measured 0.27 µg/L at the downstream site and coincided with slightly elevated EC (32 µS/cm), and magnesium (1.8 mg/L) and sulfate (4.4 mg/L) concentrations. Ecotoxicological research conducted by SSD suggests that no detrimental environmental impacts would have resulted from these short-lived EC events, and toxicity monitoring (creek side and/or in situ) has shown no biological effects for solute concentrations at this level.

Overall, the water quality measured in Gulungul Creek for the 2009–10 wet season indicates that the aquatic environment in the creek has remained protected from mining activities.

2.2.3.2 Biological monitoring in Magela Creek

Research conducted by the Environmental Research Institute of the Supervising Scientist (***eriss***) since 1987 has been used to develop biological techniques to monitor and assess the potential effects of uranium mining on aquatic ecosystems downstream of Ranger mine. Two broad approaches are used: early detection and assessment of overall ecosystem-level responses.

Early detection of effects in Magela Creek is done using two techniques: (i) in situ toxicity monitoring for detection at a weekly timescale of effects arising from inputs of mine waters during the wet season, and (ii) bioaccumulation, used to measure over a seasonal timescale a potential developing issue with bioavailability of mine-derived solutes (metals and radionuclides) in aquatic biota.

For *ecosystem-level responses*, benthic macroinvertebrate and fish community data from Magela and Gulungul Creek sites are compared with historical data and data from control sites in streams unaffected by contemporary mining.

The findings from toxicity monitoring, bioaccumulation, and fish and macroinvertebrate community studies conducted during the 2009–10 wet and early dry seasons are summarised below.

Toxicity monitoring

In this form of monitoring, effects of waters dispersed from the Ranger minesite on receiving waters are evaluated using responses of aquatic animals exposed in situ to creek waters. The response measured is reproduction (egg production) in the freshwater snail *Amerianna cumingi*. Each test runs over a four-day exposure period. This species has been shown to be among the most sensitive, to both uranium and magnesium, of SSD's suite of six local species as determined using standardised laboratory toxicity test protocols.

For the 1990–91 to 2007–08, wet seasons toxicity monitoring was carried out using the 'creekside' methodology. This involved pumping a continuous flow of water from the adjacent Magela Creek through tanks containing test animals located under a shelter on the creek bank. In the 2008–09 wet season, this method was replaced by an in situ testing method. The in situ testing was implemented following a rigorous three year period of development and comparative (creekside and in situ) testing to ensure that both methods produced similar results (see section 3.2 of the 2007–08 Supervising Scientist Annual Report for rationale and results).

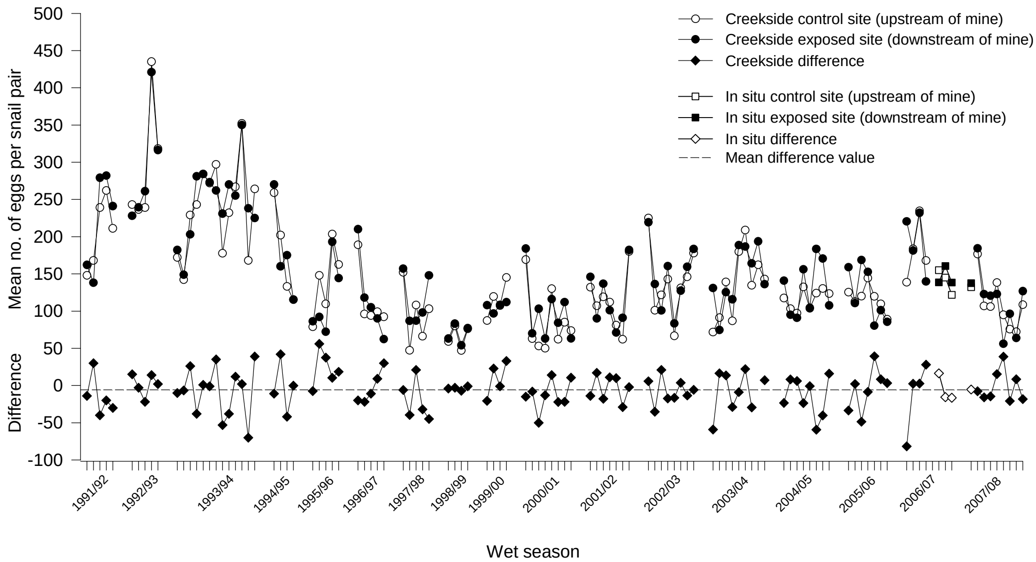
Nine in situ toxicity tests were conducted on a fortnightly frequency (ie every other week) over the 2009–10 wet season. The first started on 4 January 2010 and the final test started on 3 May 2010. Results are plotted in Figure 2.13b with egg production at upstream and downstream sites, and differences in egg production between the sites being displayed.

On average, egg numbers at the downstream site are slightly greater than that measured at the upstream control site (Figure 2.13a&b), This 'normal' level of response is most likely the result of input to Magela Creek, between the upstream and downstream test locations, of billabong-tributary waters. Inflows from Georgetown and Coonjimba Billabongs have higher water temperatures, a higher organic carbon content than Magela Creek water and (Coonjimba in particular) higher concentrations of mine-derived solutes (including $MgSO_4$ and Ca) relative to the background very soft, low solute Magela Creek water. Higher water temperatures will enhance reproductive activity in *Amerianna cumingi*. The inputs of dissolved salts, increased nutrients and natural organic matter would supplement the food supply and thereby also enhance egg production by the downstream snails.

The measured difference in water quality between the upstream and downstream sites is also highly affected by creek hydrology. On a falling hydrograph in the creek, outflowing of previously-ponded waters from billabongs located between the upstream and downstream sites occurs, accentuating solute and nutrient differences between the sites (higher concentrations measured at the downstream site, particularly along the west bank).

A different pattern of results for the 2009–10 wet season was seen from those reported in previous wet seasons. Unlike previous wet seasons, snail egg production during the 2009–10 season was *consistently* higher (8 out of 9 tests; Figure 2.13b) at the downstream site compared with the upstream site. The positive difference was particularly marked in the 3rd test and to a lesser extent in the 4th and 5th tests.

A



B

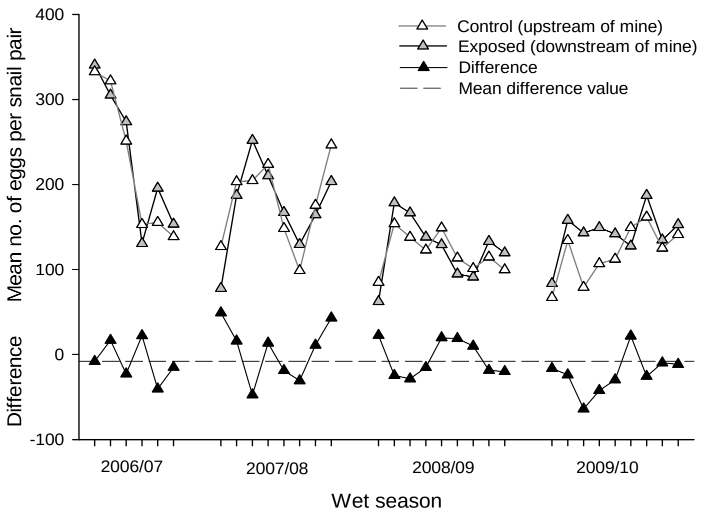


Figure 2.13 Time-series of snail egg production data from toxicity monitoring tests conducted in Magela Creek using A: (mostly) creekside tests, and B: in situ tests

Analysis Of Variance (ANOVA) testing was used to test for differences in the upstream-downstream difference values between test results for the 2009–10 wet season and all previous wet season data (see ANOVA details, section 2.2.3 of the 2007–08 Supervising Scientist Annual Report). For the first time, a significant difference was found between the data for the most recent year and that from previous wet seasons (p = 0.046), confirming the generally higher downstream egg production in 2009–10 evident in Figure 2.13b. A number of factors have the potential to cause the different behaviour observed for the 2009–10 wet season: methodological or systematic operator problems during the wet season; an unusual suppression in egg number upstream over the wet season; or enhancement of egg number downstream that may be associated with inputs of water (as measured by EC or turbidity data) from the Ranger site.

Each of the above potential causative factors was assessed in detail using the extensive available historical grab sampling and continuous water quality monitoring datasets. No correlation was found between any of these factors and the positive downstream effect on egg production. Specifically there was no evidence of any mine-related influence from either the water quality data or the macroinvertebrate community studies (reported below) that are conducted by SSD in the late wet season recessional flow period each year.

At this time it appears as though the most probable explanation is an increase in food supply downstream as a result of increased settling out of particulate matter. Field monitoring staff have noted that in recent times there has been a deepening of the channel at the downstream site. This deepening would result in a relative reduction in water velocity across the stream profile and hence an increased likelihood for deposition of suspended material. A visible increase, compared with previous years, in the amount of particulate material trapped inside the toxicity monitoring containers at the downstream site was in fact noted during the 2010–11 wet season.

Experimental studies to examine the responses of freshwater snails to a limited matrix of water quality variables, including Mg and organic carbon at low concentrations, may provide further insights into the effects of otherwise subtle variations on biological responses. A means to quantify the amount of particulate matter trapped in the test containers during the period of in situ deployment will be developed for implementation in future wet seasons.

Bioaccumulation in freshwater mussels

Mudginberri Billabong is the first major permanent waterbody downstream (12 km) of Ranger mine (Map 3). Local Aboriginal people harvest aquatic food items, in particular mussels, from the billabong and hence it is important to provide assurance that they are fit for human consumption from chemical and radiological perspectives. Concentrations of metals and/or radionuclides in the tissues and organs of aquatic biota attributable to inputs of mine-derived solutes must remain within acceptable levels. Increased body burdens of mine-derived solutes in biota compared with control sites could provide early warning of the effects of inputs of solutes. In extreme cases the concentrations could potentially reach levels that may harm the organisms themselves. Hence the bioaccumulation monitoring program serves an ecosystem protection role in addition to the human health aspect.

Uranium and radium bioaccumulation data were obtained intermittently from Mudginberri Billabong between 1980 to 2000. Since 2000, mussels have been collected annually and fish every two years, respectively, from Mudginberri (the potentially impacted site, sampled from 2000 onwards) and Sandy billabongs (the control site, sampled from 2002 onwards). The monitoring data showed that radionuclide burdens in mussels from Mudginberri Billabong were generally about twice as high compared with mussels from Sandy Billabong. A longitudinal study was conducted in 2007 to measure radium loads in mussels along

Magela Creek, upstream and downstream of the mine. The objectives were to identify whether the higher radionuclide loads are related to natural or mine inputs and whether Sandy Billabong is an appropriate control site for mussels in Mudginberri Billabong.

It was found that of all sites investigated along the Magela channel, Mudginberri Billabong mussels exhibit the lowest radium loads, age-for-age, and that differences in mussel radionuclide activity loads between Mudginberri and Sandy Billabong mussels are due to natural catchment rather than mine influences. A longitudinal study of radium uptake in mussels in Mudginberri Billabong was undertaken and showed that the location of sampling in the billabong had no significant effect on the mussel radium loads. In addition the concentration factor for radium uptake in mussels from Mudginberri Billabong has not changed significantly over the past 25 years.

Nine years of monitoring of the levels of radionuclides and metals in fish has not revealed any issues of potential concern with regards to bioaccumulation.

Given the above findings, the effort on the bioaccumulation component of the monitoring program has been reduced to analysing annually a bulk sample of mussels for radionuclides and metals, while the two yearly fish sampling program has been discontinued. The fish bioaccumulation program will be restarted in the event that it is shown that levels of metals being input from the mine increase above the current condition.

Uranium in freshwater mussels

Uranium concentrations in freshwater mussels, water and sediment samples collected annually from Mudginberri and Sandy Billabongs are shown in Figure 2.14.

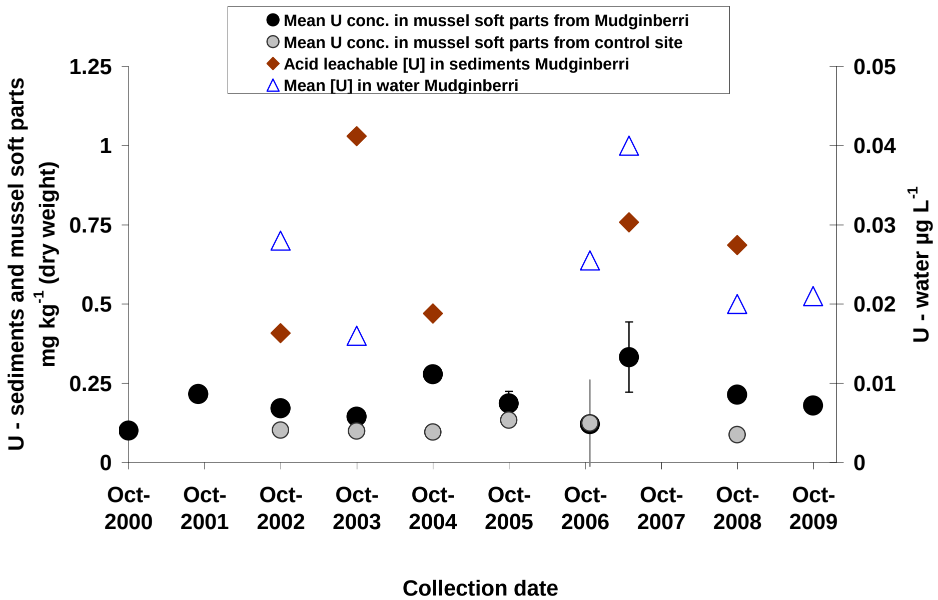


Figure 2.14 Mean concentrations of U measured in mussel soft-parts, sediment and water samples collected from Mudginberri Billabong and Sandy Billabong since 2000

This plot includes the 2009 data for the composite mussel sample and water quality data in Mudginberri Billabong. Low concentrations of uranium have been measured in mussels from Mudginberri Billabong from 2000 onwards, with no evidence of an increasing trend in concentration over time. Notwithstanding some bioaccumulation with age, uranium appears to have a short biological half-life, a conclusion that is supported by the data in Figure 2.14, with the uranium concentrations in mussel flesh being very low.

The lack of any increase in concentration of U in mussel tissues through time, with essentially constant levels observed between 1989 and 1995 (previous reports), and consistently low levels from 2000 to the last sample taken in October 2009, indicates absence of any mining influence on U levels in mussels.

Radium-226 and lead-210 in freshwater mussels

Activity concentrations of ^{226}Ra and ^{210}Pb in mussels are age-dependent and are also related to growth rates and seasonally-changing soft body weights. Consequently, ^{226}Ra and ^{210}Pb activity concentrations in mussels can vary depending on the time of collection during the year.

The average annual committed effective dose for a 10-year old child (the most conservative case) who eats 2 kg (wet weight) of mussel flesh from Mudginberri Billabong is calculated from the concentrations of ^{226}Ra and ^{210}Pb in mussel flesh. The average for all collections from 2000 to 2009 is 0.175 mSv. Figure 2.15 shows the doses estimated for the individual years, and the median, 80 and 95 percentiles for all collections. As can be seen, annual committed effective doses from the consumption of mussels collected in 2009 are indistinguishable from previous collections (Figure 2.15). Committed effective doses due to ingestion of these mussels are of no concern to human health. The Ra in the mussels is largely derived from natural catchment geology, rather than mining influences.

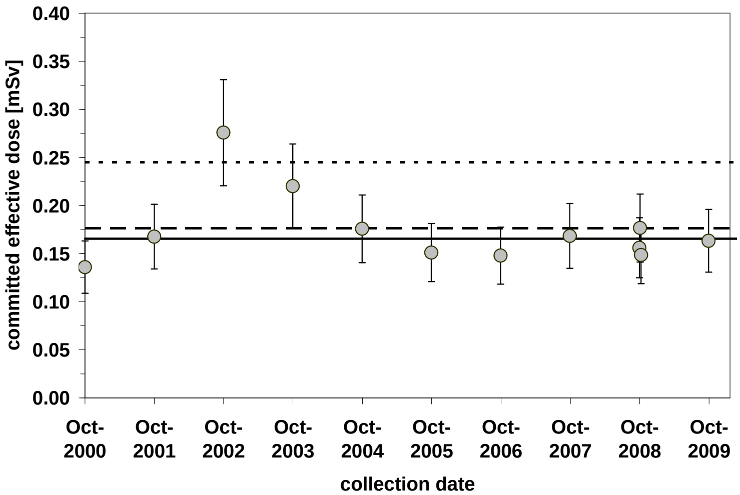


Figure 2.15 Annual committed effective doses from ^{226}Ra and ^{210}Pb for a 10 year old child eating 2 kg of mussels (wet) collected at Mudginberri Billabong. Median over all collections (solid line), the 80th percentile (dashed line) and 95thpercentile (dotted line) are also shown.

The bulk ^{226}Ra activity concentration (in Bq kg^{-1} dry weight) in Mudginberri Billabong mussels is similar for all collections from 2000 to 2009. The higher committed effective dose for the 2002 and 2003 collections is an artefact caused by higher dry:wet weight ratios due to a change in the mussel preparation method. During shucking, or opening, of the mussels, liquid inside the mussel is usually retained and included in the wet weight of the mussels. During the 2002 and 2003 collections, the liquid was drained before wet weights were measured, resulting in a higher dry:wet weight ratio. As the activity concentration (dry) is similar for all years, this results in a higher radionuclide intake per 2 kg (wet weight) of mussels ingested, and consequently a higher committed effective dose for those two years.

Monitoring using macroinvertebrate community structure

Macroinvertebrate communities have been sampled from a number of sites in Magela Creek at the end of significant wet season flows, each year from 1988 to the present. The design and methodology have been gradually refined over this period (changes are described in the 2003–04 Supervising Scientist Annual Report, section 2.2.3). The design is now a balanced one comprising upstream and downstream sites at two ‘exposed’ streams (Gulungul and Magela Creeks) and two control streams (Burdulba and Nourlangie Creeks).

Samples were collected from each site at the end of each wet season (between April and May). For each sampling occasion and for each pair of sites for a particular stream, dissimilarity indices are calculated. These indices are a measure of the extent to which macroinvertebrate communities of the two sites differ from one another. A value of ‘zero%’ indicates macroinvertebrate communities identical in structure while a value of ‘100%’ indicates totally dissimilar communities, sharing no common taxa.

Disturbed sites may be associated with significantly higher dissimilarity values compared with undisturbed sites. Compilation of the full macroinvertebrate dataset from 1988 to 2009, and data from the paired sites in the two ‘exposed’ streams, Magela and Gulungul Creeks, for 2010, have been completed with results shown in Figure 2.16. This figure plots the paired-site dissimilarity values using family-level (log-transformed) data, for the two ‘exposed’ streams and the two ‘control’ streams.

In the 2007–08 Supervising Scientist Annual Report (section 2.2.3), improvements to the presentation and statistical analysis of macroinvertebrate data were described. By deriving dissimilarity values for each of the five possible randomly-paired upstream and downstream replicates, powerful analyses are available that can be used to test whether or not macroinvertebrate community structure has altered significantly at the exposed sites for the recent wet season of interest. For this multi-factor ANOVA, only data gathered since 1998 have been used. (Data gathered prior to this time were based upon different and less rigorous sampling and sample processing methods, and/or absence of sampling in three of the four streams.)

Inferences that may be drawn from the data shown in Figure 2.16 are weakened because there are no baseline (pre-1980) data upon which to assess whether or not significant changes have occurred as a consequence of mining. Notwithstanding, a four-factor ANOVA based upon replicate, paired-site dissimilarity values and using the factors Before/After (BA; fixed), Control/Impact (CI; fixed), Year (nested within BA; random) and Site (nested within CI;

random) showed no significant difference between the control and exposed streams in the change (in dissimilarity) from values from earlier years (back to 1998) to those from 2009 (ie the BA x CI interaction is not significant). While the Year x Site (BA CI) interaction is significant in the same analysis ($p = 0.011$), this simply indicates that dissimilarity values for the different streams – regardless of their status (Before, After, Control, Impact) – show differences through time. The dissimilarity plots shown in Figure 2.16 corroborate these results, showing reasonable constancy in the mean dissimilarity values for each stream across all years.

Dissimilarity indices such as those used in Figure 2.16 may also be ‘mapped’ using multivariate ordination techniques to depict the relationship of the community sampled at any one site and sampling occasion with all other possible samples.

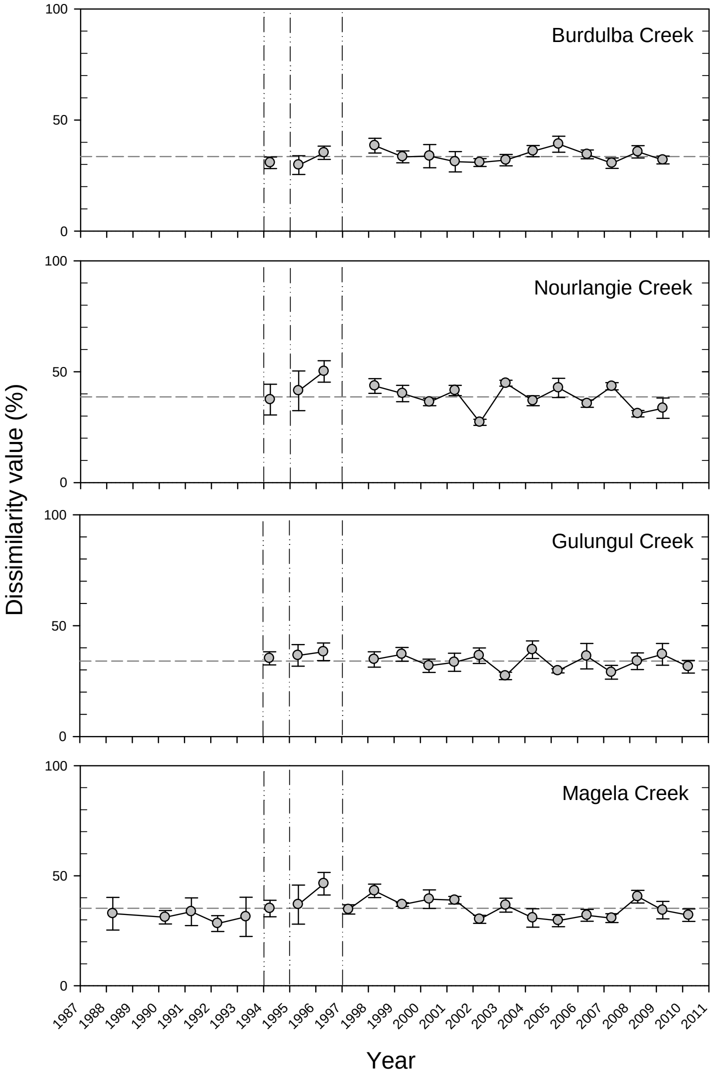


Figure 2.16 Paired upstream-downstream dissimilarity values (using the Bray-Curtis measure) calculated for community structure of macroinvertebrate families in several streams in the vicinity of the Ranger mine for the period 1988 to 2010. The dashed vertical lines delineate periods for which a different sampling and/or sample processing method was used. Dashed horizontal lines indicate mean dissimilarity across years.

Dissimilarity values represent means (± standard error) of the 5 possible (randomly-selected) pairwise comparisons of upstream-downstream replicate samples within each stream.

Samples close to one another in the ordination indicate a similar community structure. Figure 2.17 depicts the ordination derived using the *pooled* (average) within-site macroinvertebrate data (unlike the replicate data used to construct the dissimilarity plot from Figure 2.16). Data points are displayed in terms of the sites sampled in Magela and Gulungul Creeks downstream of Ranger for each year of study (to 2010), relative to Magela and Gulungul Creek upstream (control) sites for 2010, and all other control sites sampled up to 2009 (Magela and Gulungul upstream sites, all sites in Burdulba and Nourlangie). Because the data-points associated with these two sites are generally interspersed among the points representing the control sites, this indicates that these 'exposed' sites have macroinvertebrate communities that are similar to those occurring at control sites. This was verified using ANOSIM testing (ANalysis Of SIMilarity, effectively an analogue of the univariate ANOVA), a statistical approach used to determine if exposed sites (Magela and Gulungul downstream) are significantly different from control sites in multivariate space. ANOSIM conducted on (i) pooled (within-site) data from all available years and sites, and (ii) replicate data from 2010 (Magela and Gulungul Creeks only), showed no significant separation of exposed and control sites for the respective comparisons ($P>0.05$).

Collectively, these graphical and statistical results provide good evidence that changes to water quality downstream of Ranger as a consequence of mining during the period 1994 to 2010 have not adversely affected macroinvertebrate communities.

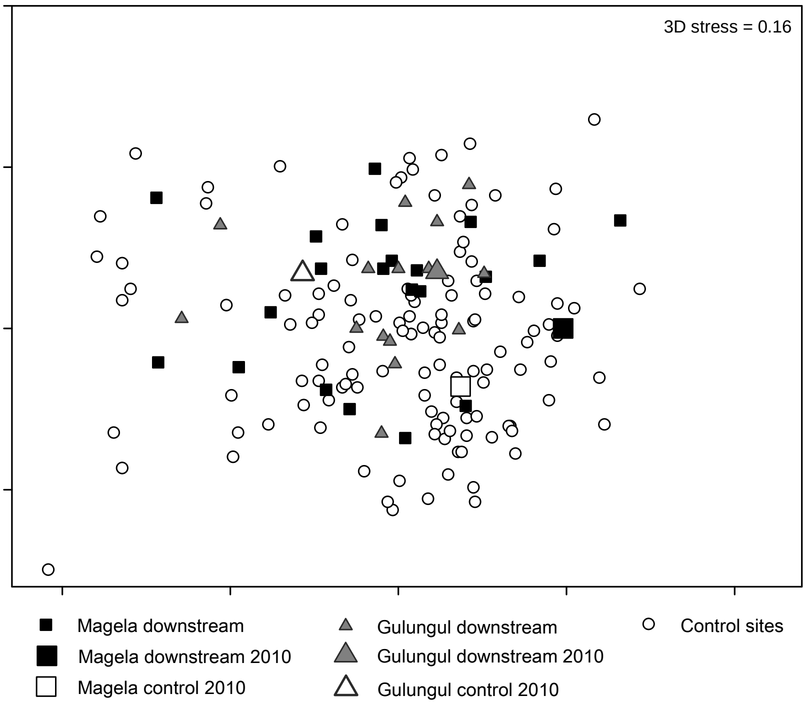


Figure 2.17 Ordination plot of macroinvertebrate community structure data from sites sampled in several streams in the vicinity of Ranger mine for the period 1988 to 2010. Data from Magela and Gulungul Creeks for 2010 are indicated by the enlarged symbols.

Monitoring using fish community structure

Assessment of fish communities in billabongs is conducted between late April and July each sampling year. Data are gathered using non-destructive sampling methods from ‘exposed’ and ‘control’ sites in deep channel billabongs annually, and shallow lowland billabongs dominated by aquatic plants, biennially (every other year). Details of the sampling methods and sites were provided in the 2003–04 Supervising Scientist Annual Report (Supervising Scientist 2004, chapter 2, section 2.2.3). These programs were reviewed in October 2006 and the refinements to their design detailed in the 2006–7 and 2007–08 Supervising Scientist Annual Reports (shallow and channel billabong fish communities respectively).

For both deep channel and shallow lowland billabongs, comparisons are made between a directly-exposed billabong (Mudginberri) in the Magela Creek catchment downstream of Ranger mine versus control billabongs from an independent catchment (Nourlangie Creek and Wirnmuyurr Creek). The similarity of fish communities in exposed sites to those in control sites is determined using multivariate dissimilarity indices, calculated for each sampling occasion. The use of dissimilarity indices has been described and defined in ‘Monitoring using macroinvertebrate community structure’ section. A significant change or trend in the dissimilarity values over time could imply mining impact.

Channel billabongs

The similarity of fish communities in Mudginberri Billabong (directly exposed site downstream of Ranger in Magela Creek catchment) and Sandy Billabong (control site in the Nourlangie Creek catchment) was determined using multivariate dissimilarity indices calculated for each annual sampling occasion. A plot of the dissimilarity values from 1994 to 2010 is shown in Figure 2.18.

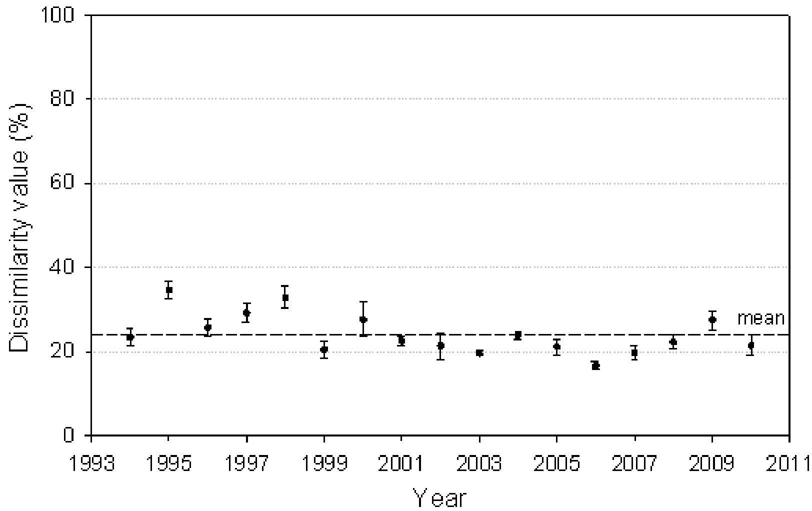


Figure 2.18 Paired control-exposed dissimilarity values (using the Bray-Curtis measure) calculated for community structure of fish in Mudginberri (‘exposed’) and Sandy (‘control’) Billabongs in the vicinity of the Ranger mine over time. Values are means (± standard error) of the 5 possible (randomly-selected) pairwise comparisons of transect data between the two.

In previous Supervising Scientist Annual Reports (up to 2008–09), a decline in the annual paired-site dissimilarity measure over time has been noted, corresponding to changes in field observation method between 2000 and 2001 and also to longer-term changes (decrease) in abundance in Magela Creek of the chequered rainbowfish (*Melanotaenia splendida inornata*), the species that has had most influence on the change in the paired-billabong dissimilarity value. In the Supervising Scientist Annual Report for 2008–09, it was observed that the changes in abundance of chequered rainbowfish in Magela Creek over time were unrelated to changes in field observation method and, importantly, to any change in water quality over time as a consequence of water management practices at Ranger uranium mine.

Rainbowfish abundance in Mudginberri Billabong for the 2010 sampling was greatly reduced from the higher fish numbers recorded in 2009 (Figure 2.19). In the Supervising Scientist Annual Report for 2008–09, the amount of wet season discharge in Magela Creek had been identified as a possible cause of natural shifts in rainbowfish abundance in Mudginberri Billabong. Specifically, that report provided evidence that larger wet season discharges result in reduced abundances of rainbowfish. The low abundances observed in 2010 support this finding, as the preceding wet season discharge was above average (Figure 2.19). Furthermore, the late rains during April may have resulted in greater migration of rainbowfish, upstream and past Mudginberri Billabong, thereby reducing the reliance of fish to use the billabong as a dry season refuge.

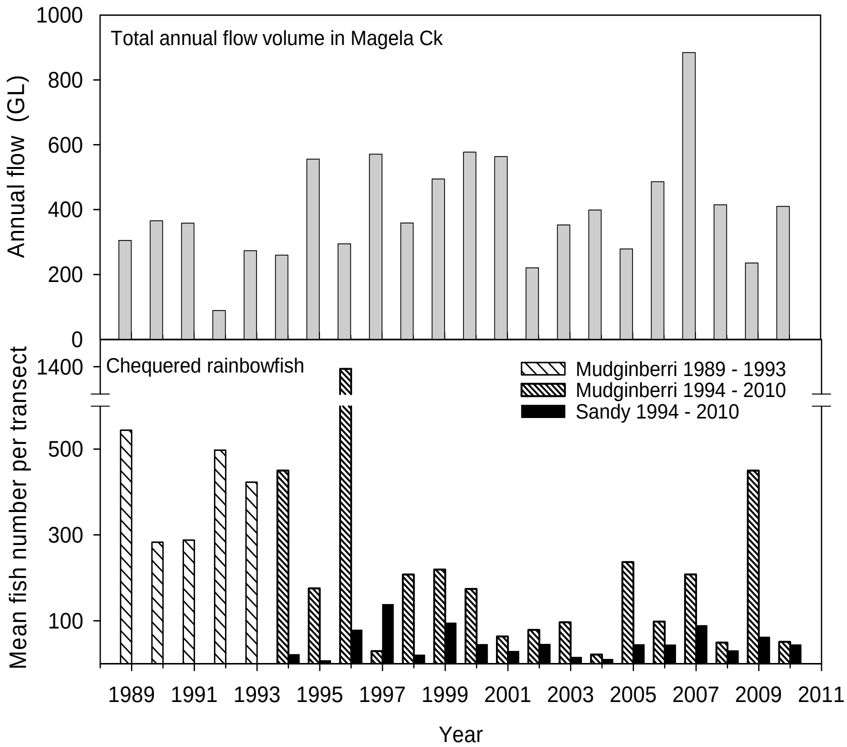


Figure 2.19 Relative abundance of chequered rainbowfish in Mudginberri and Sandy billabongs from 1989 to 2010 with associated total discharge in Magela Creek (gauging station G8210009)

A full analysis of community structure, and in particular chequered rainbowfish abundance, data for the channel billabongs in 2010 was still being conducted at the time of completing this report. At this stage, however, the conclusion reached in the previous (2008–09) Supervising Scientist Annual Report of no evidence for mine-related impact, appears to be applicable also to the results for 2010. In particular, the dissimilarity value observed in 2010 is consistent with the range of values reported since 2001, a period over which there has been no evidence of mine-associated changes to fish communities in Mudginberri Billabong, downstream of Ranger.

Shallow lowland billabongs

Monitoring of fish communities in shallow billabongs is conducted every other year (see SSAR 2006–07). The last assessment of fish communities in shallow lowland billabongs was conducted in May 2009 with results reported in SSAR 2008–09. The next assessment will be conducted during recessional flows sometime between the late April and June 2011.

2.3 Jabiluka

2.3.1 Developments

The site continues to be maintained under the long-term care and maintenance regime of management. There has been no change to the statutory monitoring program undertaken by ERA in Swift Creek (Ngarradj) during the reporting period. SSD continues to monitor downstream water quality at Ngarradj.

2.3.2 On-site environmental management

2.3.2.1 Water Management

The site continues to be maintained as a passive discharge site.

2.3.2.2 Audit and Routine Periodic Inspections (RPIs)

Three inspections were undertaken at Jabiluka during 2009–10 (Table 2.6). An environmental audit was held in May 2010 and RPIs were held in August, November and February.

TABLE 2.6 RPI FOCUS DURING THE REPORTING PERIOD

Date	Inspection type	Foci
18 August 2009	RPI	Access Road, Interim Water Management Pond, Helipad area
17 November 2009	RPI	Helipad area, Clean stockpile area, Main site / portal area, IWMP and associated choke structure, Silt trap opposite former turkey nest dam, JSC compliance point, Djarr Djarr, Ngarradj sampling location
17 February 2010	RPI	IWMP and drop structure, Hardstand revegetation, Fly-over of the JSC and JSCUS monitoring stations, Mine Valley remediation works and Djarr Djarr Camp.

2009 Audit review outcomes

Observations from the May 2009 Environmental Audit were followed up through the RPI process.

It is a requirement of long-term care and maintenance of the site that the vent rise infrastructure will be decommissioned and the vent shaft capped and converted to a decline water sampling point. ERA has reaffirmed its commitment to convert the vent raise to a sampling point and there have been no further issues identified with the reporting of water chemistry data.

The redundant boreholes in Mine Valley are required to be capped as part of the site's long-term care and maintenance. Works to rehabilitate these bore holes is ongoing. Works have commenced and stakeholders are awaiting submission of the Phase 1 report.

2010 Audit outcomes

The annual environmental audit of Jabiluka was held in May 2010 and tested compliance against 22 specific commitments taken from Authorisation 0140-05. The information collected against each criteria was assessed and given a ranking as per the grading system provided in Table 2.4. The audit process found evidence to grade one criteria as conditional and one as not verified while all other criteria was found to be acceptable. The conditional finding relates to:

- Capping of redundant boreholes in mine valley. ERA informed stakeholders works in mine valley to rehabilitate redundant bore holes are ongoing. Works have commenced and stakeholders are awaiting submission of the Phase 1 report. This aspect of this criteria has been ranked conditional on ERA providing stakeholders with the Phase 1 report in order to progress towards finalising rehabilitation of this area.

The not-verified condition relates to:

- Removal of buildings, infrastructure and miscellaneous items from the mine site and Djarr Djarr Camp. The audit team were not able to visit Djarr Djarr due to access restrictions therefore this aspect of this criteria was unable to be verified.

2.3.2.3 Minesite Technical Committee

The Jabiluka MTC met five times during 2009–10. Dates of meetings and significant issues discussed are shown in Table 2.7.

2.3.2.4 Authorisations and approvals

No applications to alter the Jabiluka Authorisation, 0140-5, were received during the reporting period.

2.3.2.5 Incidents

There was one incident reported for the 2009–10 period of a minor nature and did not require investigation or assessment.

TABLE 2.7 JABILUKA MINESITE TECHNICAL COMMITTEE MEETINGS

Date	Significant agenda items
7 July 2009	Annual Plan of Rehabilitation #12, progress of Mine Valley Bores, comments regarding the wet season report
12 November 2009	Mine Valley bore rehabilitation program, wet season report, SSD monitoring program at Ngarradj
12 February 2010	Mine Valley rehabilitation program, Annual Environment Report, Annual Plan of Rehabilitation #12, MTC member website
11 March 2010	Mine Valley rehabilitation program, Annual Environment Report
13 May 2010	Mine Valley rehabilitation program, Annual Environment Report, Annual Plan of Rehabilitation

2.3.3 Off-site environmental protection

2.3.3.1 Surface water quality

In accordance with the Jabiluka Authorisation, ERA is required to monitor a range of surface and ground waters on the lease and to demonstrate that the environment remains protected. Specific water quality objectives (criteria thresholds were described in Supervising Scientist Annual Report 2003–04) must be achieved. Each month during the wet season, ERA reports the water quality in Ngarradj (Swift Creek) to the major stakeholders (SSD, DoR and NLC). A detailed interpretation of water quality across the site is provided at the end of each wet season in the ERA Jabiluka Annual Wet-season Report.

In addition to the ERA program, the Supervising Scientist conducts monitoring in Ngarradj Creek. Jabiluka has been in a long-term care and maintenance phase since late 2003 and poses a low risk to the environment. As a consequence of this low risk and the good data set acquired over the last seven years indicating the environment has been protected, the monitoring program has been systematically scaled down.

The SSD biological monitoring program for Jabiluka ceased in 2004, commensurate with the low risk posed while the site is in long-term care and maintenance mode. Results from six-years (1999–2004) of fish community structure studies were reported in Supervising Scientist Annual Report 2003–04 along with results for macroinvertebrate community structures.

Since 2009/10, the Supervising Scientist Division has collected continuous monitoring data (electrical conductivity, pH and turbidity) from the downstream statutory compliance site only. ERA collects monthly grab samples from both the upstream and downstream site. Previous grab sample monitoring data can be found at www.environment.gov.au/ssd/monitoring/ngarradj-chem.html on the SSD website and have been reported in previous Annual Reports.

Chemical and physical monitoring of Ngarradj Creek

The first flush conditions in Ngarradj resulted in the highest EC record of the season at 26.1 µS/cm (Figure 2.20). EC levels gradually reduced during January and stabilised between 15–20 µS/cm. The EC sensor was damaged during a flood event and was inoperative from 7–25 February.

On 18 March the gauge board reading indicated water levels had dropped to <0.51 m. The low water level resulted in the EC sensor being out of the water, so there is a gap in the EC time series data around this time. The EC trace resumed with the increase in water level that occurred during April. 'Cease to flow' at the Oenpelli Highway was called by stakeholders on 23rd May 2010.

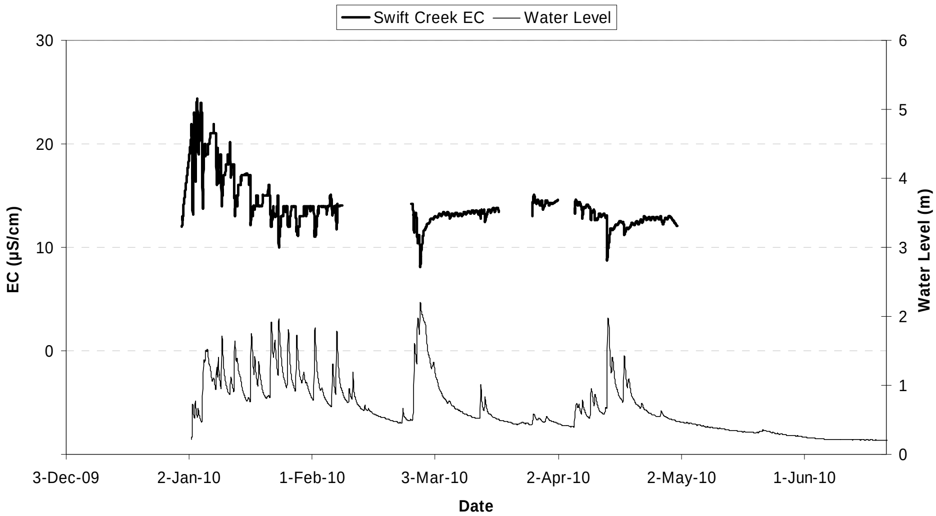


Figure 2.20 Electrical conductivity measurements in Ngarradj between December 2009 and June 2010 – continuous monitoring data

2.4 Nabarlek

2.4.1 Developments

In early 2008, Uranium Equities Limited (UEL) bought Queensland Mines Pty Ltd, thereby acquiring the Nabarlek lease, and has since developed plans to further explore the lease, clean up the site and continue revegetation and rehabilitation works. Authorisation 0435-01 was granted to UEL on the 28 May 2008 allowing exploration and rehabilitation works at Nabarlek to proceed. A revised Mining Management Plan (MMP), including revised rehabilitation bond calculations, was submitted to the Supervising Authority for approval in July 2009. The revised MMP was approved by DoR in September 2009 with $1.8 million currently held as security bond for the site. A MMP for the 2010–11 operating year was submitted to DoR on 15 June 2010 and is awaiting approval.

2.4.1.1 Minesite Technical Committee

The Nabarlek MTC has met once during the reporting period. The following items were discussed at a meeting held on 26 November 2009:

- Closure criteria
- Recalculation of the security bond
- Solute concentrations in groundwater
- Asbestos removal

2.4.1.2 Authorisations and approvals

There was no change to the Authorisation during 2009–10.

2.4.1.3 Incidents

There were no incidents reported at Nabarlek during 2009–10.

2.4.2 On-site conditions

The site is subject to at least two formal visits from ***oss*** staff during the year. In addition, ***oss*** may carry out opportunistic site inspections if in the area on other business (eg exploration inspections).

The formal site inspections carried out at Nabarlek each year are:

- Post-wet season inspection – the intent of this inspection is to check site stability and erosion following the wet season and to plan works for the coming dry season;
- Annual audit (pre-wet season) of compliance with the Nabarlek Mining Management Plan.

2.4.2.1 Audit outcomes

The 2009 audit was held on 3 November 2009 and tested compliance with 237 commitments taken from the 2009 Nabarlek Mining Management Plan as submitted by UEL. Of the 237 commitments, 152 were graded Acceptable, 11 Conditional, and 42 were Not verified, with 32 Observations being made. The audit team were generally satisfied that UEL were making appropriate progress toward achieving the commitments stated in the MMP. A large portion of audit commitments remained not verified due to delays in the proposed drilling program.

2.4.2.2 Post-wet season inspection

Stakeholders inspected Nabarlek on 22 June 2010 with site operators UEL and representatives from DoR. UEL is currently in the process of scoping the works required to complete clean up and disposal of the asbestos throughout this area. It is proposed that a pit will be dug on site for disposal of the camp infrastructure. The concrete pads and roadway will be left in place at this time. UEL has obtained approval for on-site asbestos disposal from NT NRETAS

Two new revegetation plots were planted in February 2009. The 1450 seedlings comprised mainly *Corymbia* sp, *Eucalyptus miniata* and *E. tetradonta*. A further 2500 tubestock were planted during the 2009–10 wet season, however, lack of immediate rain following planting may have an impact on survival rates. Stakeholders observed significant growth in 2008–09 wet season planting and reasonable success of 2009–10 wet season planting.

The former waste rock runoff pond was re-contoured in 2008. Minimal erosion was noted on the western edge of the recontoured area only minor works would be required to restabilise this area. UEL advised that it is planning to plant 10 000 tubestock in this area in the upcoming wet season.

2.4.2.3 Radiologically anomalous area (RAA)

The area of the RAA is approximately 0.4 ha and is located immediately south-west of the former pit area. The RAA exhibits elevated levels of radioactivity and has been identified to contribute about one-quarter of the total radon flux from the rehabilitated minesite and three-quarters of the radionuclide flux from the site via the erosion pathway (more detail is provided in Supervising Scientist Annual Report 2004–05).

The issue remains a standing item on the Nabarlek MTC agenda. UEL has conducted a detailed gamma survey of the area and is currently evaluating remediation strategies for the RAA which will be put to the MTC for approval once finalised. UEL plans to characterise the RAA during the 2010 dry season with a further view to disposing of the material with higher radiological signature in a disposal pit on site during a subsequent dry season.

2.4.3 Off-site environmental protection

Statutory monitoring of the site is the responsibility of DoR and the operator, UEL. DoR carries out surface and groundwater monitoring on and off site, including surface water monitoring downstream of the mine in Kadjirrikamarnda and Cooper Creeks, and reports the results of this monitoring in the six-monthly Northern Territory Supervising Authorities Environmental Surveillance Monitoring in the Alligator Rivers Region reports.

2.5 Other activities in the Alligator Rivers Region

2.5.1 Rehabilitation of the South Alligator Valley uranium mines

Background on the remediation of historic uranium mining sites in the South Alligator Valley has been provided in the 2008–09 Supervising Scientist’s Annual Report.

Construction of a new containment facility at the location of the old El Sherana airstrip for the final disposal of historic uranium mining waste was completed over the 2009 dry season by Parks Australia. Material was recovered from the following sites for co-disposal in the new facility:

- South Alligator Village containment
- El Sherana Camp containment
- El Sherana Weighbridge containment
- Battery Bund containment
- Contaminated soil stored in containers at South Alligator Village

In addition to this, all material with readings in excess of 1.25 µSv/h (±20%) from the following locations was placed in the new containment facility:

- Rockhole uranium processing plant tailings residues
- El Sherana mine
- Palette stockpile area

oss staff inspected both the new containment and historic containment sites on 21 June 2010. Revegetation appears to be progressing well over the old containment areas. ***eriss*** will conduct a close out radiological survey of the old containment areas during July 2010 to ensure that all radiologically contaminated material has been removed.

At the new containment site erosion was noted in the capping material and further earth works will be required to stabilise the site prior to the onset of the 2010–11 wet season. ***oss*** staff will inspect the site again in the late 2010 dry season to ensure the site is appropriately prepared for the 2010–11 wet season.

2.5.2 Exploration

oss undertakes a program of site inspections at exploration sites in west Arnhem Land where Cameco Australia Pty Ltd (Cameco) and UEL are exploring for uranium. During the reporting period, this entailed inspections of Myra Falls and King River Camps and their respective exploration activities. The inspections were held on 7–8 September 2009, when the camps were operating and exploration was being actively undertaken.

There were no drill rigs operating within reasonable proximity to Myra Falls Camp to enable inspection during the site visit. Stakeholders inspected an operational heli rig close to the King River Camp. There were no significant issues identified with the drilling operations or the operations at either camp.

2.6 Radiological issues

2.6.1 Background

2.6.1.1 Applicable standards

The radiation dose limit for workers recommended by the International Commission on Radiological Protection (ICRP) and adopted in Australia by the National Health and Medical Research Council (NHMRC) is 100 millisieverts (mSv) in a five-year period with a maximum of 50 mSv in any one year. The radiation dose limit to the public from a practice such as uranium mining recommended by the ICRP is 1 mSv per year. This limit applies to the sum of all sources and exposure pathways. As outlined in the 'Code of Practice and Safety Guide on Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing' (2005), it is the operator's and employer's responsibility to 'ensure that the workplace and work procedures are designed, constructed, and operated so as to keep exposures to ionising radiation as low as reasonably achievable'.

The Code further recommends to separate radiation workers into designated and non-designated, where designated workers are those who may be expected to receive an occupational radiation dose exceeding 5 mSv in one year. These workers are monitored more intensely than the non-designated workers.

Consequently, there are three levels of radiation dose limits to distinguish, which specify the annual radiation dose limit from other-than-natural sources:

- the public (1 mSv)
- non-designated workers (5 mSv)
- designated workers (20 mSv per year over 5 years with a maximum of 50 mSv in any one year).

In addition, the ICRP (2006) recommends the use of dose constraints for the optimisation of radiation protection:

> The principle of optimisation is defined by the Commission as the source related process to keep the magnitude of individual doses, the number of people exposed, and the likelihood of potential exposure as low as reasonably achievable below the appropriate dose constraints, with economic and social factors being taken into account. According to the Commission’s revised recommendations, this process of optimisation below constraint should be applied whatever the exposure situation; ie planned, emergency, or existing. [3]

2.6.1.2 Monitoring and research programs

ERA conducts statutory and operational monitoring of external gamma exposure to employees (through the use of gamma dose badges), radon decay products and long lived alpha activity (dust) in the air, and surface contamination levels. The statutory aspects of the program are prescribed in Annex B of the Ranger Authorisation with results reported to MTC members on a quarterly basis.

The Supervising Scientist conducts routine monitoring of the atmospheric pathways of radiation dispersion from Ranger and a number of radiation research projects for human and environmental protection.

An application to optimise the Radiation and Atmospheric Monitoring Plan was submitted to the MTC in November 2008. A second and third version of the application were received in July and December of 2009. The revised application to optimise the radiation and atmospheric monitoring plan remains under consideration by the Supervising Authority at the point of reporting.

All ERA quarterly reports, due during the reporting period, were received and reviewed by the Supervising Scientist Division.

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[3] ICRP 2006 *Assessing dose of the representative person for the purpose of radiation protection of the public and the optimisation of radiological protection: broadening the process*. International Commission on Radiation Protection Publication 101, Elsevier Ltd.

2.6.2 Radiation at and from Ranger

2.6.2.1 Radiological exposure of employees

The three primary pathways of radiation exposure to workers at Ranger are:

- inhalation of radioactive dust
- exposure to external gamma radiation
- inhalation of radon decay products (RDP).

Table 2.8 shows the annual doses received by designated and non-designated workers in 2008, and a comparison with the average doses from the year before as reported by ERA. The average and maximum radiation doses received by designated workers in the 2009 calendar year were approximately 5.5% and 23% respectively of the recommended ICRP (2007) annual dose limits.[4]

TABLE 2.8 ANNUAL RADIATION DOSES RECEIVED BY WORKERS AT RANGER MINE

	Annual dose in 2008		Annual dose in 2009	
	Average mSv	Maximum mSv	Average mSv	Maximum mSv
Non-designated worker	Not calculated[1]	0.6	Not calculated	0.9
Designated worker	1.3	4.5	1.1	4.5

1 A hypothetical maximum radiation dose to non-designated employees is calculated using the gamma exposure results of employees of the Emergency Services Group, and dust and radon results measured at the Acid Plant. Consequently, the dose is conservative and would exceed actual doses received by non-designated employees, and are hence considered maximum doses.

Mine production and processing production workers received the majority of their radiation dose from external gamma, with average doses remaining unchanged from the previous year at 0.6 mSv and 0.8 mSv respectively. The dose to processing production workers from the inhalation of radioactivity trapped in or on dust fell from an average of 1.4 mSv last year to an average of 0.6 mSv this year. The majority of the radiation doses received by workers in the processing maintenance area and electricians was received from the inhalation of dust at 0.6 mSv and 0.3 mSv respectively. Radon decay product concentrations are highest for workers in the mine area but formed an average contribution of only 0.3 mSv to that work group during 2009.

2.6.2.2 Radiological exposure of the public

The ICRP (2007) recommends that the annual dose received by a member of the public from a practice such as uranium mining and milling should not exceed 1 millisievert (mSv) per year. This dose is on top of the radiation dose received naturally, which averages approximately 2 mSv per year in Australia, but which ranges from 1–10 mSv per year, depending on location.

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4 ICRP 2007. *The 2007 recommendations of the International Commission on Radiological Protection*. International Commission on Radiological Protection Publication 103, Elsevier Ltd.

The ICRP furthermore recommends a dose constraint to be selected below 1 mSv per year according to the situation to allow for exposures to multiple sources.

There are two main pathways of potential exposure to the public during the operational phase of a uranium mine and Ranger is the main potential source of additional (to natural levels) radiation exposure to the community in the Alligator Rivers Region. The two pathways are the inhalation pathway, which is a result of dispersion of radionuclides from the minesite into the air, and the ingestion pathway, which is caused by the uptake of radionuclides into bush foods from the Magela Creek system downstream of Ranger.

Inhalation pathway

Both ERA and SSD monitor the two airborne pathways:

- radioactivity trapped in or on dust (or long lived alpha activity, LLAA)
- radon decay products (RDP).

The main areas of habitation in the vicinity of Ranger and Jabiluka are Jabiru, Mudginberri and Jabiru East. Consequently, SSD monitoring focuses on those three population centres in the region (Map 3). Airborne RDP and LLAA concentrations are measured monthly and the results compared with ERA's atmospheric monitoring results from Jabiru and Jabiru East. Of the two airborne pathways, RDP accounts for most of the dose received by the public. In the 2009 annual radiation monitoring report, Ranger reported the average mine derived airborne RDP concentration at Jabiru as 0.029 $\mu J/m^3$, in addition to background, for the 941 hours in which the wind was blowing from the mine to Jabiru. This equates to a mine derived dose from RDP of 0.03 mSv in addition to the natural background dose of 0.6 mSv per year.

Figures 2.21 and 2.22 present radon decay product (RDP) and long lived alpha activity (LLAA) data measured at Jabiru and Jabiru East, and a comparison with ERA data from July 2004 up to March 2010. Both RDP and LLAA concentrations measured by SSD and ERA show the expected seasonal trend with higher values during the dry and lower values during the wet season. Higher RDP concentrations are expected in the dry season due to dry soil allowing greater permeation of radon into the atmosphere, and LLAA concentrations are higher due to the dustier conditions during the dry season.

In 2009, the dry season average RDP concentrations measured by ERA were 2–3 times higher than those measured by SSD during the same time period (July –September). It is possible that this was caused by differences in sampling time and duration. Increases in radon and RDP concentrations have been observed during times when inversions form and inhibit effective mixing of air masses near the earth's surface. Radon becomes 'trapped' in this lower layer of air and consequently radon concentrations increase. This increase in radon concentration is most marked in the dry season when combined with the enhanced radon emanation from the soil. ERA measurements in the dry season may have captured such inversion conditions which were missed by the SSD sampling schedule. The generally higher LLAA concentrations measured by ERA in Jabiru East are due to the different sampling locations (SSD Field Station and Airport car park, respectively).

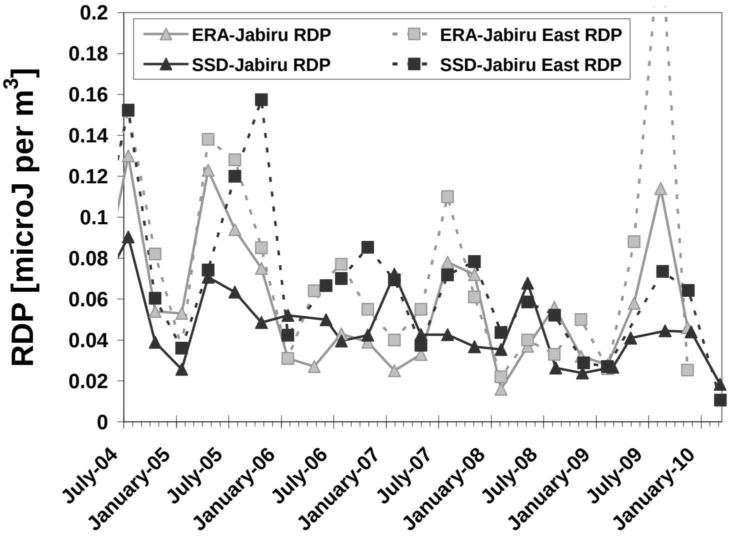

Figure 2.21 Radon decay product concentration measured by SSD and ERA in Jabiru and Jabiru East from January 2004 to March 2010

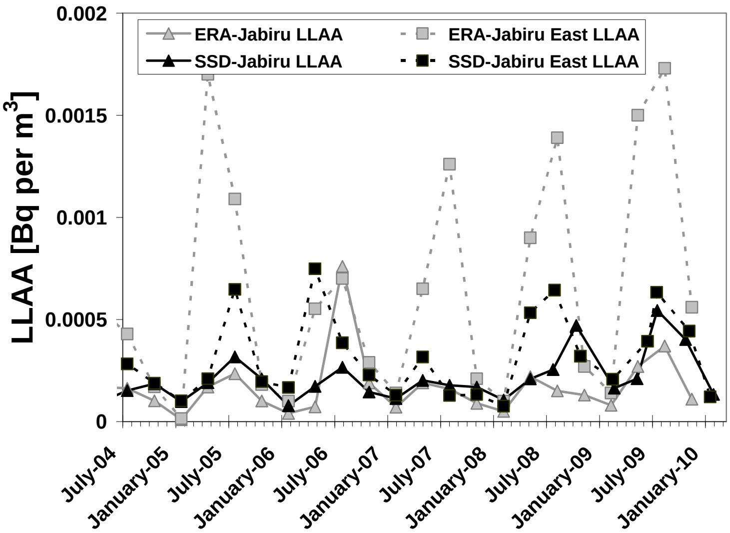

Figure 2.22 Long lived alpha activity concentration measured by SSD and ERA in Jabiru and Jabiru East from January 2004 to March 2010

Table 2.9 also shows the average annual doses received from the inhalation of radon decay products in the air, as calculated from the RDP concentration data from ERA and SSD (in brackets) at Jabiru. This is assuming an occupancy of 8760 h (one year) and a dose conversion factor for the public of 0.0011 mSv per μJ·h/m^3. Mine derived annual doses from the inhalation of radon progeny, as reported by ERA, are shown in this table as well.

TABLE 2.9 RADON DECAY PRODUCT CONCENTRATIONS AT JABIRU AND JABIRU EAST AND TOTAL AND MINE-DERIVED ANNUAL DOSES RECEIVED AT JABIRU 2006–09*

		2006	2007	2008	2009
RDP concentration [μJ/m³]	Jabiru East	0.071 (0.066)	0.059 (0.064)	0.033 (0.046)	0.100 (0.055)
	Jabiru	0.039 (0.046)	0.038 (0.049)	0.037 (0.038)	0.066 (0.039)
Total annual dose [mSv] Jabiru		0.38 (0.44)	0.37 (0.47)	0.36 (0.37)	0.64 (0.38)
Mine derived dose [mSv] at Jabiru		0.003	≈ 0	0.001	0.03**

* Numbers in brackets refer to SSD data

** Mine-derived dose calculated from the RDP concentration difference of 0.029 μJ/m³ that persisted for 941 hrs during 2009. Data provided in the ERA Radiation Protection and Atmospheric Monitoring Program Annual Report 31 December 2009

Ingestion pathway

Radium in Magela Creek waters is routinely monitored by both ERA and SSD and the limit for radium in Magela Creek is based on dietary uptake of the Aboriginal people downstream of the mine. Local Aboriginal people have expressed concern about the radionuclide concentration in mussels from Mudginberri Billabong. Consequently, SSD routinely monitors the aquatic aspects of the ingestion pathway and bioaccumulation monitoring samples have been collected each year and analysed for both radionuclides and heavy metals (see discussion above for details on the monitoring program for Ra in mussels). The collections include yearly collections of mussels at Mudginberri Billabong (the potentially contaminated site) and Sandy Billabong (control site in the Nourlangie catchment).

Routine monitoring results from 2000–2009 show that on average the ^{226}Ra activity concentration in mussel flesh from Mudginberri Billabong is higher than at Sandy Billabong and the committed effective dose from the ingestion of ^{226}Ra and ^{210}Pb in mussels from Mudginberri Billabong is about twice the committed effective dose from the ingestion of Sandy Billabong mussels (results for the 2009 collection are discussed in chapter 2, section 2.2.3). Historical data, however, show that there is no indication of an increase of ^{226}Ra (or uranium) activity concentrations in mussel flesh in Mudginberri Billabong over time and thus the difference is unlikely to be mine-related. Reasons for the higher ^{226}Ra activity concentrations measured include the mineralised nature of the Magela Creek catchment area and the associated naturally higher ^{226}Ra content in Mudginberri Billabong sediments and water, and the lower Ca and Mg concentration in water compared with Sandy Billabong. In addition, differences in mussel growth and health may affect radium uptake (see chapter 3, Supervising Scientist Annual Report 2007–08, for more detail).

With the rehabilitation of Ranger there will be radiological protection issues associated with the land use by local Aboriginal people and a shift towards terrestrial food sources. These foodstuffs include both terrestrial animals and plants. Over the last 25 years, SSD has gathered radiological concentration data on bush foods throughout the Alligator Rivers Region in the Northern Territory. New data, in particular for terrestrial food items, are acquired on an ongoing basis and are used to replace IAEA default radionuclide concentration factors with locally derived values. This provides a more reliable estimate of ingestion doses. In addition, local radionuclide concentration factors will be used to derive soil closure criteria for the rehabilitation of Ranger.

2.6.3 Jabiluka

2.6.3.1 Radiological exposure of employees

The Jabiluka Authorisation was revised in July 2003 and the statutory requirement of quarterly reporting of radiological monitoring data for Jabiluka was removed. The current Authorisation requires reporting of radiation monitoring data only if any ground disturbing activities involving radioactive mineralisation occur on site. No ground disturbing activities took place during this reporting period.

2.6.3.2 Radiological exposure of the public

Although there were no activities reported at the Jabiluka minesite, the population group that may, in theory, receive a radiation dose due to future activities at Jabiluka is a small community of around 60 individuals about 10 km south of Jabiluka at Mudginberri.

The Supervising Scientist has a permanent atmospheric research and monitoring station at Four Gates Rd radon station a few kilometres west of Mudginberri (see Map 3). RDP and LLAA concentrations are measured there on a monthly basis. In addition, radon gas is continuously measured at the station with radon data being recorded every 30 minutes.

Figure 2.23 shows the quarterly averages of RDP and LLAA concentrations measured at Four Gates Rd radon station by SSD up to March 2010.

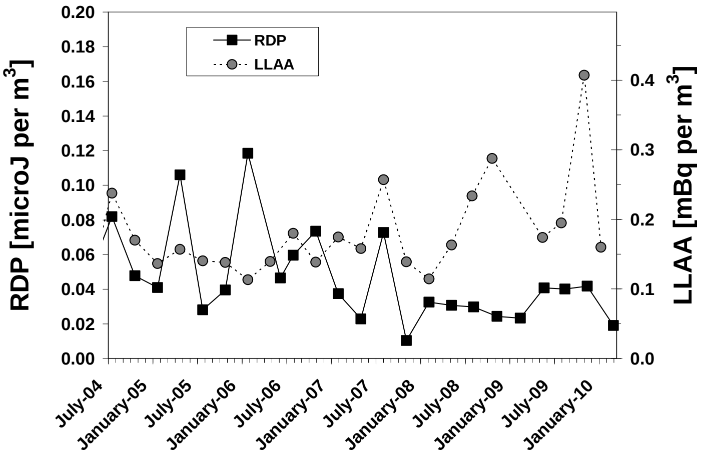

Figure 2.23 Radon decay product (RDP) and long lived alpha activity (LLAA) concentrations measured at SSD's Mudginberri Four Gates Rd radon station from July 2004 to March 2010

The average airborne radionuclide concentrations measured in 2009 would translate into an annual total effective dose, including natural background, of 0.35 mSv from RDP ~ 0.015 mSv from LLAA. Only a small fraction of these doses would be due to mine-derived radionuclides.

2.7 EPBC assessment advice

oss continues to provide advice to the Approvals and Wildlife Division (AWD) of DEWHA on referrals submitted in accordance with the EPBC Act for new and expanding uranium mines. ***oss*** provided coordinated responses from SSD on the Olympic Dam, Four Mile and Beverly uranium projects in South Australia and the Yeelirrie project in Western Australia during the reporting period.