

Alligator Rivers Region Technical Committee
Meeting 23, 18-20 March 2009
Meeting outcomes

Attendance

MEMBERS

Mr Ray Evans - Independent Scientific Member (Chair)
Dr Carl Grant - Independent Scientific Member
Prof Peter Johnston – Independent Scientific Member
Dr Simon Barry – Independent Scientific Member
Dr Terry Hillman - Independent Scientific Member
Dr Jenny Stauber - Independent Scientific Member
Prof Colin Woodroffe - Independent Scientific Member
Mr Alan Hughes – Supervising Scientist
Ms Sharon Paulka – Uranium Equities Limited
Mr Russell Ball - DRDPIFR
Mr Howard Smith - NLC

APOLOGIES

Dr Jenny Stauber - Independent Scientific Member (Wed only)
Ms Anne-Marie Delahunt – Parks Australia North
Dr Terry Hillman - Independent Scientific Member (Fri only)
Dr Tony Milnes – Energy Resources of Australia Ltd

PRESENTERS/OBSERVERS

Mr Gary Martin – DRDPIFR
Mr Geoff Kyle - Gundjei'mi Aboriginal Corporation
Mr Alan Puhlovich – EWL Sciences Pty Ltd
Dr Ping Lu – EWL Sciences Pty Ltd
Dr Riaz Akber - EWL Sciences Pty Ltd
Dr Mike Trefry - CSIRO Land & Water
Dr Wendy Timms - Water Research Laboratory - UNSW
Dr David Jones - Environmental Research Institute of the Supervising Scientist
Dr Andreas Bollhoefer - Environmental Research Institute of the Supervising Scientist
Dr Chris Humphrey - Environmental Research Institute of the Supervising Scientist
Dr Ken Evans - Environmental Research Institute of the Supervising Scientist
Dr Rick van Dam - Environmental Research Institute of the Supervising Scientist
Dr Renee Bartolo – Environmental Research Institute of the Supervising Scientist
Mr Bruce Ryan - Environmental Research Institute of the Supervising Scientist
Mr Mike Saynor - Environmental Research Institute of the Supervising Scientist
Ms Kate Turner - Environmental Research Institute of the Supervising Scientist
Ms Mel Houston – Environmental Research Institute of the Supervising Scientist
Mr Richard McAllister – Office of the Supervising Scientist
Mr Keith Tayler – Office of the Supervising Scientist
Ms Jenny Brazier – Office of the Supervising Scientist
Ms Ewa Madon - Office of the Supervising Scientist
Ms Michelle Bush - Office of the Supervising Scientist
Ms Chantal Whittaker - Office of the Supervising Scientist
Other *eriss* staff

SECRETARIAT

Mr Scott Parker – Office of the Supervising Scientist

Wednesday 18 March 2009

1 Preliminary Session

1.1 Welcome

Mr Evans opened the meeting and welcomed members and observers. Mr Evans welcomed Professor Colin Woodroffe as the new independent scientific member with expertise in geomorphology.

1.2 Apologies and Observers

Mr Evans noted apologies from Ms Delahunt, Dr Stauber (Wednesday only) and Dr Hillman (Friday only).

1.3 Correspondence

Mr Evans advised that he had written to Minister Garrett advising the outcomes from last meeting but had not received a reply. Mr Hughes confirmed that Minister Garrett had received and noted the letter. Mr Evans noted letter from Minister Garrett advising he has agreed to the Australian Conservation Foundation's request for the appointment of an environment NGO stakeholder member to ARRTC. Mr Evans also noted that the Minister has asked the Supervising Scientist to provide advice on the suitability of the ACF nominations and consult with the Chair of ARRTC as part of this process.

1.4 Conflict of Interest Declarations

Prof Johnston advised that he has recently been appointed to a position within the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) which produces guidance documents and regulations that impact on the environmental radiation aspects of the Supervising Scientist Division's operations. ARPANSA also provides advice to the Approval and Wildlife Division in DEWHA on referrals of nuclear actions (including uranium mining) under the EPBC Act and the Department of Resources, Energy and Tourism on nuclear matters. Prof Johnston advised he did not believe this should restrain him in his role as a member of ARRTC. Ms Paulka advised that as part of her work she regularly consults to industry on Environment Safety and Health matters and is currently consulting to ERA on such matters. Mr Evans advised that he has recently been employed by Sinclair Knight Mertz which is currently consulting to ERA (on site water management/water audits focusing on pumping of water) and to the NLC (on siting of remote water supplies). He advised he will maintain a watching brief and provide advice at each ARRTC meeting on any possible conflicts of interest should they arise.

2 ARRTC22 Outcomes

2.1 ARRTC22 - Summary Record

Mr Evans sought comments from members on the current format and length of the minutes and advised he thought the level of detail in the minutes was about right. Mr Puhlovich advised that ERA was happy with the quality of the minutes but would like them to come out earlier following each meeting. Mr Evans noted the significant time involved in producing the minutes to the current level of detail. Members agreed that it was important that sufficient time be allocated to preparation of the minutes and that six–eight weeks was probably more realistic than the current four week timeframe. Dr Grant advised he liked the fact that the minutes captured the detail of presentations and related discussion but he thought they could be more concise. Mr Evans suggested that the length of the minutes could be reduced by having presentations available on the ARRTC members' website. However, it was noted that "commercial-in-confidence" presentations from consultants engaged by mining companies may not be available to be displayed on the public website. It was also noted that reducing the length of the minutes by reducing the level of detail of information on presentations would remove the context for much of the recorded discussion. Dr Grant noted that having a detailed record of the discussion at each ARRTC meeting in the minutes was valuable for members and external stakeholders.

ARRTC23 Action/Outcome 2.1

ARRTC agreed that draft minutes are to be circulated 8 weeks after each ARRTC meeting.

ARRTC23 Action/Outcome 2.2

ARRTC agreed that presentations will be placed on the ARRTC members' website following each ARRTC meeting (with the agreement of presenters).

Mr Evans queried whether in some cases ARRTC decisions may not be being explicitly recorded as actions in the minutes. Prof Johnston suggested ARRTC members should be disciplined in requesting through the

Chair that critical decisions and/or information be recorded in the minutes, even though there may not be specific actions arising. Dr Hillman suggested that as much as possible individual discussions between ARRTC members and *eriss* staff should also be raised during ARRTC meetings and recorded in the minutes. Dr Jones agreed it is important that out-of-session discussion between ARRTC members and relevant staff be recorded. ARRTC agreed that the minutes should include details of out-of-session discussions between ARRTC members and *eriss* staff.

ARRTC23 Action/Outcome 2.3

ARRTC agreed that the minutes should include details of out-of-session discussions between ARRTC members and *eriss* staff.

ARRTC23 Action/Outcome 2.4

ARRTC agreed the Secretariat will revise draft minutes from ARRTC22 and circulate out of session for approval.

2.2 ARRTC22 - Business Arising

Mr Evans reviewed the status of actions arising from ARRTC22. In relation to ARRTC22 Action 2B, it was noted that ERA and UEL had agreed they would each restrict the type of information presented to future ARRTC meetings and absent themselves should the other party wish to present commercial-in-confidence information. Dr Jones asked what types of information would be affected and Ms Paulka suggested this would extend to any information that isn't already known to shareholders. Mr Smith advised he would address his outstanding action from ARRTC21 regarding the value and use of Traditional Knowledge as part of his report later in the meeting.

ARRTC23 Action/Outcome 2.5

ARRTC noted that ERA and UEL had agreed they would each restrict the type of information presented to future ARRTC meetings and absent themselves should the other party wish to present commercial-in-confidence information.

2.2.1 Environment NGO representation

Mr Evans noted that the matter of environment NGO representation on ARRTC was still under consideration by the Minister. Mr Kyle advised he understood the matter was the subject of ongoing discussion between the ACF and the Minister's office. Members noted that Mr Evans would represent ARRTC's views regarding environmental NGO representation on ARRTC. Mr Hughes noted that ARRTC member's views would be taken into account but the final decision on the appointment rests with the Minister.

2.2.2 ARRTC Confidentiality requirements

ARRTC discussed the wording of the proposed ARRTC Terms of Appointment. Mr Smith queried how the proposed confidentiality requirements would affect the transfer of confidential information between employees of stakeholder organisations, particularly in the event where a staff member moves on from a position within an organisation and a new staff member needs to access the file. Prof Woodroffe suggested the meaning of "confidential information" should be clearly defined. Mr Parker advised that "confidential information" in this context means any information the owner has identified as being confidential for commercial or any other reasons. Mr Parker advised this would include information provided to ARRTC members for the purposes of ARRTC business that the owner has requested not be used for any other purpose. Mr Puhlovich agreed that any information, including data, provided to ARRTC members for a particular purpose should only be used by members for that purpose. ARRTC agreed to review the wording of paragraph 6 of the draft Terms of Engagement. Mr Ball advised he was unsure how this would fit with his obligations as a NT public servant and will need to seek advice from his Department. Mr Evans advised he highly values the candid and unfettered exchange of information between ARRTC members but acknowledged ARRTC needs to comply with relevant government governance requirements as required.

ARRTC23 Action/Outcome 2.6

ARRTC agreed to consider the draft Terms of Engagement for members, including the wording of paragraph 6, and advise the Secretariat on their suitability out-of-session.

3 Gap Analysis - *eriss*/ERA research against Key Knowledge Needs

Mr Evans noted the KKN gap analysis table doesn't yet include *eriss* proposed research projects for 2009-10. Dr Jones advised the projects hadn't been included as they are still to be considered by ARRTC. Mr Evans advised the purpose of the KKN gap analysis is to identify any misalignment between the current

research effort and the KKNs, and whether existing resources are adequate. He noted ARRTC would advise the Minister on the results of the gap analysis and provide recommendations where necessary.

Dr Grant noted that ARRTC has previously struggled with determining the format and types of information that should be considered in assessing gaps including under resourcing. He suggested that the issue of timing of research against the mining timeframe should also be considered (i.e. timing from a prioritisation perspective – eg. projects that are a high priority have been pushed out due to the change in the mining timeline). Dr Grant commented that every time ARRTC looks at this there is a need to assess what has changed since last time. Prof Johnston suggested ARRTC consider this agenda item after the presentations from *eriss* and ERA on proposed research for 2009-10 so that the current situation and priorities can be better understood. Dr Grant queried whether ARRTC had undertaken a proper gap analysis of the KKNs to date. Dr Jones noted that ARRTC had previously considered the research review by Johnston & Milnes published in 2007, and that this work was also considered as part of the KKN prioritisation by Mr Hughes and Dr Jones in 2008.

Mr Evans requested the gap analysis table be updated with the priorities as soon as possible so it could be considered at this meeting. Mr Parker advised he would update the table overnight. Mr Hughes noted that the KKN prioritisation had used a ranking of High, Moderate and Low and Dr Jones suggested this was probably simplistic and that there are other dimensions to the prioritisation. Dr Hillman advised he wasn't clear who should be undertaking this work. He noted the prior prioritisation (Hughes & Jones 2008) was a reasonable review but stressed the importance of ARRTC also reviewing the level of effort being applied to addressing the KKNs. Dr Hillman suggested that additional columns be added to the KKN table covering priority, comment on how effective current research addresses each KNN and whether sufficient resourcing is being applied. Mr Evans noted that the current research model is based on researchers developing projects that fit the existing KKN structure and queried whether ARRTC should also identify additional KKNs.

ARRTC23 Action/Outcome 3.1

ARRTC agreed that additional columns be added to the KKN gap analysis table with the headings Priority, Urgency, Timeline and Resources.

Dr Grant suggested the key issues for consideration are the alignment between the assessed priority and the level of resources being applied for each KKN. Mr Puhlovich suggested ARRTC should focus on what isn't being done (ie. the KKNs that have no projects under them). Mr Evans reminded members the purpose of the gap analysis is to determine what research is being done and whether this is appropriate and adequate. ARRTC agreed to address the KKN gap analysis on the last day of the meeting.

ARRTC23 Action/Outcome 3.2

ARRTC agreed to address the KKN gap analysis on the last day of the meeting.

4. Activity Updates

4.1 Uranium Equities Ltd (Nabarlek) – Ms Sharon Paulka

Ms Paulka provided the update for Uranium Equities Ltd (UEL). She noted UEL has undergone significant downsizing and consolidation since the last meeting. Although UEL's operations and staffing at Nabarlek had been reduced, exploration and site management works were still progressing. Ms Paulka summarised the Nabarlek drilling program during 2008. Mr Evans asked if drill holes were being cased and plugged and Ms Paulka advised that drill holes were being partially cased. Ms Paulka advised that generally the uncased drill holes only remain open for a short period of time before collapsing. About 40 RC holes and 240 AC holes were planned to be drilled during 2009. Mr Evans asked if any geophysics were going to be undertaken and Ms Paulka indicated that some geophysics work was planned. Mr Evans asked if DRDPFR still monitored the drill holes and Mr Ball advised that this had not happened recently, although previously annual sampling had been undertaken and samples submitted for radionuclide analysis.

Mr Evans asked if near surface data sets were being collected such as soil activity assessments. Ms Paulka advised that a gamma dose rate survey of the plant runoff pond had been carried out using a 5m–10m grid which had detected a number of hot spots near visible waste rock. She noted this raised potential concerns about issues associated with old waste rock. Soil samples were being collected and the results correlated to ²²⁶Ra. Mr Evans asked to what depth the gamma survey penetrated and Ms Paulka advised up to one metre. Prof Johnston asked if UEL was mapping using just gamma measurements and Ms Paulka confirmed this is the case. Mr Hughes noted that based on ground survey measurements by *eriss*, the only spot with significantly elevated activity was the radioactive anomalous area near the former entry to the open pit.

Ms Paulka advised that weed management transects have been established over the entire site and a number of maps have been produced. She noted that there are significant areas of weeds inside the fenced area. Guinea Grass is mainly concentrated around ponds, Mission Grass is spread all over and also outside the site, and Para Grass is more focused on the wetter areas. There is such a dense coverage of weeds that there is up to a six inch thick layer of seeds in some locations. She noted there is no Gamba Grass on the site. Ms Paulka advised that weed management continues to be a challenge due to the roads through areas of weeds required for exploration. She advised the dry season weed management plan would include planning track installation, washing and inspections. Wet season activities are aimed at preventing the weed bank increasing by using burning followed by spraying of re-sprouting survivors for best effect. She noted that wet season burns were currently 40% completed and should be finalised by early May. Spraying of priority weeds inside the fence was about 60% completed and spot/boomless spraying was being done outside the fence and along roads. Ms Paulka advised that UEL had spent about \$300K on weed management from January to April 2009.

Ms Paulka advised that revegetation was a lower priority relative to weed control at the moment given that the weeds need to be controlled before revegetation could be seriously considered. She noted that planting areas had been prepared using burning and spraying and about 1500 seedlings had been planted, mainly in the western end of the evaporation ponds. Ms Paulka advised that wet season water monitoring had been conducted and results were expected by May 2009, and would be reported in the MMP. Ms Paulka advised the key activities for the forthcoming dry season included updating and submitting the MMP which would include a report on last years activities, weed management and rehabilitation planning, and an early burn of the whole site. Ms Paulka advised that NLC had found a significant number of heritage paintings on site and UEL was waiting for an archaeologist's report. Other tasks included development of a risk management plan and permitting for asbestos removal, characterisation of the Radiological Anomalous Area using trenches to determine depth and volume of affected material and submittal of an associated rehabilitation plan. She noted the plant run off pond would also be re-contoured depending on availability of funding.

Prof Johnston asked if the proposed disposal trench was going to be appropriate and Ms Paulka advised that UEL planned to profile depth and characterise the contamination. Prof Johnston asked if this would be near surface disposal and Ms Paulka advised that UEL planned to dig trenches using small back hoe to get estimated volume and would obtain an engineer's report for disposal. Dr Bollhoefer advised that SSD has undertaken grid surveys across the site and has a reasonable knowledge of where the radiologically anomalous areas are located. Ms Paulka noted this and advised UEL would take this into account.

Mr Evans asked if there is any other information that may assist UEL in addressing these issues. Dr Grant noted that this had been discussed at last meeting and that UEL already has access to a range of historical data and information in relation to the site. He also noted that the issues currently being addressed by UEL are no different to the situation five years ago and expressed concern about whether a strategic approach is being taken. Mr Ball noted that UEL may not have access to all of the information obtained by the previous owner of the lease as some of it is commercial-in-confidence. Dr Jones noted further that some of the information held by SSD is not current (ie. data from previous vegetation surveys will not show current weed distribution may have limited value in terms of assisting planning for rehabilitation of the site). Dr Grant advised that it is well documented in the rehabilitation ecology literature that just focusing on weeds can result in the ongoing situation where one weed is controlled but then another presents a problem. He advised he couldn't see a strategic approach in this case and suggested there is potential to spend a lot of money for little return.

Dr Barry asked what the final rehabilitation target is for weeds if eradication is not realistic. Dr Jones suggested that one option may be suppression of weeds by progressive establishment of framework vegetation. Dr Grant noted this point was also made at last meeting and while UEL is going into a phase of weed mapping and eradication, he didn't believe there is a clear plan yet on what is to be done to effectively revegetate the site. He suggested the current state of revegetation at Nabarlek highlights how important effective weed management is at the inception of rehabilitation of a minesite.

Dr Jones advised that SSD doesn't have any current research projects on Nabarlek given that it completed the vegetation status assessment requested by ARRTC several years ago, and is now awaiting a regulator approved rehabilitation plan to be implemented for the site. Mr Ball noted there has been multiple ownership of the site over time and UEL is having to address this legacy. Ms Paulka advised that UEL hasn't actually developed its plans as yet, noting that significant work has been carried out to date including review of the available literature and ongoing work as part of a PhD. She noted that work will continue to inform the development of the rehabilitation plan for approval by the regulator.

4.2 Department of Regional Development, Primary Industry, Fisheries & Resources

Mr Martin provided a presentation on behalf of DRPIFR. The key points included:

Exploration - All exploration (not just U) applications so far this year are down on last year and the number of granted licences has also decreased. There has been a slight increase in moratoriums from 39 to 41, and also in ALRA moratoriums. There were 62 applications for uranium exploration in the reporting period which was the same as last year, and no change in the number of operating mines. Uranium exploration licences in the ARR were currently spread over three companies.

Reviews and approvals - There were no operational approvals during the period. The Mining Technical Committee (MTC) considered four reports for Ranger covering the salt efflorescences observed adjacent to the western wall of the tailings dam, the review of performance of the RP1 wetland filter, the review of the Ranger Environment Report, the review of the annual plan of rehabilitation #34 – security. Two reports for Jabiluka had been considered covering the annual interpretative report and the review of the annual plan of rehabilitation #11. The MTC had not considered any reports or approvals for Nabarlek.

Mr Kyle advised he thought that MTC had discussed and signed off on the report on the efflorescences. Mr Evans noted that ERA had suggested that the formation of salts was due to runoff from the Tailings Storage Facility (TSF) dam walls and that TOs were not happy that the *eriss* investigation was not undertaken until a number of months after this. Mr Kyle advised that in his opinion more work needs to be done but he thought the MTC had signed off the issue, with both ERA's report and SSD's independent assessment suggesting a waste rock leachate source rather than a process water source. Mr Martin advised he also thought the MTC had signed off on this but the outcome was that ERA would do further work. Mr Evans asked if ERA has ongoing studies underway into the source of the salts and Mr Puhlovich advised that this was the case. Mr Smith indicated he thought Mr Kyle was referring to a report on sulphur isotope ratios and the results from this work suggested that there is high probability that the water producing the salts had seeped from the lower reaches of the dam wall which in turn tended to support the suggestion that there is a process water signature in the water. Dr Jones commented that SSD was not aware of any recent measurements of S isotope ratios that would support this assertion. He further noted that whilst historically there was quite a large difference between isotope ratios for S in process water and S originating from waste rock leachate (pond water), this difference had been greatly reduced following the import of elemental sulfur from other sources over the past 10 years. He further suggested that it would be worth determining contemporary S isotope ratios in the context of the shift to direct import of sulfuric acid and the baseline data this could provide for future tracking of proposed sources of seepage water. Mr Evans noted this was essentially a matter for the MTC to address. Mr Puhlovich agreed that further discussion on this matter should be pursued through the MTC.

Mr Evans advised the reason he had raised the matter was that he understood that 1's rocks had been used for the tailings dam wall lift and therefore may be representative of the composition of leachate to be expected from the final landform. Mr Puhlovich suggested there are better sources of information on this and urged caution when interpreting what this may mean in terms of the final landform. Mr Kyle suggested this information is in fact very relevant to ARRTC's purview and noted some of the studies that informed MTC discussion on this issue suggest that the signature of pond water and waste rock seepage are converging.

Mr Evans asked if ARRTC needed to examine the background information used by MTC in its deliberations regarding this matter. Mr Smith advised that he would have no problems with documenting a paper he prepared on the issue. Mr Evans advised he had no issue with ARRTC exploring the basis for the MTC decision as long as this falls within ARRTC responsibility, and noted ARRTC previously did this in relation to solutes leaching from waste rock stockpiled at Jabiluka. He suggested the key need is to understand seepage in the context of understanding the likely behaviour of the final landform behaviour. Mr Evans noted the data show that the TSF rock is leaching at a different rate to other rocks. Mr Puhlovich advised that ERA has historical data that show freshly exposed rock initially produces higher solute loadings in first few years which tapered off over time. Mr Evans asked if the event data from the TSF dam wall lift fit with what is observed in relation to fresh rock in the stock piles. Mr Puhlovich confirmed this is the case and ERA will be collecting more data on run off from the TSF wall.

Mr Evans mentioned that ARRTC previously received copies of the environmental reports and asked if members wanted to see these again, noting that some of this information may not be publicly available. Prof Johnston advised he would like to see a copy of the reports dealing with environment and radiation. Dr Hillman asked if the reports contain information that would inform ARRTC's KKN gap analysis. Mr

Puhlovich advised that much of this information is not public but that ERA would provide to ARRTC members if requested.

ARRTC23 Action/Outcome 4.1

ARRTC agreed that Mr Puhlovich would provide PDF copies of the Ranger environment and radiation report to Professor Johnston and the Ranger wet season report to Mr Evans.

4.3 Northern Land Council (NLC)

Mr Smith provided the NLC activity report and outlined the key findings from his peer reviewed study into the application of Traditional Knowledge to all levels of environmental impact assessment conducted in 2008. The principal conclusion from the study was that Aboriginal people see the environment differently to European people and their views and knowledge are valid and valuable, and should be taken into account. Mr Smith advised he had been invited to present a keynote paper to the 2009 Mine Closure seminar in September in Perth and to the UWA Centre for Land Rehabilitation. He advised the NLC is continuing to undertake ongoing consultations with TO stakeholders on various proposals as required under section 4 of ALRA, and that consultations in relation to the ERA heap leach proposal will include non-Mirrar stakeholders.

Dr Jones asked what role Traditional Knowledge could play in relation to the issue of baseline assessment in environmental impact assessment. Mr Smith advised that while it is well known that Traditional Knowledge extends back 60,000 yrs and that TOs are generally able to access living memory (past 30 yrs) and other information is available in the literature from when the Ranger project was originally assessed. Mr Kyle noted that there are a number of projects underway in Arnhemland at the moment focusing on the preservation of Traditional Knowledge that involve gathering as many Aboriginal elders as possible and walking around country recording information on sacred and culturally important sites and bush tucker. Dr Jones advised he is interested in Traditional Knowledge in relation to changes in the climate in the NT, in the context of current investigations into the possible effects of climate change on KNP. Mr Kyle noted that many Aboriginal elders have a vivid memory of recent environmental changes, for example in relation to changes in mangroves. Mr Evans noted this but asked how Traditional Knowledge fits within ARRTC's remit. Mr Puhlovich suggested that ARRTC could look at some of the points raised in Mr Smith's paper and see how they relate to KKNs and whether this might translate into future research (eg. visual amenity may not be specifically covered in KKNs but may be very important to the TOs and hence to progressing discussions on closure objectives). Mr Evans noted there is a clear connection with the development of closure criteria but he is unsure how ARRTC should deal with these issues.

Mr Smith advised he believed Traditional Knowledge is a knowledge gap which will have potential application to some things but not all things, but wasn't sure if this should be covered under a single KKN or under the existing KKNs. He suggested that ARRTC could address under a separate KKN initially. Dr Jones suggested that Traditional Knowledge could be addressed under the preamble in the KKN document. Dr Hillman advised he wasn't comfortable with creating a new KKN to address Traditional Knowledge as it appears to be a cross cutting issue/reference point and should be applied to all KKNs.

Prof Woodroffe suggested that ARRTC should ideally take account of all relevant knowledge, including Traditional Knowledge where possible, but noted while scientific knowledge is subject to standard processes of peer review, he was unclear of how Traditional Knowledge was reviewed. Mr Smith advised that the process for determining what Traditional Knowledge is valid and/or appropriate is not up to non-Aboriginal people as they are outside the culture. He advised that information is generally filtered through cultural processes within Aboriginal societies which is a different form of peer review to the classical process of scientific review. Mr Smith advised that cultural information is held in a GIS system so is accessible, but the key issue is the level of information that Aboriginal people are prepared to provide non-aboriginal people, including information they can't divulge according to Traditional laws. He acknowledged that accessing this information can therefore be difficult and the real need is to build a cultural landscape. Mr Smith noted that while Traditional Knowledge is peer reviewed within Aboriginal societies, intellectual property was an ongoing issue that needs to be addressed.

Mr Kyle noted the origins of this discussion about application of traditional knowledge stems from experience in New Zealand with mechanisms for equating Traditional Knowledge to scientific knowledge. Mr Smith noted this needs to be taken further to build a shared understanding for the development of closure criteria. He noted this is not about developing an alternate branch of science but rather enabling scientists to better understand what Aboriginal people know about and how they see the environment.

Dr Barry asked if this knowledge could be mapped into the existing KKNs. Mr Evans suggested the first question is whether this is a knowledge gap. Dr Barry suggested that if this information exists and it is geo-

referenced, the question is how do we use and which KKNs are relevant. Dr Hillman indicated he was trying to understand this issue in terms of analogues - ie. how much of this knowledge is analogous to data (eg types and quantities of food eaten) versus a conceptual view of the world and how this relates to closure. Mr Smith advised that there are statistical data on different types of species (eg. where they grow and what they are used for ie. food stuffs). He suggested in a way this addresses the basic issue of "use" of the environment, and that, in conceptual terms, much of the information is related to how Aboriginal people see the environment and the strong linkages between country and culture. Mr Smith suggested the next steps were to define the cultural landscape then address the development of cultural closure criteria. He noted that information exists on the pre-mining environment so it should be relatively straightforward to develop criteria based on how aboriginal people used the site pre mining.

Mr Puhlovich suggested that ARRTC members read Mr Smith's report to get a better understanding of the concepts. Dr Hillman suggested this appears to be a knowledge gap. Dr Jones noted that SSD is integrating Traditional Knowledge in relation to its bush tucker work. Mr Puhlovich advised another good example was what happened on the Tiwi Islands where Traditional Knowledge was collected on the location and flow regimes of springs which was then factored into water management planning. Dr Stauber suggested that ARRTC could request ERA and SSD to take account of Traditional Knowledge where relevant. Dr Hillman noted this is already happening.

Mr Hughes asked Mr Smith if there has been an official public statement about what is happening at Koongara. Mr Smith advised that a statutory meeting had been held on 26 February 2009 and as a result it was expected the tenement will be sent for moratorium for at least 5 years.

ARRTC acknowledged the importance of traditional Aboriginal knowledge, noted it is being taken into account in current research by ERA and *eriss*, and supported the incorporation of this knowledge into closure criteria.

ARRTC23 Action/Outcome 4.2

ARRTC acknowledged the importance of traditional Aboriginal knowledge and noted that this is being taken into account in current research by ERA and eriss, and supported incorporation of this knowledge into closure criteria. ARRTC would be happy to be advised by NLC on how this could be further explored within ARRTC's agenda.

4.4 Supervising Scientist Report (including Monitoring)

Mr Hughes provided the Supervising Scientist report and presented details of SSD continuous monitoring. He noted that continuous monitoring is the way of the future in terms of understanding sites and impacts. He noted that electrical conductivity (EC) is a critical parameter together with flow in Magela Creek and discharge volumes from the site, and, in general, the lower the flow in Magela Creek the higher the EC. Mr Hughes advised that when Retention Pond No1 (RP1) starts to flow into Magela Creek, the effect on EC is very noticeable. If Magela creek is running high, there is a backflow damming effect on Coonjimba Billabong. When the water level in Magela Creek subsequently falls, the higher EC water held back in Coonjimba Billabong flows out, resulting in higher downstream EC. Mr Hughes further noted that the peak EC in RP1 has been rising over the past few years but the reason for this is not well understood. Further work is required onsite to understand the sources of solute loads into RP1, especially given the rapidly increasing volumes of waste rock being stored in its catchment.

Mr Evans asked where RP1 fits into Ranger water management given it is outside the process stream and the EC at the end of the last dry season exceeded 1000 $\mu\text{S}/\text{cm}$. Mr Hughes advised that early on in the 08/09 wet season ERA commenced siphoning RP1 water into Coonjimba Billabong to clear salts from the system. Prof Johnston asked why there was a peak in EC in the middle of the dry season. Mr Hughes noted the peak actually occurred at the end of dry season, with RP1 typically not starting to discharge until January. Thus there is evapo-concentration during the dry, followed by a period of dilution in the first few weeks of the wet season as the pond fills up prior to overflowing the control spillway.

Mr Hughes noted that despite the observed pulses in EC, the actual Mg load measured at SSD's downstream station in Magela Creek had not changed much (for the same period) compared to previous years. Dr Hillman asked how Mg loads are calculated and Ms Brazier advised this was done by converting continuous EC to equivalent continuous Mg, using a measured regression between Mg and EC. This regression was produced by the weekly grab sample data collected over the past years. Dr Hillman asked if SSD was using the regression relationship to characterise peak EC events. Dr Barry advised that if the regression contains data including data pairs representing the upper end of the measured EC range then this approach should be fine. Dr Jones advised that a previous issue was that the regression fit was dominated

by mainly low to mid-range values with few high EC data points. However, this has been addressed over the past year by targeting high EC events with an event-triggered autosampler. Thus many higher EC samples have now been obtained and there is much greater confidence in the use of the regression line to predict Mg at times of elevated EC.

Mr Hughes showed the results of U analysis of grab samples compared to EC and noted considerable scatter in the data – compared with the very well defined linear correlation between Mg and EC. He advised this is to be expected given the chemically non-conservative behaviour of U and highlights the need to be careful in interpreting the results. SSD is currently determining if there may be a more robust correlation at higher EC values by assessing the data from the higher EC samples referred to above.

Mr Kyle asked if Mr Hughes was saying that continuous in-situ probe data might be able to be used in a compliance context. Mr Hughes advised his point is that continuous monitoring currently assists in determining causes for peaks in the data, and there is still significantly more work to be done before a compliance framework involving the use of continuous data could be put in place. Prof Johnston noted that, given the relatively small magnitude of the peaks in the record, this is probably more of academic interest. Dr Jones noted that work in developing pulse and chronic insitu toxicity limits means there is value in having the higher resolution in data collection to provide the basis for interpreting the significance of the pulse exposure testwork, and especially noting that the EC values in RP1 have been steadily rising through time. Mr Hughes noted that these are ongoing research issues.

Mr Hughes presented *eriss* data from Magela Creek showing EC and discharge to 17 March 2009. Dr Hillman noted the data appear highly variable. Mr Hughes advised the values are real and that *eriss* is still working on the ecotoxicological implications. Mr Hughes advised that SSD is no longer taking grab samples for water quality analysis upstream in Gulungul Creek but ERA still is. However, SSD is maintaining its continuous measurements of flow, EC and turbidity.

Mr Hughes further advised that over the years there has not been a significant change in behaviour of water quality parameters in Gulungul Creek, but this year some higher EC and U values are noticeable and probably due to impacts from the most recent lifts of the TSF wall. Mr Puhlovich advised that ERA is undertaking earthworks to slow the speed of runoff from the TSF dam wall therefore should have less of a pulse effect on EC and U in Gulungul Creek. He also advised that continuous monitoring equipment is being installed to track the composition of the wall runoff water. Mr Hughes noted the data do reflect the fact the catchment is smaller than Magela catchment and that therefore there may be a greater chance of seeing some kind of relationship between U and EC, but this needs to be further explored.

Mr Puhlovich noted it will be interesting to see where things go in relation to continuous monitoring versus grab sampling. Mr Hughes suggested that it is probably too early to start mandating anything in a regulatory sense. Dr Jones noted that ERA has also installed monitoring sondes at 009 in Magela Creek and Mr Puhlovich advised he would provide further information on this in his presentation on ERA monitoring work. Mr Evans noted proposed research projects dealing with continuous data collection and this will also be discussed later in the meeting.

4.5 Parks Australia North (South Alligator Valley)

Mr Balding provided a presentation on the status of the Gunlom Land Trust (GLT) Rehabilitation Project. Work on the rehabilitation of abandoned uranium mines and related sites within the South Alligator Valley has been ongoing for the past 10 years involving Parks Australia, traditional Aboriginal owners, NLC, SSD, ARPANSA and the NT Government. These sites include Guratba (Coronation Hill), El Sherana, Sleisbeck and the former Rockhole uranium processing site. In July 2006, the Australian Government allocated funding of \$7.33m to DNP to rehabilitate, over four years, the abandoned uranium mines and related sites in the GLT area of Kakadu. The first stage of the rehabilitation project – rehabilitation of non-radiological sites- has been completed, with only a small, ongoing monitoring component remaining. The second stage of rehabilitation work will provide a long-term engineered containment solution for uranium mill tailings residues exposed in the area of the former Rockhole uranium processing mill, a small quantity of low-level uranium mill residues that are temporarily stored in the south of Kakadu, low level radiological material from several other former sites and other wastes (mainly infrastructure such as drill cores and radiologically contaminated mining equipment that were placed in interim burial sites in the early 1990s). A detailed plan for the project was approved by the Kakadu National Park Board of Management in March 2009.

Mr Balding advised that some additional above background ($>1.3 \mu\text{G/h}$) radiological material was discovered last dry season at the former El Sherana mine site, and this will need to be moved to a new containment. A suitable site at the El Sherana airstrip has been selected based on a list of criteria developed by ARPANSA

for locating containments for radiological waste. The design of the containment has been completed by an external consultant and construction is scheduled to begin in June 2009. Mr Balding advised that the project is not expected to be deemed a controlled action under EPBC Act. He advised further work was required on identifying Aboriginal protected areas to ensure no sacred sites are impacted by the work. Prof Johnston asked why the project had been referred under the EPBC Act. Mr Balding advised the project had been deemed to be a nuclear action and therefore was required to be referred.

5 Science underpinning regulatory decisions (DRDPIFR)

The science underpinning regulatory decisions was covered as part of Mr Martin's presentation on regulatory approvals and decisions under agenda item 4.2.

6 Research Activities

6.1 Supervising Scientist Division

6.1.1 Status of 2008-09 *eriss* research program (Dr David Jones, *eriss*)

Dr Jones provided a presentation on the status of the *eriss* 2008-09 research program. Key points raised by Dr Jones included:

Monitoring -The 08-09 Jabiru wet season to date has produced significantly less rainfall than the same time last year (1130 mm versus 1330 mm compared with annual average of 1540 mm), with the most of rainfall distributed over the period rather than falling in small number of events. Dr Jones outlined the changes to the monitoring in the 2008-09 wet season compared with the 2007-08 wet season. The scope of these changes and the science underpinning them was presented and discussed at the ARRTC 22 meeting in October 2008 (see minutes of the meeting). In 2007-08, continuous monitoring was run at one upstream and two downstream stations, with grab sampling at one upstream (MCUS) and one downstream (009) locations. In 2009, only one downstream continuous monitoring station was run with weekly grab sampling being moved to this location. In situ biological toxicity testing replaced the former creekside biological monitoring program at both the upstream and downstream locations. These changes are described in the 07/08 SSD annual report, with more detail being given in the *eriss* 07/08 annual Research Summary. ERA also undertook weekly grab sampling for water quality at MCUS and 009 during the 08/09 wet season.

Dr Jones noted that the 2008-09 wet season was the first time that an uninterrupted continuous data record had been collected, and this was due to two sondes being deployed at each of the upstream and downstream locations. If system diagnostics detected a problem with any of the sensors on one sonde then the system would switch over to the second sonde. Dr Jones noted that data from the continuous monitoring is transmitted to Darwin via mobile phone link and provides the ability to monitor in real time. As indicated by Mr Hughes in his presentation, several pulses of elevated EC, and by inference Mg, had been detected by the continuous monitoring system.

Mr Puhlovich asked if there were any issues with the quality of the chemical analysis owing to samples needing to be transported to Darwin. Dr Jones advised that the *eriss* grab samples are filtered on collection so transport should not be an issue. However, the length of time that samples were held in the autosamplers prior to retrieval and filtering could be an issue for U, but not for Mg. He advised that SSD has a research project underway looking at the implications for dissolved U of length of time between collection and filtration. Mr Evans asked if SSD has obtained any comparative data from samples collected concurrently by grab and auto sampler methods. Dr Jones advised that this aspect is being specifically tested, but the results from the 08/09 wet season are yet to be assessed. Dr Barry asked if SSD calibrates the measuring equipment through a wet season. Dr Jones advised this may be required if the field measured QC data for EC, pH and turbidity started to significantly diverge from the results produced by independently regularly calibrated field meters.

Dr Jones advised that, following a request from ARRTC for a statistical analysis of grab sample location data for U, SSD had applied statistical analysis techniques to data from 2002 to 2008 which had shown that there is a statistical difference between the west and central channel locations at 009, with the west bank (009W) having a higher mean compared to the central location (009C). He noted comparison between the upstream west bank location and the downstream sites located in the west channel had shown no significant statistical difference. Mr Evans asked if this finding applied for Mg, U and SO₄. Dr Jones confirmed this and advised that generally the upstream and downstream west channel data match up very well. Dr Jones advised that the analysis of the historical data sets is complete and a report is currently being finalised. Dr Jones advised that based on the comparison of upstream and downstream (which is important due to possible mine influences), 009D2 was now established as the main *eriss* downstream monitoring site on the west bank of

the west channel (involving grab, continuous (two sondes), EC and turbidity triggered autosampler and biological in situ snails).

Mr Evans asked if this compromised the ability to determine loads of solutes given there is no continuous record from 009C. Dr Jones advised there has never been a continuous record from 009C and that information tabled at ARRTC22 on load analysis had shown that the downstream station close to the west bank (009D2) appeared to provide a good indication of mass balance and that further work was being done to better understand this. Mr Smith asked which site has higher U levels and Dr Jones advised that the west channel (009D2) has higher U values.

Dr Jones advised that the aquatic snails used for the in situ toxicity measurements are quite sensitive to U. He noted that seven in-situ snail tests had had been carried out this wet season and that so far these had shown no significant statistical difference between upstream and downstream results. Dr Jones provided an update on the cross section flow measurement work. He advised that SSD has acquired a new Doppler cross channel profiler instrument which is much quicker and safer than the previous manual method. The new tool measures the cross channel distribution of flow velocities and enables the apportionment of flows down the west and central channels. Dr Jones advised that results indicate that there appears to be a fairly consistent flow going down the west channel, between total flows of 30 to 80 cubic metres per second (cumecs) in Magela Creek. Dr Jones advised that the highest flow recorded thus far in the 08/09 wet season was 111 cumecs and that a reasonable number of cross channel profiles flows had been measured. He noted that high flows involve more turbulence which provides better mixing laterally.

Ecotoxicology - Dr Jones advised that pulse exposure is now a critical aspect of SSD research which is important for improving understanding of toxicity exposure guidelines, especially for assessing the significance of these events compared with guideline values based on chronic exposure results. He advised that work on Mg pulse exposure effects on *cladoceran*, *hydra* and *Lemna* had been assessed and further work was planned for three additional species. Mr Evans noted that the detection of pulses in the west channel downstream may be providing a biased impression of what is happening across the channel as a whole – in the context of incomplete lateral mixing. Dr Jones noted this is an important issue which relates to the effects of flows and mixing zones, and this is why work is being done to measure the distribution of flows across the creek, and also to measure cross channel EC profiles. Dr Humphrey advised that early Rhodamine dye studies had shown that flows tend to hug the western channel. Mr Evans noted that previous work had also shown fairly discrete packets of solutes that don't mix and just move down the west channel, even at reasonable high flows.

Dr Stauber asked if SSD was only using a single pulse exposure for the ecotox testwork, as distinct from a series of pulses. Dr van Dam confirmed this is the case. Dr Jones advised that the trace shows that pulses occur reasonably frequently and noted that if pulses keep happening at a reasonably high frequency then this may effectively equate to chronic exposure. He further noted that SSD does not have in situ toxicity data from any event that would constitute a significant acute pulse exposure – given that such an event has not occurred during the period that continuous monitoring has been in place.

Dr Jones advised that initial work had been done on the development of test methodologies for the effects of suspended sediments. He noted SSD is initially looking at suspended sediment in terms of physical effects such as clogging and shielding of light. He noted SSD staff are currently developing the most appropriate method for particle sizing and fractionation of the fine-grained weathered waste material from the mine site. This is complicated by the irregular shapes of the particles. The isolated fines fraction will be used for the laboratory testwork.

Dr Jones advised that work on the effect of Dissolved Organic Carbon (DOC) on metal toxicity was continuing using the international Swanee fulvic acid standard and that this work had been extended to assess how natural organic matter isolated from water in Sandy Billabong ameliorates U toxicity. Dr Hillman noted the ARRTC meeting papers did not provide an indication of how Dissolved Organic Matter (DOM) actually reduces toxicity. Dr Stauber advised that in simple terms DOM binds with metals and reduces their biological availability. Dr van Dam advised this effectively means that U travels through the gut of an organism but is not taken up. Dr Jones noted that some organisms can break down DOM. Dr Stauber acknowledged this and advised further work is being done on this issue. Dr van Dam suggested that respiratory transport of U across gill surfaces is probably more important than ingestion in the gut.

Dr Jones advised work is also being done looking at Al toxicity and Dr van Dam noted this is a metal of significance in terms of mining across northern Australia. Dr Jones advised this is not so much an issue for Ranger but is a general landscape issue on the Magela floodplain with the occurrence of horizons of acid

sulfate soils. Mr Evans noted this raises issues in terms of the potential solute load off the rehabilitated landform and asked if it is worth looking at EWLS data on solutes in terms of constituents in site runoff water versus what naturally occurs in the creek. Mr Puhlovich doubted there would be significant amounts of Al compared to Mg, SO₄ and U. Dr Jones advised SSD has looked at the components of runoff and Al did not appear to be significant given the process is strongly pH controlled, with the solubility of Al being at a minimum in the circumneutral pH range. Mr Puhlovich noted that in the landform, exposed laterite soils may produce fine suspended material containing Al as a component of the clay fraction, but the rehabilitation strategy is to cap these materials. He suggested the focus is more on ammonium ion, which is a component of the process water system, and which will be present at high concentrations in the tailings pore water. Dr Jones noted in this context that SSD staff are involved in the Working Group developing Terms of Reference and scope for the revision of the National Water Quality Guidelines, and that a revisiting of the guidelines for ammonia will be part of this.

Ranger Trial Landform - Dr Jones advised that SSD was continuing to work with ERA/EWLS on defining the scope and objectives of the long term plot trial to evaluate vegetation establishment and test management strategies. He advised a number of collaborative projects with ERA were underway addressing erosion and hydrology, water quality and long term radon exhalation rates, and vegetation aspects. He noted these projects are important for the process of determining final closure criteria. Dr Jones noted the location of erosion plots had been modified from the original design. Prof Johnston asked how much U is in the rock materials being used in the trial landform and Mr Puhlovich advised that rock material used was all 1's grade on average (ie < 200 mg/kg U). Dr Evans noted that concrete was also being used in the construction of sections of the erosion plots and that sealants will be used to cover the concrete to minimise possible contamination of the runoff water that is being collected for chemical analysis. Mr Evans asked if the collection points will be covered to minimise both the diluting effect of directly incident rainfall, and evaporation between periods of rain.

Prof Johnston asked if there is any danger that rainfall may cause overflows or flooding of the flumes, and added that an extreme event which may be important in terms of landform changes could be missed if the system isn't able to cope with peak flows. Dr Evans advised the design criteria for the flumes had been based on extreme events so it would have to be a very significant event to flood out the flume. Mr Evans asked about seepage and Dr Jones advised that seepage would be collected in a sump constructed at the base of the landform. Dr Jones advised the erosion plot instrumentation would include a flume at the plot outlet, stage height (measured by pressure transducer and shaft encoder), turbidity and conductivity probes, an automatic water sampler and a rain gauge. He noted this would provide the basis to obtain a correlation between turbidity and suspended solids, and the rainfall-runoff relationship for the landform. Prof Woodroffe asked what previous work has been done on erosion of landforms at Ranger. Dr Evans advised that previous erosion plots had been set up many years ago on a waste rock only surface, which had been highly crushed by vehicular traffic. Mr Puhlovich noted the material used in these earlier trials was from Pit#1 and the material being used in the current trial is from Pit#3 so this should provide a better understanding of the erosional potential from the final landform. Dr Evans also noted that larger erosion plots are also being used than previously.

Dr Jones advised that a workshop involving SSD, CSIRO, ERA and CDU staff had been held in January 2009 looking at the issue of U in sediment, as well as outstanding geochemical issues relating to understanding the performance of wetlands. The workshop discussed a range of topics and identified knowledge gaps that need to be addressed including the need for more detailed characterisation of Georgetown Billabong sediment, the planned field sediment spiking experiment to establish local sediment quality guideline criteria for U, and other projects looking at sediment geochemistry relating to uptake and release of metals in wetland and billabong sediments. Dr Jones noted deriving sediment criteria for U toxicity is internationally relevant but not an easy task. Dr Stauber advised the work will involve in-situ experimentation. She noted that concentration of U is known to be high in constructed water bodies on site, and is higher than non-mining impacted reference waterbodies in some of the billabongs (eg Georgetown Billabong) receiving runoff from the site. There is reduced abundance and diversity of benthic fauna in Georgetown Billabong, but it is not currently known if this is U-related or due to specific habitat factors. Dr Stauber advised the research on U sediment toxicity aims to drive the development of guidelines for U toxicity in sediments.

Prof Woodroffe asked if the sediments being looked at are coarse sands or fine suspended sediments. Dr Jones noted that the sediment in Magela Creek is sandy, whilst the billabongs contain a substantial proportion of fine-grained material. Prof Woodroffe commented that much of the current discussion appeared to be focused on suspended sediment loads. Dr Jones advised that what is being discussed here related to bed sediments, rather than suspended sediment that is the subject of the ongoing work being conducted in

Magela and Gulungul Creeks. Prof Woodroffe noted the current research is not looking at deposition on floodplains. Dr Jones advised that this issue is being examined indirectly by the work being done on the uptake of Ra by mussels in Magela Creek and in Mudginberri Billabong downstream. In the context of the floodplain environment there was a considerable amount of data on metal content of billabong sediments along the floodplain reported as part of the Jabiluka environmental approvals process. Prof Woodroffe noted that bedload (sand) has lower retention of U than fine sediments. Dr Jones advised SSD is looking at quantifying the composition of sediments as a component of its suspended sediment load project for Magela Creek. Mr Evans asked if the project will characterise sediment both physically and chemically, and Dr Jones replied that it would.

Mr Smith asked how much sediment is coming off the Ranger lease versus the upper catchment. Dr Evans advised there continues to be a supply of fine sediments that moves through the floodplain but most of this does not come from the mine site. Dr Jones advised that based on work to date using isotope signatures it appears that very little of the Ra present in the sediment in Mudginberri Billabong originates from the mine site. Mr Smith asked how this is going to be monitored to definitively establish how much sediment is getting into the Ramsar wetlands. Dr Evans advised that there are data available on continuous turbidity and suspended sediment from samples both upstream and downstream. He advised it is planned to derive loads but noted what comes from upstream is mainly natural contribution.

Mr Evans suggested that work could be done looking at differences between upstream and downstream where flux in terms of total load is different to what is coming off the minesite and then hypothesise about fate. Dr Humphrey gave Coonjimba Billabong as an example of where sediment that is mobilised during extreme events can be deposited. Prof Woodroffe noted this but suggested this would still only be a small proportion of total sediment in the system. Prof Woodroffe noted there are enormous volumes of sediments locked up in the system and assumed that most of this must be being deposited on the Magela floodplains.

Environmental Radioactivity - Dr Jones advised work on Bioaccumulation and Bush tucker is continuing with samples being obtained from a range of bush tucker (especially plants) from reference areas as well as naturally radiogenic areas and areas impacted by mining (eg land application areas). Mr Smith asked about the selection of species of native fruit trees used on the trial landform. Mr Puhlovich advised ERA doesn't want to exclude various species from the landform trial since the results will provide information on uptake of radionuclides into bushtucker. However, he further noted that it is not intended at this time to include bushtucker species in the list for revegetation of the final landform. Mr Smith suggested that fruit trees be used so the level of U uptake could be measured. Mr Puhlovich noted that some of work by Dr Akber is covering this. Prof Johnston suggested there is no need to worry about trees on the landform as this is less of an issue compared to trees that might grow on the LAAs.

Dr Jones advised that the results from the longitudinal study of Radium uptake in mussels from Magela Creek had been presented at a conference and a journal paper had been also submitted. He noted *eriss* would continue to update the diet profile of Traditional owners. Mr Kyle asked when the last dietary survey was undertaken. Dr Bollhoefer advised the last survey was done a few years ago and that the survey included consumption of buffalo meat. Dr Jones advised that the Bushtucker work started 10 years ago and has been reported on at previous ARRTC meetings, and results provided back to Traditional Owners.

Characterisation of LAA (work with ERA) - Dr Jones advised a large number of soil samples had been analysed from Ranger LAAs via gamma spectrometry (> 200). A Radon exhalation study had also been conducted at the LAAs, with various measurements performed in *eriss*'s laboratories. Dr Jones advised the focus in 2009 would be on atmospheric pathways for loss from LAAs (in particular dust). Dr Jones noted Dr Akber would be providing further information on the project in his presentation later in the meeting.

Spatial Sciences and Data Integration Group - Dr Jones advised that a new Spatial Sciences and Data Integration group has been established in *eriss* to bring together the spatial science and remote sensing expertise previously distributed across the Institute. He advised the group would be responsible for developing leading edge products for assessment of land condition and cover (including freshwater wetland areas), with a primary focus on those aspects related to the operational impacts and rehabilitation of minesites in the tropics. The group will also provide GIS/spatial sciences expertise for projects across the Division and develop and implement frameworks for corporate storage and retrieval of spatial, water, soils, biology and photographic data. Dr Jones noted that much of SSD's data holdings are suited to spatial representation. Prof Woodroffe welcomed the establishment of the new spatial group and agreed that spatial representation was a good way of utilising relevant data.

South Alligator Valley - Dr Jones advised SSD has continued to provide assistance to PAN with radiological assessment and identification of amounts of materials at various sites within the South Alligator Valley as part of the rehabilitation projects being managed by PAN. He noted SSD has confirmed the success of cleanup activities at the Sleisbeck site and reviewed consultant advice regarding proposed rehabilitation works at the El Sherana site. Dr Jones advised that a 5 year program of monitoring at Rockhole Creek adit had shown that most metals are declining and that specific rehabilitation works are probably not required at this location.

6.1.2 Proposed *eriss* research for 2009-2010 against ARRTC 2008-10 KKNs (Dr David Jones, *eriss*)

Dr Jones provided presentation on proposed *eriss* research against the ARRTC 2008-10 KKNs.

Land Application Areas KKN 1.2.2 - Dr Jones advised that a collaborative project with EWLS was proposed to develop a dose model that will underpin a rehabilitation strategy for the Land Application Areas (LAAs). This would involve analysis of a range of samples of soil, leaf litter, dust and bush tucker, and the assessment of doses from Radon progeny and dust inhalation.

Ecotox KKN 1.2.4 - Dr Jones advised projects proposed included looking at the effects of pulse exposure of Mg. He noted there is a need to better understand how pulse (acute) exposure fits with toxicity guidelines which to date have been derived from chronic exposure tests. Dr Jones noted the process water permeate toxicity evaluation had been delayed again due to problems with commissioning of the WTP at Ranger. Dr Jones noted the current national guideline for nitrate was not well derived and there are questions in relation to its application within the local environment. The technical basis of the nitrate guideline is currently being reviewed. Dr Jones advised that laboratory work is continuing to better understand how suspended (fine) sediments interact with various species.

Dr van Dam advised that experimental design issues for work on the effects of fine suspended sediment are in the process of being resolved. Dr Jones advised there is also an issue with use of a coulter counter to count and size organisms in water samples that contain suspended inorganic particulates. Mr Evans asked if it is proposed to move away from U toxicology and look at other potential environmental harm pathways. He further suggested that the current approach appears to be moving towards linking physical factors to biological effects rather than just looking at water quality guidelines and using statistics to set limits. Mr Evans noted that, in relation to nitrate, a range of parameters may have a biological effect in a nutrient limited system.

Prof Johnston suggested another issue is the change from a focus on the operational phase of the mine to what happens to water bodies during and post closure. Mr Evans noted this is being addressed under the current research program and asked if the current biological monitoring. Dr Humphrey advised that biological monitoring allows the researcher to look for threshold responses in the field. Dr Barry noted that this monitoring may not detect changes that are happening 50km away so there is always the need to ask if we are looking at the right factors. Mr Evans noted the work started out looking at radiological pathways but is now looking at a range of other potential pollutants. Dr van Dam advised there is also a need to look at far field effects - for example in relation to nitrate, one wouldn't just look at nitrate without looking at its biological effects and where sediments are being deposited over the floodplain.

Dr Stauber noted that in relation to the research into the biological effects of U in sediment, work is looking at different end points other than just ecotox issues. Dr Jones noted that, in terms of developing a risk framework, one can't do a risk assessment unless one knows where the risk threshold sits – you can derive statistical figures and apply these to defined guidelines but you need to have information on biological effects to correlate. Prof Woodroffe suggested the information on suspended sediment isn't probably going to be specific for organisms but agreed it is good to have the data. Dr Jones noted that the issue of persistent fine suspended sediment is likely to be more important in stationary or near stationary water bodies.

Dr Jones advised the proposed pilot field sediment transplant study would inform the development of protocols and procedures for establishing U sediment quality criteria. Gulungul Billabong had been provisionally selected for the project, pending approval. Traditional Owner approvals to undertake the study had not yet been sought, but would be done as soon as possible given the need to start preliminary work in May/June. He advised the proposed approach would involve collecting sediment in the field, mixing this with U in the laboratory and then placing containers of the spiked material back in the field for the 09/10 wet season. The next step would involve undertaking a biological effects (recolonisation) assessment around April/May 2010 to compare the spiked sediment containers with the unspiked controls and the surrounding natural billabong sediment. Dr Jones advised the methodology for this project was critical and was still being

refined. Dr Stauber asked if there were any threats to the project proceeding and Dr Jones noted that ARRTC endorsement and TO approvals were required as a pre-condition.

Dr Jones noted the current PhD work on effects of dissolved organics on modifying metal toxicity would continue, focusing on the Al and As testing and writing up.

Monitoring KKN 1.3 - Dr Jones advised that the new wet season monitoring regime for Magela Creek will continue together with interpretation of 08/09 and 09/10 data, including analysis of data in a whole-of-catchment context and assessing implications of EC data for trigger framework taking into account results of pulse exposure work from KKN 1.2.4. He noted this would include estimation of fine suspended sediment loads upstream and downstream of the mine to derive provisional guidelines for turbidity and suspended sediment loads. Dr Jones noted SSD is developing a good understanding of physical issues related to sediment but less so at this stage in relation to the effects of metals in sediments.

Mr Puhlovich asked what triggers Dr Jones was referring to. Dr Jones advised the EC guideline in the Ranger ERs, but noted there is an issue in relation to how this value relates to short duration pulse exceedances and how it should be applied in a regulatory sense to such excursions. He noted there is also uncertainty over whether the current trigger level is appropriate given that it was derived from a modified baseline dataset, and is not specifically related to the findings from the recent Mg ecotoxicity test work. Mr Puhlovich asked if the work will refer to error bands regarding the relationship between EC and Mg, and whether there are any signs at this stage from the continuous monitoring in relation to temperature effects. Dr Jones advised that EC measurements are automatically corrected for temperature variation so this factor should not be an issue.

Mr Evans asked if there was any work being done on obtaining an increased sample size range to gain greater confidence in the Mg-EC correlation at higher EC values. Dr Jones confirmed this was the case (refer to discussion above on this same issue) with the most recent work specifically targeting the mid to high EC range to expand the range of sampling points so if there is a higher peak in the future there will be good confidence in the use of the correlation to infer Mg concentration values. Mr Puhlovich advised the reason why he raised this was that ERA has been using telemetry around the Pit for some time but has had problems with drift in EC in instruments and other sampling issues. Mr Hughes noted that drift can generally be engineered out by having two probes which check each other. Dr Jones noted this can also be addressed through a regular QC checking program. The SSD system comprises replicate sondes and weekly QC checks.

Mr Evans asked how well the in situ values measured at time of grab sample collection and the continuous monitoring compared and Dr Jones indicated there was typically very close agreement. Mr Hughes noted the correlation was typically one percent or better. Dr Jones advised that when continuous monitoring first commenced the gaps in data sets were due to problems with equipment reliability. These problems have now been "engineered out" as far as practicable. Mr Hughes suggested it is important to note that SSD is not trying to establish a new regulatory trigger for the sake of it through this work, but rather is looking at better ways to ensure the environment remains protected. He suggested the current guideline values (based on the weekly grab sample data) are probably flawed because they don't include some of the higher values in the long term dataset.

Ranger Rehabilitation KKN 2 - Dr Jones advised proposed work included measuring erosion rates and solute loads in surface runoff from the two surface treatments of the trial landform (KKN 2.2.1, KKN 2.2.3) in collaboration with EWLS, landform evolution modelling simulations that will use erosion input parameters from the field measurements (KKN 2.2.4) and input data from KKN 2.2.1 to assess capacity of LEMs to predict erosion rates during initial period of landform stabilisation (informs KKN 2.7.1 – rehabilitation risk assessment). He noted the field work will be very intensive when the four erosion plots are running.

Prof Woodroffe asked whether a stable climate is used or whether a changing climate is factored in when simulating landform evolution over very long time periods. Dr Evans advised a stable climate base was used with both the CAESAR and Siberia models. Dr Jones advised that the CAESAR model had been run with the 2007 high rainfall event year as part of the 20 year simulation sequence. The NT annual rainfall pattern is already highly variable, and the key question is whether the effects of climate change will result in events, or frequency of events, that fall outside the available historical record. He noted SSD would look at this in the future in order to understand how the landform will perform over time – noting that the most sensitive (ie highest risk) period is probably immediately after construction. Mr Evans asked how decisions on which extreme events to model were made and if the previous modelling had incorporated an extreme event. He also noted the model is still based on the observed record and asked how this would be expanded to include

possible future scenarios. Dr Evans advised that historical records would be used to determine which previous flood events should be used to determine return records - for example the 2007 flood event caused a lot of sediment movement in the catchment of Magela Creek.

Mr Evans noted other work on the Indian Ocean Dipole looked at correlating coral growth rates with regional climate circulation patterns. Prof Woodroffe advised the concept is that there is long-term correlation between climate and the El Niño-Southern Oscillation, and previous work has also shown a strong correlation with the Indian Ocean Dipole. He noted as climate is not stationary, climate change should also be factored into the model. Mr Evans advised this could be addressed by running the model with different scenarios and Dr Evans advised that it was already planned to use different scenarios as part of the next stage of the work. Dr Barry noted it comes down to the level of sensitivity of the model to extreme events. Mr Evans noted that it should be possible to do inverse modelling to determine what level of rainfall would be required to trigger a major erosion event. Dr Barry suggested the previous record could be used but the magnitude would need to be increased to account for the anticipated effects of climate change. Prof Woodroffe noted this is a big issue and a key knowledge gap, and now is the right time to factor in the climate change issue. He strongly recommended the project determine what climate drivers are likely to change and the potential implications of this.

Mr Evans noted the two key issues are (i) determining what an extreme event is and (ii) the need to have another look at climate change effects. Mr Hughes sought Prof Woodroffe's views on whether there is a need to tweak the model if running a static model and then changing using extreme events. Prof Woodroffe suggested there may be several different climate drivers so its not as simple as tweaking the model (eg. changes in sea level from 1 in 30 depends on threshold or if trees in landform cant survive drought in March and there is more rain overall). Dr Jones noted he provided a presentation on extreme events to a Parks Australia North symposium last year in which he suggested shifts in climate and seasonality could have critical ecological impacts (eg. effect of temp on flowering of species). Dr Barry suggested there is a need to work out the plausibility of the events and then base the analysis on that. Dr Jones noted the CSIRO regional climate scenarios would be useful in this. Prof Woodroffe advised he wasn't suggesting that further research be undertaken at this stage but the climate drivers should at least be taken into account.

Mr Evans noted the Murray Darling Basin Sustainable Yield work identified increased frequency of extreme events leading to higher groundwater recharge. Dr Jones suggested that a sensitivity analysis should be undertaken first. Dr Barry suggested that a range of scenarios be examined ranging from nothing through to very extreme, and then identify if there is a threshold and focus on that, and then consider what's physically plausible. Prof Johnston suggested the focus should really be on closure and in the current timeframe (2020), climate change is not really an issue. Mr Puhlovich noted the issue of implications of climate change on closure are always put forward but suggested water quality issues and erosion of the site are probably the more pressing issues to focus on.

Dr Jones advised the outputs of the work on erosional stability of the final landform will feed into KKN 2.7.1 Rehabilitation risk assessment.

Radiological KKN 2.2.5 - Dr Jones advised proposed work included Radon exhalation measurements on the trial landform taking account of seasonal effects and the effect of vegetation development (intermediate to long term), development of a pre-mining radiological baseline for the site and a whole-of-site dose model (a possible ARC linkage project with ERA & RMIT). Work on the accumulation of radionuclides in bush tucker will continue with the work program to include analysis of a wide range of food types from different exposure locations, refining uptake factors by applying selective extraction results (from soils) to a range of plant food types and integration of all of the associated provenance data into a spatially-based Google Earth platform.

Ecosystem Establishment - Dr Jones advised proposed work included finalisation of statistical analysis of vegetation and soils and landform/landscape data from analogue and mine trial rehab sites (KKN 2.5.2) and development and testing of remote sensing approaches to tracking and quantifying evolution of vegetation (KKN 2.6.1). Prof Woodroffe asked if the remote sensing would be airborne or satellite-based. Dr Jones advised that airborne remote sensing is expensive so the proposal is to use existing satellite platforms combined with groundtruthing using a high resolution spectrometer to obtain the required spectral data for individual species. It is proposed to combine spectral analysis with object-based classification to develop an efficient procedure for tracking the maturation of the vegetation assemblage using remote sensing. Dr Barry asked how the work will fit into post closure remote monitoring and Dr Jones advised the traditional approach is to do groundtruthing, but if a remote sensed tool can be developed then this could be more efficient, and permit greater temporal coverage than able to be provided by time consuming groundtruthing. Dr Barry asked why it needs to be done now instead of later when products become available. Dr Jones advised SSD

currently uses three or four packages to undertake all the analysis required with no single one addressing all requirements. This is likely to remain the case for some time. Dr Jones also advised that irrespective of its sophistication, such software needs to be initially calibrated by ground-based measurements. It is the aim of this work to have a capable and validated platform developed in advance of closure. Such a platform would also be useful for tracking rehabilitation at other mines in the northern tropics, including Nabarlek which remains to be revegetated. Prof Woodroffe asked why remote sensing is being used to monitor plants individually and whether this can also measure plant health. Dr Jones replied that it is only in the initial development stages that individual plants will be tracked using a combination of ground truthing and high resolution remote sensing. It was noted that plant health can also be assessed by wavelength band ratio measurements.

Dr Grant questioned the value of monitoring the rehabilitation of individual plants when closure criteria will likely be focused on overall successional success not on individual plants. Prof Woodroffe noted remote sensing offers a range of opportunities but in this case he was unsure what was being proposed. Dr Grant asked what remote sensing will achieve if all it shows is that rehabilitation has failed. Mr Evans noted the remote sensing platform measures a range of spectral signals so there will be a need to deconvolute components of the spectra to see what is going on. Prof Woodroffe indicated he understood this but was still unsure why this was needed. Dr Jones noted the concerns raised by various members as to whether this is a high priority and undertook to provide further advice to ARRTC out of session.

ARRTC23 Action/Outcome 6.1

ARRTC queried whether the proposed remote sensing work by eriss under KKN 2.5.2 is a high priority. eriss to provide out of session advice.

Closure Criteria (KKN 2.2.2) - Dr Jones advised proposed work included derivation of provisional water quality closure criteria for Georgetown Billabong (GTB) and completing characterisation of spatial and temporal trends of U in GTB sediment to determine if the currently measured concentrations were likely to be an issue for benthic macroinvertebrates. He noted if the level of U concentration in the sediment was found to be causing impacts then there may be a need to adjust the proposed water quality closure criterion for U since the water column will be the most likely source of the U that is being absorbed by the sediment bed. Dr Jones further advised that a project proposed for 09/10 would look at the effects of turbidity (fine suspended sediment) on billabong limnology (complements KKN 1.2.4 – ecotoxicology of suspended sediment). This is relevant to closure since one of the most significant risks posed by a newly constructed landform is likely to be wash off of fine sediment. The work program for this project will comprise reviewing historical (dry season) datasets for turbidity and chlorophyll a in billabongs and in-situ measurements in GTB of effects of development of turbidity during the 09 dry season on physicochemical parameters (DO, pH, Temp), and chlorophyll a. Dr Jones advised that the natural development of a turbidity maximum in GTB during the dry season provides a unique field-based opportunity to quantify the effects of turbidity on billabong limnology. The only way that this could be done during the wet season (which is actually the time of most risk for turbidity impacts from the mine site) would be to carry out experiments in mesocosms. Such work is typically fraught with difficulties of scale.

Dr Jones noted the project will look at the effects of turbidity on billabong limnology, in particular the effects of turbidity on the diurnal DO levels (a measure of benthic photosynthesis) close to the bed of the billabong. The diurnal O₂ concentrations will be tracked through time using continuous monitoring to establish the threshold turbidity at which significant suppression of oxygenation starts to occur. Dr Hillman suggested that low levels of oxygen in such a system may not be a bad thing, but noted this depends on diurnal issues, the levels of suspended material and any chemical effects. He noted it may be difficult to separate out this from climate effects. Dr Jones noted that the relationship between suspended sediment and light is generally well documented in the literature but advised that this particular project was about better understanding the local situation, and developing locally applicable criteria for concentrations of suspended sediment (as per the recommended approach in the Australian Water Quality Guidelines) and relating this to closure criteria. Dr Hillman suggested it may be difficult to know when this could present a problem and Dr Jones advised this is why the use of a field analogue was proposed. Dr Humphrey advised there are various lines of evidence and that's why *eriss* is using a combination of laboratory-based and field-based approaches to addressing the suspended sediment issue.

Ecological Risk Assessment - Dr Jones advised this project will inform KKN 1.2.1 and provide a better understanding of the comparative significance of mine related effects versus other threats such as weeds and fire. He noted the project would also provide established data for the decommissioning phase from the trial landform and from the radiological surveys of the LAAs.

South Alligator Valley - Dr Jones advised the containment would be constructed over the next dry season and SSD would be involved in measuring success of the project. SSD will also assess the radiological status of the Rockhole tailings residues area, and other sites, following removal of material and rehabilitation of the footprints.

Mr Evans asked for comments from members on the material presented and the meeting papers. Prof Woodroffe noted the landscape scale analysis proposal mentioned climate variability and change issues but suggested the issue needs more emphasis generally. Dr Barry questioned the need to consider climate change issues if the timescales involved means this won't affect the initial success of rehabilitation of the Ranger site, noting that closure is currently planned for 2020 which is substantially in advance of the leading edge of predicted significant climate change impacts. Prof Woodroffe suggested there are two issues. Firstly, he noted that the extreme rainfall event in 2007 triggered landslips in landscapes where such events were not previously known, so it's important to understand the implications of increased extreme events due to climate change. Secondly he suggested there is a need to consider ecological effects of climate change and the sensitivities of ecosystems to climate drivers and integrate these into closure planning. He noted given the national interest in climate change this should be being factored in. Dr Barry agreed climate change is certainly important in terms of landform and vegetation but suggested the threshold issue is less clear.

Dr Jones suggested a perhaps more important question is whether the species being selected for rehabilitation are the most appropriate for the landform in the next 50 years given climate change. Dr Grant advised that if native species are being used and there is a reasonable mix of species, you would expect the same climate change effects will apply to the rehabilitated landform as to the surrounding natural landscape. Dr Barry noted that at the end of the day the landform needs to be designed so that it is able to meet expectations of stakeholders over time. Dr Grant suggested that climate change effects will probably be seen at a larger geographic scale rather than being a specific issue for the rehabilitated landform.

Dr Grant queried what in situ monitoring using snails is adding in terms of understanding impacts on the environment. Dr Jones advised that the snails are acting as a biological sentinel for impacts, noting that the snails are one of the more sensitive species to both U and Mg. Dr Stauber strongly supported insitu monitoring as it's the only means of measuring in almost real time biological response to impact, it's not resource intensive and it's relatively simple to operate. She noted without this there would be no field measurement of biological response and this is an important line of evidence to complement the continuous measurement of physicochemical parameters.

Dr Humphrey noted measurements using snails are not continuous since the snails are deployed every second week. Dr Grant suggested this could result in some events being missed and therefore queried the value of such measurements. Dr Humphrey advised such measures provide ongoing assurance to stakeholders that the environment is not being impacted. Prof Johnston noted that much of the monitoring being undertaken by SSD and others is about stakeholder reassurance. Dr Jones noted this is why the effort is being put into the snail work. Dr Humphrey advised the in situ snail method has high power and provides relatively unequivocal results. Prof Johnston suggested the downside with the method is that there could be an issue if all snails perish and there is nothing untoward captured in the continuous monitoring record.

ARRTC23 Action/Outcome 6.2

ARRTC endorsed the proposed eriss 2009-10 research program as presented.

ARRTC23 Action/Outcome 6.3

ARRTC requested that eriss review available information on climate change, what this may be predicting for the Alligator Rivers Region and any implications for the work program. This is to be reported at ARRTC24.

ARRTC23 Action/Outcome 6.4

ARRTC welcomed and commended eriss on progress to date in the proposed U in sediment work.

6.2 Energy Resources of Australia Pty Ltd

Presentation on Pit #1 Closure: hydrogeological conceptualisation and initial calibration of solute transport model (Dr Wendy Timms)

Dr Timms provided a presentation on Pit #1 Closure focusing on hydrogeological conceptualisation and initial calibration of a solute transport model. The project is looking at seven major hydrogeological units using a 14 layer groundwater model. A particular focus was the defining of the depth of the weathered profile and groundwater behaviour and interactions in between the weathered zone and fractured rock systems.

When the project started, a review of regional geology and earlier conceptual models had been carried out. Dr Timms advised that geological sequences had previously been inferred to dip to the east at angles of 30-40° (on the basis of in pit observations) and early conceptual models, prior to Kalf (2004) model testing, were based on 4 conceptual hydrogeological units. Dr Timms advised that review of conceptual models developed by Kalf and Townley in 2004 had shown that MBL aquifer extent was uncertain, but thought to be more extensive and less compartmentalised than some earlier conceptual models (supported by Kalf, 2004). She noted that pegmatite occurrence correlated with groundwater occurrence but the importance of this is not clear and there was some uncertainty in unconsolidated zone hydrogeology.

Dr Timms advised an initial Water Research Laboratory (WRL) conceptual model of surface water interactions had been developed. She advised that the CSIRO Georgetown Billabong (GTB) studies published in March 2009 had shown that there is potential for upward groundwater fluxes of 20 mm/year estimated from weathered rocks to shallow aquifer and lateral groundwater discharge of 120-160 m³/day estimated to GTB during March-April when SWL >12 m RL. Dr Timms noted this is opposite of what previous conceptual models where concentration was occurring during dry season. Dr Timms noted there is a much improved understanding of surface water interactions but still a number of uncertainties. She advised that surface and groundwater interactions had been modelled with FEFLOW using the same concepts and calibration parameters as Kalf (2004) and that surface water heads had been predicted with a calibrated SWIM model.

Dr Timms advised that a finite element model had been developed as given on the presentation with a Pit #1 barrier resolution, lower mesh resolution south of the Ranger Fault, high mesh resolution in vicinity of Pit #1 SE corner permeable zone (as there was more data available), medium level of refinement along creek lines and within Georgetown Billabong and a low level of refinement elsewhere. She noted the Pit walls were modelled as vertical elements at the RL 0m contour, and that the model reproduces surface area, depth and volume of Pit #1 with an accuracy of 20%. Mr Evans asked what time step was used for the steady state rainfall and Dr Timms advised that the model was generally operated daily but scenarios were run depending on specific information requirements. Dr Timms advised that modelling was being run on a high spec PC so runs were able to be done in several days.

Dr Timms stated the key findings from the first revision of the conceptual model were that weathered/fractured rock and HWS/UMS contact zone aquifers overlapped in the Pit #1 S-E corner permeable zone and extended below RL 0m where seepage was observed. Initial scatter plots of weathering depth showed significant spatial variability and a zone of very deep weathering above the MBL aquifer was inferred. She noted that Kalf (2004) applied 20% rainfall recharge to this area to achieve calibration, but field data show upward hydraulic gradients in the same area. Dr Timms further advised that the dip angle of the HWS/UMS sequence has been found to be 2 degrees rather than the 30 degrees that was previously inferred. This is a very important finding that has significant implications for the construction of the latest model grid. WRL inferred that structural controls were responsible for seepage into Pit #1 (from URS (2005) geotechnical report provided during December).

Dr Timms advised that preliminary quasi-3D mapping and numerical test models were used to revise the conceptual model and provided useful information. Bore log and URS (2005) pit face mapping data were analysed and interpolated across the study domain. She suggested that future mapping should consider more advanced 3D visualisation and geological mapping techniques. She noted that three types of pegmatite intrusions were inferred in the bore logs and one type, in HWS rocks, was projected across the model domain. Dr Timms advised that model grids of depth, elevation and thickness for various geological layers, contact zones, observed weathering profiles and a pegmatite sheet were prepared. She noted this work highlighted the need to confirm the extents of the Pit #1 fault zone, variability in the depths to various conceptual hydrogeological units, and that structural features other than the Pit #1 fault were influencing permeability distributions within the study area (supports assumptions made by Kalf, 2004).

Dr Timms advised that a key finding from the testing of the initial conceptual model was that inclusion of structural features (such as pegmatite intrusions) is essential to be able to effectively calibrate the model for seepage into the pit. She advised that 80% of seepage into Pit#1 was occurring through discrete fractures and that by adopting various combinations of permeability and layering, it should be possible to use the outcomes of proposed field investigations to better refine the model. Dr Timms noted permeability distribution was highly variable within the inferred weathered/fractured aquifer and that the pegmatite and other structures inferred during preliminary mapping work are the most likely explanation. Dr Timms noted that previous models focused on high permeability zone but the layered model has the limitation that it can't predict contaminant pathways in terms of temporal scale. She advised the revised model geometry with pit seepage structures will be used for ongoing modelling.

Dr Timms advised that the conceptual model selected for numerical testing improves previous flow models in that it represents the majority of seepage into Pit #1 with structural elements, has improved distribution of hydrogeological units across the study domain, incorporates a variable weathering profile across the entire site, has a low permeability zone along the Ranger Fault and a lower permeability north-south shear zone to the west of Pit #1. She noted that models that do not incorporate structures such as the pegmatite contacts would not provide a realistic assessment of the migration pathways and timing of possible contaminant movement. Dr Timms noted that in this complex hydrogeological environment, generalised layer models could be used to approximate a flow regime but would be limited by significant uncertainty in predicting the potential for contaminant transport.

Dr Timms advised that zonal permeability values developed by Kalf (2004) are being loaded into the revised model layers developed by WRL and are being modified to account for the importance of near pit structural features. The model is being conditioned to develop an appropriate 'steady state' condition for long-term testing with similar recharge, evapo-transpiration and surface-water interaction concepts developed and calibrated by Kalf (2004). Dr Timms advised the revised model concept will then be verified against Pit seepage observations and changes in response to pumping drawdown observations from the 1986 pump test, aquifer levels during dewatering of Pit # 1 (1987 – 2003), upwards groundwater fluxes about Georgetown Billabong and aquifer levels at the end of the 2004 and 2008 dry seasons.

Dr Timms advised a reasonable match to the available field data is anticipated and that additional field data will enable an improved representation of the system. Mr Evans asked what the timetable is for the project and Mr Puhlovich advised that ERA is working with CSIRO looking at data gaps and where more field investigation will be done during the dry season. Mr Puhlovich advised that probably in the next three to six months ERA will start to put forward documentation on Pit#1 closure. He noted however that this is complicated as there are other studies underway that need to inform this project. He noted the need to also reassess transport mechanisms. Dr Jones asked if there were any indications at this stage as to what changes these may have on flow rates going down the system. Dr Timms advised it is still early days in terms of model development but that Franz's model assumed low flow boundary.

Mr Puhlovich advised that the University of NSW was also looking at conservative solute transport and will also look at reactive transport later in the year. Mr Evans noted shallow groundwater is discharging to Georgetown billabong but suggested a boundary condition is required and asked how discharge is being constrained at the bottom end of the system. Dr Timms agreed that a flow boundary condition is needed and further work is required but suggested it would probably be a flux boundary. Mr Evans asked if the structure of the sediment body under Magela Creek was known. Mr Puhlovich advised that ERA has some information on the NE of Pit#3 rather than from GTB and noted there is a significant paleochannel under Magela Creek. Mr Hughes asked if there are any intersections at high conductivity zone at minus 80m. Dr Timms advised this had been projected from the contact zone several hundred metres away so it was planned to extend drilling down to 80-100m depth zone and also do some pump testing.

Update on Ranger operations (Mr Puhlovich EWL Sciences)

Mr Puhlovich provided an update on Ranger operational activities.

Staffing - There has been no significant change in Ranger operations since last meeting. The positions of Manager, Health and Safety and Manager Mine Operations are currently vacant. Mr Puhlovich advised the current trend in indigenous employment was encouraging with ERA having 102 indigenous employees as at the end of December 2008.

Current operational activities - Current operational activities include the western stockpile expansion; the raise of the TSF dam wall to RL53 then to RL54; the cessation of tailings deposition in Pit#1 which are now being directly deposited into the TSF; exploration of Pit#3 deeps (one exploration rig operating); the Shell 50 cut back – SE corner of Pit; and the ongoing construction of the trial landform. A long-term Process Water Management Strategy is being developed. Options being considered included possible additional capacity for treatment by the WTP, dry season evaporating ponds and wet season covers for process water storage.

Resources and Reserves - Resources at Ranger have increased by 128% to 115,000 t U3O8 and exploration has identified a significant ore body at Ranger 3 Deeps. ERA has received a substantial settlement from its insurers in December 2008, arising from impacts to property and business interruptions as a result of Cyclone Monica in 2006 and the Feb-Mar 07 Deluge Event.

Production - Total Production for 2008 (tonnes drummed) was 5,339 t U3O8 compared to 5,412 t U3O8 in 2007.

Safety - A few incidents have occurred in last 6 months with lost time frequency rate for contractors being better than employees. This was still a good performance but more work needs to be done.

Water Management - Rainfall at site was at or below average and the pond water inventory is staying below 30% confidence trace but trending upwards. The process water inventory is being tracked to ensure nothing out of scope. The pond WTP was shut down in mid 2008 to conserve water for operational use. The WTP deals with around 5.5 ML of pond water per day and the Osmoflo plant is running well. Due to concerns that there may be insufficient water for operations, the LAAs were also shutdown early in the 2008 dry season. Commissioning of process water treatment commenced at the end of February 2009. There is currently less pond water this year compared to last year. The osmoflow plant continues to operate. The final lift of the TSF dam wall to RL 54 will proceed in April/May 2009 with practical completion to 53MRL at this time. Real time environmental monitoring is improving ERA's ability to manage water on and off site. Monitoring is focused at the operational end to better understand the source terms for solute exports from the site.

Closure Planning - The Closure Criteria Working Group has reached agreement on its Terms of Reference and has met monthly since August 2008, usually back to back with MTC meetings. The WG is focused on identifying closure criteria themes and associated agreed closure criteria, and the data and research required to support them. Initial discussion has been held in relation to water closure criteria and potential knowledge gaps. A post closure landuse/beneficial use statement is being developed. Mr Evans asked if and when ARRTC may be involved in the process and Mr Puhlovich advised the Working Group needs to reach agreement on draft closure themes and criteria before engaging *eriss* and ARRTC on the related research questions. Mr Evans asked about the likely timeframe to get agreed criteria and Mr Puhlovich advised it would probably be a number of months but ERA wanted to focus on identifying the required criteria first and then look at identifying and addressing the associated knowledge gaps. Mr Puhlovich advised the Ranger expansion referral had been submitted and it addresses some aspects related to closure.

Trial landform - Mr Puhlovich advised that work is continuing on the trial landform including experimental design, revegetation strategy, growth media mixing methods, erosion monitoring (*eriss*), construction issues and supplementary watering.

Revision of Closure Model - ERA is currently revising the closure model and SSD has provided advice in relation to this.

Other key R&D projects - Other key R&D projects include addressing Pit#1 closure, TSF seepage and recovery, and rehabilitation of the LAAs.

Expansion planning/Heap leach project - Mr Puhlovich advised a 10Mtpa heap leach facility is proposed to recover 15,000 -20,000t of U-Oxide from existing low grade stockpiles and in-situ ores. The proposed facility is an extension of the concepts considered in the Ranger EIS & the Fox Inquiry dealing with treatment of low grade ores (0.05 to 0.02% U3O8). ERA has reviewed world best practices and believes these can be directly applied to Ranger. Existing environmental management controls at the site will be maintained and are appropriate to protect the surrounding environment. The heap leach pad will be ~5m in height and occupy an area ~60 - 70ha. With associated infrastructure, the project will occupy ~170ha. Mr Puhlovich advised that the project would be subject to obtaining the required approval. There would be ongoing regulatory review and stakeholder engagement will be primarily through the Ranger MTC.

Mr Puhlovich advised a pre-feasibility study will be completed in first half 2009 to inform the decision on whether to proceed with full feasibility study and the next steps. Prof Johnston asked where the heap leach would be located and Mr Puhlovich advised there are key environmental risks associated with the liquor ponds so the location would need to take this into account. Mr Evans asked what the leach pad would be constructed of and Mr Puhlovich advised the leach pad would be fully lined and have leak detection systems. Prof Johnston asked how the heap leach facility would be rehabilitated and Mr Puhlovich advised that crushed and screened material would be placed on the pad and subject to leaching, then ultimately deposited in Pit#3 along with the liners. Mr Kyle noted that the surge ponds in the Gulungul catchment have been moved in latest plan and Dr Milnes confirmed this is the case. Mr Puhlovich advised having ponds in Coonjimba catchment would be better as RP1 would be available for containment if escape of leachate was to happen. Prof Johnston asked if the leaching process would involve recycling and Dr Milnes advised the extraction fluids will be recycled. Raffinate (spent leach liquor) from the existing process plant will be used for leaching rather than separately made up dilute sulfuric acid.

Mr Puhlovich advised that ERA had submitted a referral under the EPBC Act and assumed the project will be deemed to be a controlled action and therefore subject to an EIS. He noted ERA had also submitted a Notice of Intent to the NT regulator for assessment under the NT Environmental Assessment Act. Detailed controls on the operation of the heap leach facility are expected to be incorporated through existing requirements under the Mining Management Act and relevant Authorisations. Mr Puhlovich advised that ERA proposed an environmental best practice approach incorporating lining with leak detection for the heap leach pads and ponds, and perimeter containment berms around the facility, the elimination of acid misting via the use of low pressure drippers and containment of residues in engineered storage facilities. He noted that the benefits of heap leach included lower acid and energy requirements, the elimination of some process reagents (pyrolusite), improved water management and management of leached rock (20mm size gravel) versus finely ground mill tailings.

Exploration decline - Mr Puhlovich advised the proposed decline portal and ancillary facilities will be located within the boundary of the current operations. Radiation exposure will be controlled and surface water and groundwater protection measures will be implemented. Mr Puhlovich advised that ERA considers that the exploration decline is not a controlled action but is submitting a formal Referral under the EPBC Act and NT Environmental Assessment Act. He advised that if exploration does not support an underground mine, the decline will be backfilled and rehabilitated using the Jabiluka decline model. Prof Johnston asked what grade of ore is expected and Dr Milnes advised that drilling shows many intersections up to 0.08 % U₃O₈. Dr Milnes noted that the exploration decline will miss the main ore body so shouldn't involve any major radiation issues however the actual mining process would.

Prof Johnston asked if the heap leach project would have any impact on mine closure timelines and Dr Milnes advised that, based on what is currently known, both heap leach and underground mining won't involve an extension to the current mine life. He noted Pit#3 would be mined out in 2012. Dr Humphrey asked if the heap leach material that goes into Pit#3 would be neutralised and Mr Puhlovich advised that neutralisation may be an option but currently was not planned. Dr Milnes noted that after leaching was complete the ore is washed.

Pit #1 Closure: geochemical studies (Dr Jeffrey Trefry)

Dr Trefry provided a presentation on proposed geochemical studies for Pit#1 closure. He advised that the project proposal had only been submitted in January 2009 so he wasn't in a position to present results but would focus on proposed workplans at this stage. He noted that a number of other CSIRO staff were involved and contributing to the project. Dr Trefry advised that in 2008 EWLS asked CSIRO to perform a review of the geochemical aspects of Pit#1 to: (i) identify knowledge gaps in respect of closure criteria for Pit#1 in respect of contaminant hydrogeology, hydrology, Pit#1 tailings geochemistry and reactive solute transport; (ii) identify and make recommendations as to what is required to address knowledge gaps and deficiencies; (iii) provide an assessment of the information quality; and (iv) identify critical deficiencies or knowledge gaps in the information that could negatively impact on identification of successful closure strategies for Pit #1.

The review considered nearly 80 reports dating back to 1980 on Pit#1 or related subjects and made 17 recommendations for further investigations. Dr Trefry advised the focus of the project is on how the contents of Pit#1 might migrate to environmental receptors over next 10,000 years. He noted there are quite different pore fluids in Pit#1 and the TSF, with Pit#1 lower pH and more dissolved U species, and different chemistry and hydrochemistry. He noted the supernatants (above tailings interface) in Pit#1 contained a higher level of U and that the fluid within the tailings mass in Pit#1 was different to fluids in the underdrain. Dr Trefry advised that the Pit#1 is cone shaped and 100m deep. He noted tailings were originally deposited with lime but this has stopped so the fluid coming out of the underdrain may be the original tailings but this wasn't a natural flow circuit. Dr Jones noted that previous work had suggested there is short-circuiting of the flow path with some water infiltrating down through the fractured rock walls as opposed to infiltrating through the tailings mass. Dr Trefry noted the key issue is that Pit#1 is very different in its contents to the TSF. Dr Jones noted that the TSF has mainly tailings sourced from Pit#1, whereas Pit#1 contains mainly tailings produced from rock mined from Pit#3.

Dr Trefry advised the key knowledge gaps can be grouped under three broad areas: tailings geochemistry, hydrogeological setting, and the transport and fate of solutes. In relation to tailings geochemistry there is a need to better understand the long term stability of tailings in Pit#1 and the interaction with Pit walls and waste rock backfill. In relation to hydrogeological setting, it is known that Pit#1 penetrates 2 lithological assemblages so the issues include the level of transmissivity of fracturing in deeper formations, permeability distributions are not well known, connectivity between upper and lower formations, the water balance is not

well known, groundwater discharge mechanisms need further study as do possible climate change implications. In relation to the transport and fate of solutes, the knowledge gaps include sorption mechanisms, influences of redox state and U complexation along flow paths and the lack of a reactive transport model for Pit#1 means there is no integrated framework to support assessment of transport and fate of solutes at site.

Dr Trefry advised that to address these knowledge gaps several discussions have been held involving EWLS, UNSW, CSIRO and USGS to prioritise gaps, expedite proposal development and facilitate the overall closure planning process. He noted a range of studies are being established to address the priorities, with the aim of building a sound conceptual model of long-term geochemical stability within Pit#1, and an appropriate reactive transport model for any fluids that may escape the pit. Proposed hydrogeological studies included the installation of 3 full depth bores, extra piezometers to study vertical head gradients around the Pit, enhanced groundwater sampling for WQ indicators, extra bores near GTB to better understand g/w flow and discharge mechanisms, and direct measurements of recharge to assist in closing out the water balance.

Proposed geochemical studies included comprehensive batch testing of tailings fluid interactions with local (external to the pit) sediments and fresh core materials to quantify sorption and retardation mechanisms. Detailed testing of fracture aperture response to tailings fluids if required, if practicable, sampling of pit wall rocks to assess physical and geochemical effects of exposure to tailings fluids over decade time frames, batch testing of tailings fluids with potential waste rock materials for backfill (water quality evolution), sampling of tailings fluids for chemical analysis at various depths within Pit#1. These data will be used to construct a conceptual model of pH zonation and U/metal immobilisation within the tailings profile, and construction of PHREEQC kinetic models to describe major fluid-sediment reactions.

Proposed solute transport and fate studies include scenario modelling of density driven flow near Pit#1 full depth, and relying on results of hydrogeology and geochemical studies (and in concert with the UNSW flow model), construction of a high ionic strength reaction module for the major local lithologies and redox zones, incorporating the tailings fluid compositional model and lab sorption data, identification of potential fluid egress pathways from Pit#1 to the groundwater system, and discharge pathways to receptors, 1D reactive transport modelling to validate against lab testing, 3D reactive transport modelling to incorporate fluid dispersion and dilution, and 3D modelling and density effects.

Dr Trefry advised that the above studies were expected to commence within the next 2 months and anticipated much of the field and lab results would be available in Q3/Q4 2009. He noted that reactive transport modelling is a longer term effort and probably would be available in Q3 2010. Dr Jones noted that carbonate at the bottom of Pit#1 wasn't mentioned and probably should be considered. He asked when information about the findings from this will be available for review by SSD and the NT Govt as there are now only a few years to go before it is planned to backfill and cap Pit#1. In addition the regulator still needs to give final approval to what is judged to be an environmentally "safe" final level of tailings in the pit. Mr Puhlovich advised a discussion paper outlining the science underpinning this work needs to be done so the information can be sent out for review and to start consultation on closure criteria. Dr Jones asked if closure of Pit#1 could be delayed and Mr Puhlovich advised he wasn't able to answer at this time. Prof Johnston noted the need for water quality indicator sampling and Dr Trefry also advised that full water quality testing was required. Mr Evans asked if he could get copies of the WRL and CSIRO progress reports and Mr Puhlovich agreed to provide.

ARRTC23 Action/Outcome 6.5

Mr Puhlovich to arrange for progress reports on the WRL and CSIRO work on hydrology and tailings modelling to be provided to Mr Evans.

ARRTC23 Action/Outcome 6.6

ARRTC welcomed and commended ERA on its comprehensive forward program for the two Pit#1 closure studies and endorsed the proposed approach.

Assessment of radiological contamination levels in the LAAs: progress update (Dr Riaz Akber/ Dr Ping Lu)

Dr Akber provided a presentation covering progress in the assessment of radiological contamination in LAA and associated rehabilitation planning. He advised that the project is due to be completed by December 2009.

Radiological aspects – Land Application Areas (LAA) - Dr Akber advised a total of 338 ha of land application area has been commissioned in common woodland around the Ranger site between 1985 and 2007, with 84 ha being used for disposal of polished water and 254 ha used for disposal of raw water. He advised that LAAs receive water from RP2, and some areas to the north receive water via a wetland filter so are expected to have lower levels of contaminants. Dr Akber advised that pipes on the LAA are both above ground and buried in places. He noted that seasonal differences may pose a range of issues in terms of potential migration of contaminants through different pathways.

Characterisation of applied radioactivity - Dr Akber advised that as Ranger is a uranium mine, the important radionuclides are generally in the series from ^{238}U through to stable ^{206}Pb . He noted that different radionuclides are important in relation to exposure through different pathways. Dr Akber identified the key issues associated with the Uranium series as being dust inhalation, radon progeny inhalation and external irradiation. Dr Akber advised that isotopes in the Thorium (^{232}Th) series are at ambient levels in the LAAs and that the Actinium series (^{235}U to ^{227}Ac), while not a formal part of this study, would also be considered. Dr Akber advised that the levels of isotopes are expected to be in natural decay chain equilibrium in the mined rock at Ranger but in gross disequilibrium in the LAAs. He noted there may also be differences between natural rock and the LAAs in terms of the distribution of U on the soil grains and in the soil profile. In LAAs radioactivity is expected to be on the outside of the soil grain due to sorption of applied pond water. Dr Akber advised that the LAAs have higher levels of ^{238}U but relatively lower levels of ^{226}Ra and ^{210}Pb . He noted that soil samples from LAAs contain high levels of U but very little Th so Th concentration can be used as proxy for ambient values of radioactivity. Dr Akber advised that the relative concentrations of radioisotopes is expected to change post rehabilitation as parent isotopes disintegrate and the progeny radionuclides gradually seek equilibrium with ^{238}U .

Distribution of radioactivity - Dr Akber advised that 200 soil samples had been taken from selected locations in the LAAs using a sampling depth of 10 cm. He advised that U and Th analysis had been done on 200 samples and detailed radionuclide analysis done on 50 samples. Samples were taken as a function of distance from a sprinkler. The general finding from this work was that in the LAAs, applied radioactivity decreases approximately exponentially with the distance from the nearest sprinkler, however pockets of above ambient natural radioactivity also exist in the LAAs. Mr Kyle asked how many data points came from the old fashioned impact sprinklers and Dr Akber advised that most data from Magela Land Application Area were obtained when lines of old sprinklers were present. He advised that for 8 or 9 sites, samples taken from the same distance from individual sprinklers were combined to generate a composite sample for analysis (eg. 3 sites of 6 metres from sprinkler)

Mr Kyle recalled that there are no instances where the sprinklers are greater than 50 m apart. Dr Jones asked if Dr Akber is confident he has good coverage given access was limited in some areas. Dr Akber advised that the background levels are estimated and that grid measurements were done on irrigated areas to understand the effects of distance between sprinklers and confirm that activity values are higher closer to sprinklers and decrease exponentially with distance. Mr Puhlovich suggested that there must be some relationship between the volume of water sprayed onto the ground and the level of isotopes and Dr Akber agreed this appears to be the case. Dr Akber noted in some cases the concentration of radioactivity was still higher further out from the sprinkler which could be due to experimental error but more likely due to there being pockets of natural hotspots in these areas. This has been substantiated by the fact that ^{238}U and ^{226}Ra values at those sprinkler locations approach equilibrium as expected from natural rocks and ores. Dr Jones suggested this could be due to some sprinklers having a different or variable spray distribution pattern. Mr Evans asked if the pockets of hotspots were at or approaching equilibrium and Dr Akber advised there is a combination of applied radioactivity and equilibrium natural radioactivity. Mr Evans queried whether based on this there could be other sites that may be in equilibrium and Dr Akber noted that the hotspots had higher gamma levels.

Methods for measuring radiation dose - Dr Akber advised the measurement of external radiation dose rate involved 50 sampling locations across the LAAs where all year measurement are being conducted divided into four quarters. Samples were taken at a height of 1 m and also at ground level. Samples were taken at different distances from sprinklers. Soil radioactivity was also measured. Dr Akber advised the work suggests that the level of external radiation dose at ground level is approximately 22% higher than at 1 m height although this needs to be confirmed. He noted there may be seasonality differences. Dr Akber advised radiation dose can be estimated using UNSCEAR 200 conversion coefficients and that for common woodland areas dose at 1 m height can be calculated if the radioactivity concentration in soil is known. He noted that the gamma radiation signal in LAAs is predominantly from natural radioactivity in the soil. Prof Johnston asked if any beta component was measured. Dr Akber indicated he suspected there would be a low penetrating radiation dose but the results are not available as yet and he would be looking at this.

Radon exhalation - Dr Akber advised that nuclear disintegration of ^{226}Ra gives birth to ^{222}Rn but only a fraction of ^{222}Rn formed in the top few metres of the ground surface is exhaled. He noted that applied activity on the soil surface will also contribute to the total. Dr Akber advised charcoal cups were used measure radon exhalation rate in 50 locations in duplicate during August 2008. He noted the results show that Radon exhalation rates vary significantly and the relationship between ^{222}Rn exhalation and ^{226}Ra for common woodland. Mr Evans asked if a different result would have been expected if sampling was conducted during the wet season and Dr Akber advised that if the soil is too wet Radon exhalation is much less. Mr Evans asked if this is event based and Dr Akber advised this is complex and obtaining wet season values would be problematic.

Atmospheric Radon - Dr Akber advised that atmospheric Radon was measured across 50 sampling locations in the different LAAs. Sampling will occur all year using sampling heights of 1.5 m, 0.75m and 0.3m. Samples are being taken at different distances from sprinklers and soil radioactivity is also measured. Dr Akber advised the results from this work are complicated but show that Radon concentration at ground level is higher than at 1m height, and looking at site by site basis, there appears to somewhat more mixing at the 1.5m height. Mr Puhlovich suggested that this may mean that there may be greater mixing in areas that have been cleared of vegetation. Dr Akber advised there are no data on this and this is not well understood but seasonality and possibly bushfires could be factors. Mr Hughes asked if there could be density effects and Dr Akber advised there could be thermal and diurnal effects as well but it is important that direct measurements continue to be taken. Prof Johnston noted that each site seems to have a defined range and queried if this was just showing the differences between the various LAA sites. Dr Akber advised there is a broad correlation between atmospheric radon concentration and exhalation rates. Dr Akber advised the key findings from the radon exhalation work to date include: dry season radon exhalation rate in LAAs varies between 10-1000 $\text{mBq m}^{-2} \text{ s}^{-1}$; radon concentration at ground level is higher somewhat than that at higher levels; mixing of air may occur more readily at 1.5m than 0.3 m meaning radon concentration at 1.5m represents origins from a relatively larger area; and atmospheric radon concentration is broadly related to radon exhalation rate.

Resuspension of radioactivity in dust - Dr Akber advised this work is looking at how far dust can travel in and out of LAAs. Based on 3 months sampling it appears that values decrease with distance above ground. Dr Akber advised that airborne radioactivity is not transported in large amounts out or into the LAAs and that airborne dust concentration at 0.3m is perhaps greater than that at higher levels in the breathing zone.

Next steps - Dr Akber outlined the next steps as being to complete field measurements for the annual cycle, laboratory measurements, estimate radioactivity distribution at LAAs, review information for different exposure pathways and develop dose vs. applied radioactivity relationships. He noted the project was delayed and is running over time due to a wild fire damage to the field monitoring stations (posts) but is expected to be completed by April 2010. Mr Kyle asked if the intention of the study is to develop a dose-based approach for the rehabilitation of LAAs, does this mean that the intention is to replace the current concentration based soil guidelines and limits with dose-based assessment criteria. Dr Lu advised this isn't the intention and that heavy metals are also looked at together with vegetation. Prof Johnston advised that he was surprised that natural background activity was high but Dr Bollhoefer advised these levels are consistent with the values *eriss* has also measured previously for Jabiru East. Prof Johnston asked if there is background concentrations available to compare with given the values for radon are so low. Dr Bollhoefer advised that historical data are available including from pre mining and these figures are well above these values (eg. Jabiru was around 10). Dr Bollhoefer asked if the higher values were sampling artefacts and Dr Akber confirmed the values were real and based on actual samples. Prof Johnston noted the work appears to be covering the key issues and the key issues are not so much the actual values being measured but the difference between pre mining and present. Prof Johnston asked for a copy of Dr Akber's presentation.

ARRTC23 Action/Outcome 6.7

ARRTC Secretariat to provide Prof Johnston with a copy of Dr Akber's presentation.

Trial Landform: progress update (Dr Ping Lu)

Dr Lu provided an update on status of the establishment of the trial landform project and the associated infrastructure and revegetation works. The landform physical construction is almost completed as at the end of February 2009 and the effective area for planting is around 6.8 ha. Soil moisture probes (96 soil moisture probes in the centre of 6 plots down to 5-6m below surface) were installed during February and the planting of tubestock commenced on 2 March 2009. All tubestock areas should be completed by 20 March 2009. Installation by *eriss* of one of the 4 erosion plots is almost completed and an initial area of 2.67 ha of irrigation had been installed. A larger area will be irrigated than initially proposed but there will still be a 50m

strip (including the *eriss* erosion plots) without irrigation as a control. The pump out sump has been enlarged to store more water for the irrigation. Mr Evans asked where the irrigation water would be sourced from and Dr Lu advised water would be drawn from the irrigation sump and from a number of bores with initially good quality water.

Dr Lu advised that there had been good mixing of waste rock and laterite in the 2m and 5m capping treatment areas. Dr Grant noted that special tyres can be used successfully for mixing down to 2m depth. Prof Johnston asked how large the rocks in the mix are and Dr Lu advised up to 50cm. Mr Evans noted that the paper from TOs placed a limit on rock size for the rehabilitated surface. Dr Lu advised there are other sites around the lease up to 8 years old that provide a good sense of what the rehabilitated landform will look like.

Dr Lu advised that planting had been carried out and due to lack of consistent rainfall this wet season and the high surface temperatures (~ 50deg C), plants in the erosion plot without extra watering experienced stress and around 40% mortality. As a result, planting was stopped and supplementary watering was commenced. Dr Lu advised that based on the success and vigour of plantings in watered plots versus plants in unirrigated erosion plots, he believed irrigation is necessary. Dr Grant asked how many tubestock species were being planted and Dr Lu advised around 28 species. Dr Lu advised that TOs have been involved in planting, and he would report on the results of surveys of 10 year post rehabilitation plots at next meeting. Dr Grant asked if differences in mortality between waste rock and laterite plots were being detected. Mr Evans noted that laterite would provide higher water retention but only if there was rainfall. Dr Lu advised that a number of plants had recovered following supplementary watering so total mortality was actually closer to 20 percent. Mr Evans asked whether the surface is compacted and Dr Grant noted it would be interesting to have some penetrometer readings in rocky areas.

Dr Lu advised the actions to be completed prior to the next ARRTC meeting included direct seeding in early April, commissioning of the 6 soil moisture monitoring systems (96 TDR probes) and the automated weather station, characterisation of the physical, chemical and nutritional properties of the surface materials, surveys of 4 weeks, 3 months and 6 months plant survival rates, completion of erosion plots and deployment of the Radon caps. Prof Woodroffe noted that looking at the 10 year plot versus the situation with planting given current mortality it is difficult to see how vegetation could develop to that stage. He noted there is a long history of rehabilitation of landform in Ranger area. Prof Woodroffe also noted the absence of soil and organic material. Dr Lu advised in the 10 year revegetation plot there is termite activity and leaf litter, nutrient cycling, birds and other animals present. He indicated he is highly confident that the final landform will look better than the existing 10 year landform site. Prof Woodroffe advised he would also like to see more discussion on climate change implications and suggested the rehabilitation site and analogue ecosystem sites should be surveyed every ten years to detect any ecological changes associated with climate change.

Dr Grant welcomed the progress in the establishment of the demonstration trial landform and noted this has involved significant drive to progress within the company given the current economic climate. He noted there were reasons for the delay but this was still cause for concern. He further indicated that the management of the irrigation regime on the rehabilitated site will be critical and should be documented. Dr Lu advised soil water conditions and irrigation will be closely monitored and the irrigation regime will be actively managed so that the plants will not develop a dependence on irrigation. Dr Lu advised that it is necessary to gain valuable knowledge and experience on revegetation during the dry season using irrigation - it is looking as if this approach may be vital if we are to complete revegetation in the planned timeframe, although we will attempt to start early where possible. A cost/benefit analysis of this trial will be important for closure planning.

6.3 Other stakeholder research activities

There were no other stakeholder research activities tabled.

7 Communication and Knowledge Management

Dr Jones provided an overview of SSD communication and knowledge management activities. He advised that the SSD website was currently being reviewed and updated. The 07-08 research summary report will be published shortly and this is a milestone as it's the 100th such publication and represents the culmination of several years' research. The SSR will be uploaded to the SSD website. Dr Jones advised that information on proposed *eriss* research in Kakadu National Park in 2009-10 was being prepared for presentation to NLC and PAN by 30 April 2009. Dr Jones advised that a large recessional wet season biological sampling and assessment program will be conducted in May, and SSD would seek to engage local indigenous stakeholders in undertaking pop netting. He advised that stakeholders find this activity interesting and it provides a valuable opportunity to find out more about SSD work. Mr Kyle noted that pop netting was very popular with Aboriginal stakeholders.

Dr Jones advised that *eriss* has established a new Spatial Sciences and Data Integration Group which would be tasked with developing a range of corporate knowledge and data management systems, integrating a range of datasets and establishing associated infrastructure to manage the corporate data library. Mr Evans asked if any data would be served externally and Dr Jones advised that data would likely be served to DEWHA, and to other stakeholders on request. He noted this would include species distribution and other ecological data. Mr Evans asked about monitoring data and Dr Jones advised SSD would be looking at this and other technical data management, and building a common data framework including spatial referencing.

Mr Evans noted that there is a lot of work being done on national data standards for water (by BOM and others) which is being done in ARC-Hydro. Dr Barry asked if this is an open format and Mr Evans advised this is just a data standard and that BOM would be developing and offering to serve jurisdictional data to other jurisdictions. Dr Jones noted that data standards are certainly important and underpin SSD's data holdings. He noted there is currently no international standard for raster data. Mr Evans advised that BOM is looking at temporal data as well and suggested that ERA may be interested in the data collation project being undertaken by Ecowise as part of this work. Dr Jones advised that SSD currently uses Hydstra to store its continuous monitoring data. Prof Woodroffe suggested SSD required a staff member to be across all of the licensing issues and Dr Jones advised this would be a key task for the Spatial Sciences group.

Mr Evans noted that there can be significant legal issues involved with data licensing and Dr Jones noted SSD had already faced this with its work on the TRIAP project which proved to be very time consuming. Dr Barry noted data management is always a problem. Dr Jones noted that SSD is also implementing a photo database and due to issues associated with large file sizes and storage requirements, the photos that are imported into it will be resized to 2 MB if they are initially larger. Dr Barry asked if this was standard approach and Dr Jones advised that for the corporate photo database routine images could be used but if images are required for image analysis this can involve very large file sizes, which will be stored in a separate location. Dr Jones noted the project has required a cultural change process within SSD.

Mr Evans noted that ARRTC has previously expressed interest in the number of journal papers being published by SSD scientists. He noted that SSD staff have published 9 papers in the last 6 months and questioned if ARRTC believes this is sufficient. Dr Jones advised that he continues to impress on staff the importance of writing up and publishing projects and noted that the SSD publishing rate is improving. He noted however that there needs to be a balance between delivering on the statutory requirements of SSD and publishing results for peer review. Prof Johnston advised he thought there has been some improvement. Mr Evans suggested it is also important that ERA endeavours to publish the results of its research.

Mr Hughes advised that staff generally appreciate the opportunity to write up their work. Mr Evans noted that sufficient time needs to be allocated to writing up and publishing. Dr Stauber asked if an index based on the level of publishing is taken into account in the internal promotion of staff. Dr Jones advised that publishing history is taken into account. Dr Stauber advised that CSIRO uses the H index and Prof Johnston noted that publishing history is a standard metric used by grant referees. Dr Barry noted that publishing requirements of work in SSD is more linked to individual scientists' standing within scientific community. Prof Johnston asked how the level of research for external consultancy work was determined and Dr Jones advised that although SSD is not driven by external work, it believes that undertaking a certain amount of well targeted external work is of strategic importance. He noted proposals are assessed in terms of relevance to SSD core business, potential conflicts of interest and dollar return. Mr Hughes noted the other criterion is whether the work will enhance SSD's ability to undertake core business. Dr Jones offered to provide ARRTC with further details of SSD's commercial work but Mr Evans advised that ARRTC did not need to get into that level of detail.

ARRTC23 Action/Outcome 7.1

ARRTC commended SSD on progress in finalising reporting of research outcomes and improved data management arrangements to support communication and knowledge management.

Prof Johnston suggested it would be valuable for ARRTC to have social interaction with indigenous stakeholders and asked Mr Kyle if GAC could arrange this as part of the proposed ARRTC field trip next meeting. Mr Kyle undertook to make some enquiries to assess whether this was possible.

ARRTC23 Action/Outcome 8.1

Mr Kyle to advise the Secretariat on feasibility of having an appropriate social interaction between ARRTC members and relevant aboriginal stakeholders during the proposed ARRTC fieldtrip to Ranger at the next meeting.

8 Other Business

Mr Kyle agreed to provide a copy of the report GAC commissioned in relation to tailings seepage to Prof Johnston and the Chair.

ARRTC23 Action/Outcome 8.2

Mr Kyle to provide copy of report commissioned by GAC in relation to Ranger tailings seepage to Mr Evans and Prof Johnston.

KKN Gap Analysis – Day Three

Dr Stauber suggested there is a potential gap in the KKNs regarding the ecotoxicology pulse work and suggested as this is now part of the *eriss* ecotox program, this should be reflected in the KKNs. She also noted there is no mention in the KKNs of Groundwater Dependent Ecosystems (GDE) in lowland areas and questioned whether this is a potential knowledge gap. Mr Evans noted there is a national initiative addressing GDEs and there are legal requirements that GDE environmental water requirements be assessed prior to groundwater development. Mr Puhlovich noted the issue of GDEs was also raised in the Jabiluka independent panel process. Mr Evans suggested the issue of groundwater environmental water requirements of terrestrial ecosystems also needed to be looked at. Dr Stauber noted the current workplan doesn't include this and suggested ARRTC consider if this should be included in the KKNs. Dr Humphrey suggested GDEs could be addressed under the surface water closure criteria. Dr Jones noted that generally there is a large cone of depression around open pits so the issue is really at what stage do decisions need to be made about impacts on GDEs. Mr Puhlovich agreed that ARRTC should specifically flag that GDEs should be considered and noted that aspects of GDEs are already being included in ERA research. Mr Evans suggested that ERA contact the NT Government regarding their current activities in relation to GDEs. Mr Puhlovich noted that GDEs are likely to be raised with ERA in the context of closure criteria anyway.

In relation to insitu snail monitoring, Dr Stauber suggested that she would like to see resources available to make this continuous or weekly or some other way of doing on a continuous basis as the current deployment schedule every second week may be missing the effects of pulses in the system. In relation to KKN 1.3.1 dealing with water transport, Dr Stauber questioned if diffuse sources of solutes are going to be differentiated between surface and groundwater, and noted that the contribution of solutes from LAAs to Magela Creek is currently derived on difference, rather than absolute measurement. Mr Evans noted the mass balance that is currently used is not very accurate and Dr Stauber suggested that more resources may improve the current approach. Dr Jones noted that load is currently being measured both downstream and upstream, with the difference being attributed to inputs from the site. Dr Humphrey noted that previous assumptions were based on what happened in a single wet season and Dr Jones added that this assumed full flushing of the applied salts from the soil profile each wet season. Mr Evans asked if this was a knowledge gap. Dr Stauber asked if diffuse sources from LAAs are being fully taken into account. Dr van Dam advised the project has several elements but was not sure this is being addressed.

Dr Grant suggested the invertebrate baseline data in Gulungul Creek under KKN 2.1 could be a possible gap especially in terms of the proposed heap leach operation, and also the baseline water quality and sediment quality in all catchments may need to be looked at rather than the current focus on just one catchment. Mr Puhlovich noted the Closure Working Group may also raise this issue and agreed sediment quality is important. He noted that ERA may be required to remove contaminated sediment in waterways to protect water quality criteria, so having baseline on sediment quality would be useful. Dr Grant suggested that there may also be a gap under KKN 2.2.2 which probably needs to mention the key role of the closure criteria Working Group in identifying the gaps and required actions. Dr Grant noted in relation to KKN 2.2.3 that while there should be significant information coming from the trial landform, predictive models of seepage and runoff quality over the 5-10 year timeframe were also required. Dr Grant suggested that KKN 2.5.3 has a possible gap in operationalising the seed biology work which is being done but should be explicitly linked. He noted there was also a gap in having sufficient capacity with just having single supplier and there is probably a need for capacity building. Dr Grant also asked Ms Paulka to provide comments on possible gaps regarding revegetation under KKN 4.1.

Dr Humphrey suggested that Dr Barry should see the pollution pathways document and it was agreed that Dr van Dam would provide the report on contamination pathways to relevant ARRTC members.

ARRTC23 Action/Outcome 8.3

Dr van Dam to provide copy of contamination pathways report to relevant ARRTC members.

ARRTC discussed how to best progress the KKN gap analysis and agreed to allocate members to various KKNs based on their expertise as follows:

KKN 1.2.1 TH/SB	KKN 2.2.4 RE/CW/KE	KKN 2.7 SB	KKN 5.2 AH/ PAN
KKN 1.2.2 TH/SB	KKN 2.2.5 Done	KKN 2.8 GM/HS	KKN 5.3 GM/RB
KKN 1.2.3 TH/SB	KKN 2.3 all - RE/AP	KKN 3.1 AP/AH	KKN 5.4 done
KKN 1.2.4 Done	KKN 2.4 All DJ/AP	KKN 3.2	
KKN 1.2.5 TH/RE	KKN 2.5 done	KKN 4.1 CG/SP	
KKN 1.3.1 PJ/JS/AP/SB	KKN 2.6 CG	KKN 5.1 SB/RE/CW	

Mr Evans requested that all members review the KKNs they have been listed against out of session and provide advice on gaps to the Secretariat for collation.

ARRTC23 Action/Outcome 8.4

ARRTC agreed that:

- i) Members will provide comments against relevant KKNs to the Secretariat;***
- ii) Secretariat will update table and circulate to members for review;***
- iii) Members will send back comments for collation; and***
- iv) Secretariat will forward collated comments to Mr Evans and Mr Hughes, and then recirculate to Members.***

Mr Puhlovich agreed to include details in the KKN table on ERA's resources against each project in person weeks.

ARRTC23 Action/Outcome 8.5

Mr Puhlovich to include details in the KKN table on ERA's resources against each project in person weeks.

9 Next Meeting

ARRTC agreed to hold the next meeting in late September/early October 2009 (possibly in the week commencing 12 Oct 2009). Members also agreed to undertake a fieldtrip to Ranger immediately prior to the next meeting. The Secretariat will confirm next meeting date in consultation with members out of session.

ARRTC23 Action/Outcome 8.6

ARRTC agreed the next meeting would be held sometime in late September/early October 2009 and will be preceded by a fieldtrip to Ranger.

10 Meeting Close (1230pm)

No.	Action/Outcomes	Responsibility
2.1	ARRTC agreed that draft minutes are to be circulated 8 weeks after each ARRTC meeting.	Secretariat
2.2	ARRTC agreed that presentations will be placed on the ARRTC members' website following each ARRTC meeting (with the agreement of presenters).	Secretariat
2.3	ARRTC agreed that the minutes should include details of out-of-session discussions between ARRTC members and eriss staff.	Secretariat
2.4	ARRTC agreed the Secretariat will revise draft minutes from ARRTC22 and circulate out of session for approval	Secretariat
2.5	ARRTC noted that ERA and UEL had agreed they would each restrict the type of information presented to future ARRTC meetings and absent themselves should the other party wish to present commercial-in-confidence information.	Mr Puhlovich; Ms Paulka
2.6	ARRTC agreed to consider the draft Terms of Engagement for members and advise the Secretariat on their suitability out of session.	Members
3.1	ARRTC agreed that additional columns be added to the KKN gap analysis table with the headings Priority, Urgency, Timeline and Resources.	Secretariat
3.2	ARRTC agreed to address the KKN gap analysis on the last day of the meeting.	ARRTC
4.1	ARRTC agreed that Mr Puhlovich would provide PDF copies of the Ranger environment and radiation report to Professor Johnston and the Ranger wet season report to the Chair.	Mr Puhlovich
4.2	ARRTC acknowledged the importance of traditional Aboriginal knowledge, noted that this is being taken into account in current research by ERA and eriss, and supported incorporation of this knowledge into closure criteria. ARRTC would be happy to be advised by NLC on how this could be further explored within ARRTC's agenda.	ARRTC; Mr Smith
6.1	ARRTC queried whether the proposed remote sensing work by eriss under KKN 2.5.2 is a high priority. eriss to provide out of session advice.	ARRTC; Dr Jones
6.2	ARRTC endorsed the proposed eriss 2009-10 research program as presented.	ARRTC
6.3	ARRTC requested that eriss review available information on climate change, what this may be predicting for the Alligator Rivers Region and any implications for the work program. This is to be reported at ARRTC24.	Dr Jones
6.4	ARRTC welcomed and commended eriss on progress to date in the proposed U in sediment work.	ARRTC
6.5	Mr Puhlovich to arrange for progress reports on the WRL and CSIRO work on hydrogeology and tailings modelling to be provided to the Chair.	Mr Puhlovich
6.6	ARRTC welcomed and commended ERA on its comprehensive forward program for the two Pit#1 closure studies and endorsed the proposed approach.	ARRTC
6.7	ARRTC Secretariat to provide Prof Johnston with copy of Dr Akber's presentation.	Secretariat
7.1	ARRTC commended SSD on progress in finalising reporting of research outcomes and improved data management arrangements to support communication and knowledge management.	ARRTC
8.1	Mr Kyle to advise feasibility of having an appropriate social interaction between ARRTC members and relevant aboriginal stakeholders during the proposed ARRTC fieldtrip to Ranger at the next meeting.	Mr Kyle via Secretariat
8.2	Mr Kyle to provide copy of report commissioned by GAC in relation to Ranger tailings seepage to the Chair and Prof Johnston.	Mr Kyle via Secretariat
8.3	Dr van Dam to provide copy of contamination pathways report to relevant ARRTC members.	Dr Van Dam
8.4	ARRTC agreed that: i) Members will provide comments against relevant KKNs to the Secretariat; ii) Secretariat will update table and circulate to members for review; iii) Members will send back comments for collation; and iv) Secretariat will forward collated comments to the Chair and Mr Hughes, and then recirculate to Members.	Secretariat; Members
8.5	Mr Puhlovich to include details in the KKN table on ERA's resources against each project in person weeks.	Mr Puhlovich
8.6	ARRTC agreed the next meeting would be held sometime in late September/early October 2009 and will be preceded by a fieldtrip to Ranger.	Secretariat