Environmental Impacts of Uranium Mining

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INTRODUCTION

Aims and Objectives
The aim of my project was to improve my knowledge and understanding of the environmental impacts of uranium mining.

I have been involved in the policy side of radioactive waste management in the UK for a number of years and I am a member of the Committee on Radioactive Waste Management (CoRWM). In 2006 CoRWM recommended to Government that geological disposal was the best long term option for the management of higher activity radioactive waste. Finding a solution to the problem of managing the waste arising from nuclear power station has been an issue for the last 30 years and its solution is considered by many to be a necessary prerequisite for any programme of new nuclear power stations. Advocates of nuclear power argue that this form of power generation is ideal because it does not result in carbon emissions that would contribute to global warming and, unlike various forms of renewable energy, it is reliable and steady. However, these claims do not take account of the environmental impacts of obtaining uranium, which is the primary fuel for nuclear power stations and there have been suggestions that these might outweigh the benefits of nuclear power. Because nuclear power generation is such a controversial social issue, it is difficult to obtain unbiased information so my main objective was to visit uranium mining areas so that I could gain first-hand experience which would help me to form an opinion for myself.

Study Plan
Uranium mining takes place in a number of countries in many parts of the world. I wanted to compare the environmental approaches in two very different countries where I thought there might be a difference in environmental stewardship. My first choices for countries to visit were Australia and Kyrgyzstan. Australia was of particular interest because it has three mines, operating rather differently but all, I believed, with international environmental management accreditation. I also had close contacts with colleagues who have worked in the nuclear industry in Australia who could assist me in making the necessary contacts. Australia was also interesting in that the Federal Government had openly stated its interest in hosting an international radioactive waste repository. Kyrgyzstan, in contrast, no longer mines for uranium but has had considerable environmental problems dealing with its mine tailings and casting residues. It had received international help on this problem and I had been put into contact with experts from the UK who had been involved.

In the event, I was strongly advised against trying to visit Kyrgyzstan because it was considered unlikely that I would be able to obtain access to sites without going under cover and acting illegally. I decided, therefore, to visit Namibia instead. This proved highly fortuitous. In the short time following my first consideration of it as a potential country to study, interest in uranium has increased greatly and the country was at the beginning of a “uranium boom” at the time of my visit.

My plan for each country was to try to meet people directly involved with site management, preferably on-site. I also wanted to speak to the regulators so that I could get a feel for the standards that were being applied. If possible, I also hoped to speak to organizations that were opposed to the mining.
NAMIBIA

Introduction
Mineral mining contributes about 40% of the Gross Domestic Product in Namibia. Uranium mining plays a small but increasing part and Namibia is a major international supplier of uranium ore to nuclear power companies. It does not have its own nuclear power programme although this may change in the future. The World Nuclear Association (WNA) estimates that Namibia holds about 7% of the world’s uranium. The Erongo region in the central and western parts of Namibia is rich in uranium. Much of this land is within the Namib-Naukluft Park, which encompasses the Namib Desert and is an area of considerable environmental significance and fragility. At the time of my visit there were two operating mining concerns which, together, have the potential to supply 10% of the world’s uranium output. Of greater potential significance, there was a plethora of uranium exploration being undertaken by a number of international mining companies under licence from the Namibian government. If even a small number of these move on to production, there are likely to be significant environmental impacts on the National Park.

The Namib desert hosts a unique ecological community known as the Lichen Fields. The ground surface is covered with liken growth. This unique community exists because of an unusual combination of physical, chemical and biological conditions. It is dependent on day time fog and the absence of other vegetation that would prevent the moisture from reaching the soil surface. The chemical properties of the soil, especially in combination of inorganic ions, together with the chemistry of the fog, ensure an appropriate supply of nutrients. It is thought that some of the lichens may be hundreds or even thousands of years old but this ecosystem is extremely specialised and vulnerable to even slight changes in surrounding conditions. Mechanical disturbance, such as that caused by off road vehicles, is a particular threat. The Namib desert is also the home of a “living fossil”, Welwitschia mirabilis which is related to our modern day conifers. Photos showing this plant and the desert conditions can be seen in Appendix 6.

Figure 1 shows the location of the principal uranium exploration and mining sites in the Erongo area of Namibia and their position in relation to the National Park.

Visit Details
I was very fortunate to make contact with Dr Wotan Swiegers of the Uranium Chamber of Mines who was able to introduce me to a people involved in uranium mining from all sectors including, government regulation and research, health and safety, mining companies and environmental bodies. The outline of my schedule of meetings can be found at Appendix 1. While I was in Windhoek I was able to visit the relevant ministries and speak to people working on aspects of mining, health and environmental management. I then travelled to Swakopmund, stopping en route at towns dependent on the mining industry (Arandis, Usakos). Swakopmund is the main administrative centre for the uranium mining sector and I was able to visit company headquarters. My trip coincided with a visit to Namibia by Geraldine Bennet from the WNA and I was able to join her and others in a field trip to visit both operation mines and a number of exploration sites. The itinerary for the field trip is given in Appendix 2.

Details of key visits are listed in Table 1 below.
Figure 1 Uranium Mining and Exploration Sites in Erongo Region, Namibia

Geraldine & Lynda
Visit to Namibia

08/05/2008 - 18/05/2008
Table 1 Discussions held in Namibia

<table>
<thead>
<tr>
<th>Name</th>
<th>Organisation</th>
<th>Role</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr Gabi Schneider</td>
<td>Geological Survey, Ministry of Mines &amp; Energy</td>
<td>Director</td>
<td>Provided very useful background to governance of uranium mining in Namibia.</td>
</tr>
<tr>
<td>Mr Veston Malango</td>
<td>Chamber of Mines</td>
<td>General Manager</td>
<td></td>
</tr>
<tr>
<td>Chris Brown</td>
<td>Namibia Nature Foundation</td>
<td>Director</td>
<td>Both had previously worked as Director of Environmental Affairs in the Namibian Government but had left because they felt they could have greater effect in the NGO sector. Useful discussion of biodiversity and ecological issues.</td>
</tr>
<tr>
<td>Peter Tarr</td>
<td>South African Institute of Environmental Assessment</td>
<td>Director</td>
<td></td>
</tr>
<tr>
<td>Bertchen Kohrs</td>
<td>Earthlife</td>
<td>Director</td>
<td>Meeting over coffee in which she highlighted her concerns over uranium mining in general and the environmental issues for Namibia in particular.</td>
</tr>
<tr>
<td>Dr Pretorius</td>
<td>Technical Advisory Group</td>
<td>Member (Medical Doctor)</td>
<td>Discussion of plans for a medical centre to provide environmental health services and data collation in relation to radiological protection of workers</td>
</tr>
<tr>
<td>Dr Herman Strauss</td>
<td>Technical Advisory Group</td>
<td>Member (Medical Doctor)</td>
<td></td>
</tr>
<tr>
<td>Michelle Yates</td>
<td>Langer-Heinrich Uranium</td>
<td>Environmental Adviser</td>
<td>Discussion of management issues in the mining companies and their approach to environmental management.</td>
</tr>
<tr>
<td>Dr Sam Nuuyoma</td>
<td>Erongo region</td>
<td>Honourable Governor</td>
<td>Courtesy visit to raise profile of environmental issues with senior local politician</td>
</tr>
<tr>
<td>Wyatt Buck</td>
<td>Langer-Heinrich Uranium</td>
<td>Managing Director</td>
<td>Discussion of main issues relating to uranium production industries in Namibia and, in particular, the challenge posed by cumulative impacts from multiple enterprises.</td>
</tr>
<tr>
<td>Malcolm Lindsay-Payne</td>
<td>Uranim</td>
<td>Administration Manager</td>
<td></td>
</tr>
<tr>
<td>Klaus Frielingsdorf</td>
<td>Reptile</td>
<td>General Manager</td>
<td></td>
</tr>
<tr>
<td>Jamie Vecchio</td>
<td>Bannerman</td>
<td>Logistics Manager</td>
<td></td>
</tr>
<tr>
<td>Rod Braby</td>
<td>Namibian Coast Conservation and</td>
<td>Director</td>
<td>Discussion of environmental impact in context of integrated coastal zone</td>
</tr>
</tbody>
</table>
Governance of Uranium Mining in Namibia

Uranium mining is the responsibility of the Ministry of Mines and Energy. Mining is regulated under the Minerals (Prospecting and Mining) Act No 33 of 1992. Unfortunately, Namibia does not have comprehensive environmental legislation, despite the importance of the natural environment to the country’s economy through its tourism industry, but the Ministry of Mines and Energy works in close co-operation with the Ministry of Environment and Tourism. Although an Environment Management Act was promulgated in 2007, this post-dates most licences.

The main objectives of the Ministry of Mines and Energy with respect to uranium mining are to encourage private sector investment that stimulates the economy and provides employment and to generate income from levies from uranium exports and from taxes. At the time of my visit there were about 4 mining licences allowing companies to operate to the production stage but there were over 50 exploration licences and a few retention licences. The moratorium on applications was issued in 2007 to give the Ministry a chance to catch up with the backlog of outstanding applications.

The licensing procedure was explained to me during my visit to the Ministry of Mines and Energy (MME). Application for an Exclusive Prospecting Licence (EPL) is made to MME. Licences are granted for up to 3 years initially with a possibility of renewal. It is not a bidding system on the basis of a release of blocks but rather a case by case application based on the knowledge of the applicant. The Mining Commission Office has to check that the area proposed is in fact free of other claims. The Minerals Act – which was under review at the time of my visit – allows an overlap of EPLs for different groups of minerals. This can create problems, for example where dimension stone (i.e. stone to be used in blocks for work surfaces etc.) is found to be uranaceous granite. There were proposals to remove this provision in the revised Act. The Mining Commission Office vet the application checking on the company, its shareholders, nationality, finances and the geological model presented. Depending on the prospecting required the licence will be granted for 1-3 years. Financial commitments (expenditure costs) are appraised. Information is passed to the Mining Licensing Committee which is made up of MME, the Ministry of Environment and Tourism (MET), Ministry of Finance and, where appropriate (e.g. for sea floor mining) the Ministry of Fisheries. This committee makes a recommendation to the Minister. The Minister normally follows the recommendation. A letter of intent is then sent to the applicant listing conditions, including the requirement for an Environmental Impact Assessment (EIA) and for the company to enter into an environmental agreement with MET. Another condition is the need to report regularly. If further work is needed beyond 3 years the licence may be renewed twice for 2 year periods. Meeting the reporting requirements is an important factor in determining whether to grant a renewal. In exceptional cases the EPL may be extended beyond 7 years. It was noteworthy that, at the time when the moratorium was introduced in 2007, most of the suitable areas were already under licence. As it is politically, and arguably legally, difficult to refuse a mining licence if the holder of the relevant EPL applies for one, this means that there is a very real...
danger of massive expansion of mining enterprises in the Namib with consequent environmental impacts.

Assuming exploration is successful, a mining licence (ML) is granted for 25 years or the operational life of the mine and can be renewed in 15 year periods. Sometimes an EPL will not move straight to a ML but will convert it to a Minerals Deposit Retention Licence which provides a holding ground. They are granted for 5 years and can be renewed once for a further 2 years but are not often granted.

It was proposed to update the mining legislation and a revised Minerals Bill was at an advanced stage of preparation. The present mining policy lacked provision for a funding mechanism for environmental rehabilitation and aftercare. This was considered necessary because there have been a few cases of sudden mine closures resulting in liability falling to taxpayers contrary to the polluter pays principle. The Chamber of Mines had set up a Mine Closure and Rehabilitation Committee to work with the MME Committee to consider the issue of funds and also how the funds should be used and in particular what will happen to the community after the closure of a mine. The Minister wants the mines to finance a social fund as part of the closure plans. The alternative would be to go for retraining on an ongoing basis. A draft was produced 2 years ago and was out for peer review at the time of my visit. It was noted that the mines did not favour a general levy but two or three mines had already set up environmental trust funds. Progress with the legislation was expected to be slow. It had taken years for the Environment Management Bill to be passed; it eventually did so in 2007.

The current Act based licensing on minerals or groups of minerals. It had been proposed to move to area permits and the Bill was accordingly so drafted. But there had been a re-think and a U-turn because of concerns that it would lead to areas being landlocked and thereby denying optimal utilisation.

In order to prepare for the impacts of a big uranium boom, the independent Chamber of Mines has set up a Uranium Committee to provide a stewardship function and ensure that agreed international best practice standards are applied.

The Ministry of Health and Social Services is responsible for radiation protection. There is basically a 1 man department looking after radiation. There is now an inter-ministerial radiation committee formed of 5 ministries. There is also a standing committee between the Ministry of Health and Social Services and the Stewardship Council which meets monthly. There is one code of practice for mining under development. The Atomic Energy and Radiation Protection Act 2005 lacks the necessary regulations but these are in draft and were expected to go to review shortly after my visit. It is likely that a subset may be needed for uranium mining.

I questioned whether there was strategic thinking within Namibia to ensure that it retained uranium for its own nuclear power plants should these be forthcoming. There was no indication that this was the case and it was noted that the cost of uranium was only about 3% of the cost of nuclear power production. Electricity has been very cheap – mainly imported from South Africa. South Africa now had a power crisis, however, mainly because of poor maintenance of its nuclear facility and was not exporting – indeed there were regular planned outages. I was able to experience these first hand in the few days that I spent in Cape Town en route to Namibia from the UK. The energy crisis was not regarded as all bad news, though, because it has encouraged innovation and greater energy efficiency. Namibia needs about 420-430 MW pa but only generates 385 MW. A new nuclear power station would generate about 1200 MW. It was agreed that the time was ripe for an
innovative nuclear programme. There was talk of government support for the South African (German) pebble bed modular design nuclear reactor.

In my discussions with Chris Brown and Peter Tarr, both of whom had previously worked for the Government, concerns were raised over the capacity of the government to address environmental issues, especially in relation to environmental assessment. It was implied that staff lack confidence and are sometimes bullied by developers seeking licences. On the other hand, there is no huge disagreement over what needs to be done; differences lie in how to get there. It was abundantly clear that there was a severe shortage of qualified staff in the public sector, especially in relation to radiological protection. Salaries are low and the industry offers far better terms of employment. Also most of the senior staff positions, both in the public and private sectors, are held by non-nationals many of them on temporary contracts.

**Site Visits**
The most exciting part of my visit to Namibia was undoubtedly my participation in the field trip around the mines and exploration sites in the Erongo Region. This not only provided me with the chance to see the enterprises for myself, it also gave me the opportunity to talk with key persons in an informal setting over the course of several days. As an unexpected added bonus, I was also able to experience the beauty of the Namib-Nauklift Park and explore areas that are normally out of bounds to visitors all in the company of experts in desert ecology. The sites visited are listed in the following table.

**Table 2 Site Visits in Namibia**

<table>
<thead>
<tr>
<th>Site</th>
<th>Activities</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rössing</td>
<td>Operating Mine</td>
<td>View of mine pit, tailings and processing plant. Talks on environmental and health management.</td>
</tr>
<tr>
<td>Trekkopje</td>
<td>Proposed mine site</td>
<td>Discussion of exploration process and environmental management practices and regulations. Discussion of pollution impacts if proceed to production.</td>
</tr>
<tr>
<td>Valencia</td>
<td>Proposed mine site</td>
<td></td>
</tr>
<tr>
<td>Bannerman</td>
<td>Proposed mine site</td>
<td></td>
</tr>
<tr>
<td>Swakop Uranium</td>
<td>Proposed mine site</td>
<td></td>
</tr>
<tr>
<td>Langer-Heinrich Uranium</td>
<td>Operation Mine</td>
<td>Tour of processing facilities. Talks on environmental management and health and safety procedures</td>
</tr>
<tr>
<td>Wlotskabaken Desalination Plant</td>
<td>Desalination plant for mine</td>
<td>Visit to construction site. Discussion of impact on coastal environment and potential community benefits.</td>
</tr>
</tbody>
</table>

**The Mines**
The location of the main mining and exploration areas is shown on the map in Figure 1.

**Rössing**
An outline itinerary for the site visit is given in Appendix 3. Rössing Mine was commissioned in 1976 and reached full production levels in 1980. Rio Tinto is a major shareholder. It is an open pit mine excavating low grade uranium ore (uraninite), a form of uranium dioxide, from granitic rocks known as alaskites. For every 1000 tonnes of uranium won some 3 million tonnes of rock have to be excavated. Once the ore-bearing rock has been excavated it has to be processed to extract the
uranium. This is done through a series of mechanical and chemical processes carried out in the following stages. Once rock has been removed by drilling and/or blasting it is tested for uranium content and any non-ore bearing loads are disposed of to waste tips. The uranium-bearing rock is then crushed and then ground down to a coarse sand. The uranium is then leached out following an oxidation process using ferrous sulphate and then dissolved in dilute sulphuric acid. The result of the leaching process is a pulp consisting of sand and slime. The sand is separated by cycloning and, after washing, is disposed of to mine tailings. The slime is then thickened by removing water – which also goes to the tailings – and is then passed through an ion exchange system to extract the uranium. After passing through the ion exchange system the solution (called the eluate) is further extracted using an organic solvent and dissolved in a neutral solution of ammonium sulphate. This solution is then precipitated and filtered to produce “yellow cake” which is a form of uranium oxide (U₃O₈).

The processing plant and the associated tailings disposal operations consume most of the water at the mine. Tailings – which are the remaining crushed and milled ore rock from which uranium is extracted – are pumped as a mixture of sand, fines and water to the tailings facility. The water forms a pond on the tailings facility, and from there it is recovered for reuse in the mills.

**Langer-Heinrich**

The Langer-Heinrich mine was commissioned in 2007 and was expected to reach full production by 2010. Because the uranium is associated with different geological conditions from those found at Rössing, the production process is somewhat different, most obviously in the absence of a deep mine pit. The mine is based on a calcrete-hosted secondary uranium deposit associated with valley-fill sediments in an extensive Tertiary palaeo-drainage system. Calcrete is a secondary, chemically precipitated limestone that forms under arid to semi-arid climatic conditions. Uranium occurs as carnotite, an oxide mineral containing both uranium and vanadium, deposited as thin films lining cavities and fracture planes and as grain coatings and disseminations. Mineralisation is near-surface, between one metre and 30m thick, and between 50m and 1,100m wide, depending on the width of the palaeo-valley. The deposit occurs over a 15km length in seven higher grade pods within a lower grade mineralised envelope. At the time of my visit there was a proven and probable reserve base of 24.5 million tonnes at a grade of 0.07% U₃O₈ which suggests a 27 year life for the mine with the potential for extension of the reserves and mine life given favourable surrounding geology.

Because the uranium is present as a coating on the sediments, it is not necessary to grind the material finer, but only to remove the surface layer from the individual grains. So instead of crushing and grinding, as at Rössing, the process at Langer-Heinrich uses crushing and scrubbing to break down agglomerates into individual grains and to remove the uranium minerals from the grain surfaces. A process of screening and centrifuging is then employed to separate the high grade fines (Leach Feed) which are then thickened. The resulting slurry is mixed with carbonate and bicarbonate, heated and pumped to the leach circuit and then a decantation circuit in which the high grade uranium solution is removed from the solids. After clarification the uranium is recovered onto an ion exchange resin from which is stripped, precipitated as sodium diuranate and redissolved in sulphuric acid before being re-precipitated with hydrogen peroxide. The product is dewatered, dried and drummed as UO₄, rather than the more usual yellow cake product.

**Exploratory Activities**

At the time of my visit, several different companies were undertaken exploratory drillings to determine whether it was worthwhile applying for a licence to proceed further to a mining operation. I visited field sites under investigation by Uranim, Reptile and Bannerman. There is little to see at these field sites. The general procedure is to undertake a series of pre-planned
drillings from which cores are bagged for later examination in the laboratory. There may or may not be associated temporary buildings to provide offices and facilities for workers. Most of the exploration sites I visited were on flat sandy desert but we also saw excavations in rocky outcrops in the more mountainous regions to the East (the so-called “moon landscape”).

Environmental Issues
All of the companies that I visited were well aware of the need to take account of environmental protection in their work. Most were large international companies with head offices based in developed countries. For the operating companies, there are strict environmental and health and safety protocols set up as part of company policy and to comply with legislation – both in Namibia and in the home country. Radiological protection is an issue, but not on the same magnitude as occurs in nuclear power stations. Uranium needs to be enriched before it can be used in power generation and the potential doses for nuclear power plant workers are much higher than for mine workers. The main environmental issues, therefore, were not about radioactivity but as such but were more to do with the impact of a mining operation in a fragile and arid environment with a low human population.

The main environmental issues can be categorised under the following headings:

- the potential incompatibility of mining operations within a national park;
- the need for housing and social services for employees;
- provision of infrastructure including access roads, electricity cables, water pipelines;
- water resources and electricity supply;
- public health issues related to radiation (mainly airborne);
- groundwater pollution;
- impacts of biodiversity, especially in fragile desert ecosystems.

All of these are exacerbated by the prospect of cumulative effects from a burgeoning uranium production industry spread across many different players. Although each company can claim to be achieving high environmental standards, these claims have to be judged against the lack of any uniform minimum environmental standards and a fragmented and incomplete legal framework. Worker health and safety for on-site workers is probably higher than might be expected for the rest of the population and I saw plenty of evidence of efforts by individual companies to minimise their environmental impacts. Nevertheless, it is impossible to carry out full scale uranium mining without having an environmental impact. In my view, the main issues for the Erongo region are:

- damage to the fragile ecosystems in the Namib occasioned by soil disturbance from vehicles and pipelines and disturbance by people;
- the need for large quantities of water, in excess of that which could be provided by the national water company. The construction of desalination plants to provide water for the industry mitigates this problem but creates its own environmental concerns, not least the energy costs involved in the desalination process;
- lack of effective governmental control over the exploration process because of the largely indiscriminate granting of exploration licences in previous years with the expectation that these would be upgraded to production licences if uranium was found.

In my discussions with Michelle Yates, who had recently taken up the post of Environmental Adviser to Langer-Heinich, she started by referring to the big environmental threats presented
by the uranium boom. However, she would not, or could not, articulate what these threats were and instead focused on governance issues, her thesis being that the problems were easy to solve if there was the correct management structure to do so. She does not think the environmental issues are the problem; it is more about attitudes and behaviour, corporate governance and ethical behaviour.

**Personal Highlights**

The field visit was definitely an unrepeateable and wonderful experience. I greatly enjoyed being able to visit a unique ecosystem and get close up views of the famous lichen fields and the living fossil plant *W mirabilis*. I also took a boat trip in Walvis Bay during which we had extremely close encounters with sealions and pelicans and the eerie experience of being caught in one of Swakopmund’s notorious sea fogs.

The journey from Windhoek to Swakopmund (by car) took us through some spectacular scenery and provide the opportunity to visit some small villages and experience local hospitality. While in Swakopmund, I took the opportunity to take a personal tour around the local township to see how the local residents live. Again I was greeted with great kindness – even when I decline the offer of eating some gross caterpillars!

The most important aspect of the trip, however, was getting to know Dr Wotan Schneider without whose help and kindness I would have achieved far less.
AUSTRALIA

Introduction
Australia is rich in minerals and mining has a long history as a major industrial sector in the country. Uranium mining is fairly small in the minerals sector in Australia. I was told that in terms of dollar export it probably does not feature in the top 20 minerals. The main ones are iron and coal and in terms of these, uranium mining is a tiny fraction. Nevertheless, Australia holds the world’s largest uranium reserves (nearly a quarter of the total) and is the second largest exporter of uranium ore. Production averages at about 10,000 tonnes of uranium oxide per annum which is equivalent to 8,500 tonnes of uranium. There are three operating mines at Olympic Dam, Beverley and Ranger and strong prospects for more facilities to open. Uranium mining has been a politically sensitive issue in Australia for several decades and for many years there was a moratorium against new mines. The main issues are (1) a strong anti-nuclear stance and (2) the possibility of interference with Aboriginal land holdings.

The environmental issues are comparable to those in Namibia – disturbance, nuisance, radiological protection, water pollution and water resources, energy needs, ecological impacts, national parks – but the social and political contexts are very different.

Figure 2 shows the location of the mining operations in Australia.

Visit Details
It was my intention to visit mining operations in the desert area of South Australia and compare these with Ranger mine which is located in the Northern Territory. I also wished to gain an understanding of the legal and regulatory regimes governing uranium mining as well as the political attitudes towards it. The position is more complex than in Namibia because of the need to take account of both Federal and State regimes. There is also a far more developed support system in the shape of research institutes, notably the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

My starting point was to renew my contact with Dr Ann Littleboy, who I had met when she was working in the UK. I am very grateful to her and her colleagues at CSIRO for spending time with me and, in particular, for explaining the nuances of the cultural and political situation pertaining at the time. It is also thanks to her that I was able to get into contact with senior staff at the three operating mines and to arrange meetings with regulators at both State and Federal level. Unfortunately, because of my need to return home at short notice, I was unable to meet any regulators and could not visit Ranger. However, I did have a very full programme of meetings and visits in Brisbane and Adelaide, including an overnight visit to Olympic Dam.

Key meetings are listed in the following table.

Table 3 Discussions held in Australia

<table>
<thead>
<tr>
<th>Name</th>
<th>Organisation</th>
<th>Role</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anna Littleboy</td>
<td>CSIRO</td>
<td>Director of Minerals Future</td>
<td>Background information on uranium mining in Australia.</td>
</tr>
<tr>
<td>Paul Degnan</td>
<td>CSIRO</td>
<td>Geoscientist, Minerals Future</td>
<td>Detailed discussions of the problems of acid in situ leaching</td>
</tr>
<tr>
<td>Rhys Worrall</td>
<td>CSIRO</td>
<td>Researcher, Minerals Future</td>
<td></td>
</tr>
</tbody>
</table>
Governance of Uranium Mining in Australia

The Australian Government

Day to day management of the mines comes under State jurisdiction but mining operations do have to comply with Federal laws and meet prescribed national standards. In particular, the Australian Government has a strong influence on environmental management through the Environment Protection and Biodiversity Conservation Act 1999 (EPBC). Amongst other things, this Act sets out requirements for environmental impact assessments (EIA). Before any new mine can open, approval is required from the Australian Government. Such approval is also a requirement for any major expansion, intensification or moderation of mining operations if these are likely to trigger the need for an EIA. At the time of my visit the proposed expansion of the Olympic Dam mine was being assessed under the EPBC Act.

Environmental health issues of uranium mining come within the remit of the Australian Radiation Protection and Nuclear Safety Act 1998 under which various codes of conduct are promulgated, mainly covering aspects of safe transport of radioactive materials.

There is also national legislation enacted to ensure that the rights of indigenous people are properly respected. This is particularly important with respect to Ranger mine as this is situated in Aboriginal land in Northern Territory.

State Government

The role of the State Government is to ensure that the mining operation meets the requirements of international and national standards. The regulatory regime appears to be at least as strict as that applying in the UK and, unlike the situation pertaining in Namibia, there seem to be sufficient resources and capacity to ensure that standards are enforced.

In Western Australia exploration licences are time limited to five years with annual audits to check that the company is spending to the extent proposed. After five years any renewal could be for a smaller area with a greater spend per square metre. The idea is to stop prospectors sitting on the resource. There are prescribed conditions for rehabilitation etc. Prior permission is required for disturbance of the surface and for drilling and there are conditions relating to groundwater. There may be a requirement to plug abstraction holes to prevent mixing of aquifers. Once exploration is finished the operators are required to remove all materials brought in and rehabilitate surface by scarifying. For mining, it is a condition to back fill and bury all tailings. This requirement has not been tested in other states for uranium mines yet but I was told that it was expected that the same rules would apply, although this would not be possible for the planned Olympic Dam expansion given the scale of that operation. Instead, the idea there would be to contour it.
Under the Mining Act 1971, mine operators have to obtain a mining lease. The lease is renewed at regular intervals, generally every seven years. Inspections are conducted to ensure compliance with the conditions of the mining lease. Operators must also produce a ‘mining and rehabilitation program’ to minimise the environmental effects of mining and milling and ensure adequate rehabilitation of mining sites. It is also necessary to have an approved ‘environmental management and monitoring plan’ covering waste management, flora and fauna, groundwater, spills and air emissions.

The main piece of radiation regulatory legislation is the Radiation Protection and Control Act 1982. This sets out the procedure for obtaining a Licence to Mine or Mill Radioactive Ores. The Minister for Environment and Heritage issue such licences subject to conditions, the most important of which is a requirement to comply with the Australian Government's 2005 Mining Code. Under this code, uranium mines must have an approved 'radiation management program' and an approved 'radioactive waste management program' in place. Results of environmental radiation monitoring conducted under the requirements of the radioactive waste management program are analysed and reported annually.

**Research and Development**

CSIRO is a federally funded agency with about 6500 staff across Australia carrying out research in many areas but concentrating particularly on medical and biodefence issues. It had recently been asked by the Government to launch a number of initiatives in collaboration with others. These come under the banner of ‘National Research Flagships’ and one of these is Minerals Down Under which is designed to provide a better understanding of mineral deposits and to look at new reserves with a view to economic exploitation while at the same time considering social and environmental aspects. Minerals Futures is one of the research stream subsets within the Flagship, and is being undertaken at the Queensland Centre for Advanced Technologies near Brisbane.

**Visit to Olympic Dam**

Olympic Dam is Australian’s largest underground mine extracting several different minerals. It is primarily a copper mine but is also exploiting the world’s largest uranium deposit. Unlike the operations in Namibia, Olympic Dam is an underground mine. I decided that it was not good use of my limited time there to go underground although the opportunity was offered so I was not able to see all of the processes involving in producing the uranium ore. However, I did have a personal tour of the processing facilities including taking a trail around the tailing ponds. These are enormous – we went around them in an off road vehicle and the whole trip took nearly an hour.

Most of Olympic Dam's employees live in Roxby Downs township, about 16 km south of the operations. The township has a population of about 4000 and is, in essence, a mining town owing its entire existence to the Olympic Dam mine. The houses are modern, well laid out and the town has all the usual modern facilities expected of a small remote town. It is serviced by its own airstrip and there are scheduled flights from Adelaide (which I used). A few miles north of Roxby Downs there is another mining settlement of a very different nature. This is Andamooka. It grew up around fossickers – from many different parts of the world – all prospecting for opals. I was fortunate enough to stay in the Andamooka Dukes Bottlehouse Motel overnight and thus able to get an insight into a very different mining experience. There are small slag heaps everywhere, giving the town a moonscape landscape, and the settlement has clearly developed in a higgledy piggledy fashion. These can be seen in Appendix 7.

The underground mining operation is highly mechanised. Once the ore reaches the surface it is taken through a series of grinding stations. The resultant slurry passes to a flotation circuit where a
series of flotation stages and a further regrinding activity produce a copper concentrate. The concentrate then passes through a leaching circuit which is principally designed to extract uranium from the copper minerals. Uranium is extracted in a solvent extraction plant, producing yellow-cake, which is subsequently calcined to produce uranium oxide concentrate and then packaged in drums for export sales.

I spent a lot of time with Frank Harris, the Environmental Manager at Olympic Dam. BHP Billerton, which owns Olympic Dam, prides itself on its environmental management and has achieved ISO 14001 accreditation. The main issues are the management of the tailings dams and the need to obtain the necessary approvals for a proposed mine expansion. The surrounding desert ecosystem is clearly very sensitive and the company is spending considerable time and money on ecological studies.

The proposed mine expansion would take Olympic Dam up to a new level. The planned expansion is massive. At the time of my visit 9.5 m tonnes were being taken out from underground and there was a slight increase on the books to 12 m tonnes. Stage 2 would be massive open cast pit that would be bigger than the entire inner city of Adelaide. If the expansion goes ahead it is expected to produce 19-20,000 tonnes of uranium oxide. It would be a very costly enterprise. It would take four years, using 100 trucks to get down to the 400 meter depth band where the ore is found. The resulting open pit would be almost an order of magnitude bigger than Rössing in Namibia.

Issues Surrounding Uranium Mining in Australia
It is impossible to separate out the environmental issues from the cultural and political context operating in Australia. Because I was unable to visit Ranger, I have not been able to draw comparisons between the two mining operations based on personal experience. Instead the following paragraphs highlight some of the issues that were raised in discussions.

Political Issues
Uranium mining is highly contentious in Australia. For a long time there was a ‘3 mines’ policy which limited further mine development but this was abolished and the cap has remained off even with the change in Federal Government which occurred shortly before my visit. On the other hand, no one thought there was any likelihood of a boom although some commentators felt that the relaxation could well stimulate exploration and wider definition of resources. Getting these on-stream will take a fair while however. There are huge resources there but considerable issues surrounding the prospect of further exploitation, including damage to important natural sites and the impact on indigenous people. So there was a strong undercurrent within Australia that the people do not want to allow it again. On the other hand, Australia recognises the economic potential of India and China and has allowed uranium ore exports to China; these had previously been prohibited because they are not signed up to the Non-Proliferation Treaty. This new trade might stimulate growth.

Water Resources
Water resources present a huge problem in Australia. Desalination is being introduced for the first time in New South Wales and the Queensland coast for domestic use. This is not without controversy given the enormous costs and the use of fossil fuels; it is hugely energy intensive. Yet Australia remains profligate with its water. The Environment Manager at Olympic Dam confirmed that water is a critical issue. It was acknowledged that it would not be possible to get enough water from the Great Artesian Basin. There were plans to create a major desalination plant 300 km to the and there were indications that the Government might piggy back onto this and use it to supply water to the whole of the State. The alternative of taking water from the Murray River was a non-starter. I heard from several sources that management of the Murray/Darling River basin – which
crosses the State boundary – had been very unsatisfactory, largely because of a lack of joined up government.

**Site Rehabilitation**
The management of tailings is a major issue, especially in the public’s mind because this is the visible outcome of mining wastes. By way of illustration, I was told of a current issue in South Australia where a mining company carried out explorations in what had been described as a ‘sanctuary’ although this had no legal status. The company had not followed the correct procedures although they did not cause harm to environment. They buried some residues in sample bags in trenches, some of which were radioactive - which was against the regulations. It has become an issue with the State Governor getting involved and it is unclear whether this company would be granted a licence should they wish to go forward with the site.

**Personal Highlights**
The field visit to Olympic Dam was spectacular, not least because of the location. The Tailing Dams, while potentially an environmental hazard, look spectacular and have a beauty of their own. It was also fascinating to compare an old-fashioned very low scale mining operation at Andamooka with the modern set up at Olympic Dam.

I took the opportunity to do some sight seeing while in Brisbane and Adelaide. I greatly enjoyed seeing such interesting and unusual wildlife ranging from garish and noisy parrots through to hole-nesting penguins and enormous seals through to cuddly looking koala bears.

Again, as in Namibia, I was overwhelmed with the kindness of everyone I met and their generosity in giving me their time. Not least, I am very grateful for the concerns expressed by people at my sudden departure back to the UK. I very much hope to be able to continue where I left off at some time in the not too distant future.
Fig 2 Australian Uranium Resources
Postscript
It had been my intention to follow up my study visit with one or more publications that would enable me to disseminate some of the outcomes of my visit to the nuclear community. I was encouraged in this intent at the selection interview for the award.

This is still my intention, but I was reluctant to proceed without completing the work. My father now needs full time care, however, and I doubt that I will be going back to Australia in the near future. However, I hope to be able to follow progress with the various exploration and expansion activities remotely through the contacts I established during my visit.

The table below gives an indication of my intended publications at the time of my visit. It is likely that I will have to revisit this to some extent but I still intend to proceed with this work as time permits.

*Table 4 Proposed Dissemination Plan*

<table>
<thead>
<tr>
<th>Topic</th>
<th>Type of Publication</th>
<th>Possible Outlet</th>
<th>Audience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental analysis of nuclear fuel cycle</td>
<td>Academic</td>
<td>Academic Journal (eg Global Climate Change)</td>
<td>Social scientist academic community</td>
</tr>
<tr>
<td>Regulation of uranium mining in Namibia and Australia – a comparative study</td>
<td>Academic</td>
<td>Environmental law journal (eg Journal of Environmental Law)</td>
<td>Environmental lawyers</td>
</tr>
<tr>
<td>Environmental impacts of uranium mining – regulation and mitigation</td>
<td>Academic</td>
<td>Academic journal (eg Environmental management)</td>
<td>Environmental management professionals and academics</td>
</tr>
<tr>
<td>Ethical and societal issues of uranium mining in the context of nuclear new build in the UK</td>
<td>Popular</td>
<td>Environmental journal (eg Ecos)</td>
<td>Interested public</td>
</tr>
<tr>
<td>Biodiversity impacts of uranium mining</td>
<td>Academic</td>
<td>Academic (eg Conservation Biology)</td>
<td>Professional conservationists</td>
</tr>
<tr>
<td>Date</td>
<td>Day</td>
<td>Itinerary</td>
<td>Actions</td>
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<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
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</tbody>
</table>
| 08/05/08  | Thursday  | • Geraldine and Lynda arrive in Windhoek. Pick up WRSS                     | • Flight No: SA 074 1155  
• Flight No: SA Express 0720  
• Accommodation: Pension Onganga (N$=R1)NS 407 PP/PN+ B/F(inc)  
www.onganga.de                                                                 | L W G B WRS        |
| 09/05/08  | Friday    | Consultations with MME, MoHSS, MET and Earth life                         | • 09H00 - Veston Malango - GM CoM, Dr. G Schneider DGS and Mr E Shivolo DM- MME  
• 12h30 Lunch Peter Terr (SAIEA) and Chris Brown (NNF) at NICE  
• 14h30 Mrs. E Awaseb – DD MoHSS  
• 16H30 Bertchen Kohrs – Director Earth Life                                                                 | WRSS               |
| 10/05/08  | Saturday  | Drive to Swakopmund via Omaruru and Usakos WRSS (Very nice scenic route)  | • 08H00 to +/- 16H00  
• Accommodation: Swakopmund Sea – Side Spa & Hotel (N$=R1)N$ 700 PP/PN + B/F (inc)                                                                 | WRSS               |
| 11/05/08  | Sunday    | Enjoy Swakopmund and Walvis Bay                                            | Suggested tours:  
• Dolphin Tours  
http://www.namibiancharters.com/walvis-bay/  
• Desert (the small S)  
http://namibia-1on1.com/Namibia-Tour/Advertizers/Living-Desert-1.html                                                                 | LW GB              |
| 12/05/08  | Monday    | Visit RUL (Mike Leech, Rainer Schneeweiss and Co) +/- 70 km               | • 08h00 – Mike Leech MD RUL  
• 09h00 - Rainer Schneeweiss Supt SD  
• 11h00 – Mine visit  
• 12h30 - Lunch  
• 13h00 - Meeting Environmental & Sustainable Development Group  
• 16h00 - Back in town                                                                 | RS                 |
| 13/05/08  | Tuesday   | • LHU/ Trekkopje(Area), Reptile Uranium consultation  
• Consultations NACOMA                                                                 | • 08H00 Wyatt Buck (LHU) & Malcolm Lindsay-Payne(Uramin) & Klaus Frielingsdorf (Reptile) & Jamie Vecchio (Bannerman)  
• 10H00 - Rod Braby Director (NACOMA)  
• 12.30- Lunch Brauhaus  
• 14H00- Hon Governor Sam Nuuyoma                                                                 | WRSS               |
| 14/05/08  | Wednesday | Discussions Technical Advisory groups Swakopmund. Municipality of Swakopmund. | • 09H00 - Meeting TAC at Stadtmitte CoM Office (M Yates, Amanda Horn, Herman Strauss, J Pretorius, A Brummer, S Labuschagne)  
• 14H00 Township Tour                                                                 | WRSS               |
| 15/05/08  | Thursday  | Depart on Desert Tour with Pieter Mostert  
Mining Environmental Tour                                                                 | 08H30 - Depart from RUL Offices Swakop to Omdel Dam, RUL, Trekkojie and Valencia, Overnight at Vergenoeq Desert Camp                                                                 | PM                 |
| 16/05/08  | Friday    | Desert Tour and discussions with Environmentalists and Pieter Mostert     | 08H00 - Travel via Swakopmund to Bannerman, Swakop Uranium, LHU, overnight Gobabeb Research Station                                                                 | PM                 |
| 17/05/08  | Saturday  | Return to Swakopmund                                                     | 08H00 - Return to Swakopmund via Kuiseb river mouth and visit Desalination Plant Wlotskasbaken  
14H00-Free                                                                 | PM                 |
| 18/05/08  | Sunday    | Lynda & Geraldine back to the UK from Walvis Bay?                         | 13h20 Departure Windhoek  
13h15                                                                 | LW GB              |

- Whk – Swakopmund 385 Km
- Swakopmund – Desalination plant 35 Km
- Swakopmund – Walvis Bay 33 Km
- Swakopmund – Rossing 70 Km
- Swakopmund – Langer Heinrich 80 Km
Appendix 2 Chamber of Mines / Rössing Conservation Trail to Visit the Uranium Mining and Exploration Operations in the Erongo Region: 15-17 May 2008

- 15 May 2008
  - Depart Rössing corporate offices: 08h00 – 09h00
  - Rössing Tour: 09h00 – 10h00 (Alwyn Lubbe)
  - Travel to Trekkopje: 10h00 – 11h00
  - Site visit Trekkopje: 11h00 – 13h00 (Paul Day /Jonathan Church)
  - Lunch 13h00 – 13h30 (Pieter Mostert)
  - Travel to Valencia 13h30 – 14h30
  - Site visit Valencia 14h30 – 16h30 (Lima Maartens)
  - Travel to Vergenoeg 16h30 – 17h30
  - Discussions/Braai/overnight

- 16 May 2008
  - Travel to Swakopmund 08h00 – 9h00
  - Travel to Goanikontes/Bannerman & Moonlandscape 09h00 – 11h00
  - Travel to Swakop Uranium 11h00 – 11h30
  - Site visit Swakop Uranium 11h30 – 13h00 (Martin Spivey)
  - Lunch 13h00 – 14h00
  - Travel To Langer Heinrich 14h00 – 14h30 (Wyatt Buck)
  - Site visit Langer Heinrich 14h30 – 16h00
  - Drive to Gobabeb 16h00 – 17h00
  - Discussions/braai/overnight 17h00 -- 18h00 (Joh Henschel)

- 17 May 2008
  - Visit Reptile Uranium 08h00 – 09h00 (Klaus Frielingsdorf)
  - Drive to Walvis Bay via Kuiseb 09h00 - 11h00
  - Drive to Wlotzskabaken & Des. Plant 11h00 – 12h30
  - Drive to Swakopmund 12h30 – 13h00
Appendix 3

VISIT BY

Mrs Geraldine Bennett, World Nuclear Association

Professor Lynda Warren, Winston Churchill Memorial Trust

on

Monday, 12 May 2008

Monday, 12 May 2008

08:00 Dr Wotan Swiegers to accompany the visitors to the Swakopmund Corporate Office
08:00 Meet with Michael Leech, Managing Director, Corporate Offices
09:00 Meet with Rainer Schneeweiss, Superintendent Land Use Management
10:00 Drive to mine site with hired vehicle
10:45 Park vehicle at the parking area to the right of the main gate; Clear Visitors’ Permit;
Met by Alwyn Lubbe, Acting Supt Corporate Communications; Transfer to Rössing Combi; drive to Visitors Centre
11.00 Refreshments; corporate audio-visual, with Frances Anderson, Manager Sustainable Development & Amanda Horn, Supt Community Relations
11:30 Tour of Open Pit & Tailings Dam with Frances Anderson & Amanda Horn
12.30 Light lunch – Alaskite Boardroom, New Management Building
13:00 Discussions with Frances Anderson & Amanda Horn at the Alaskite Boardroom
15:00 Return to main gate and depart with own transport

Please cut out and keep information below on your person while you are on site:

Rössing Uranium Limited Visitors
Contact phone numbers Rössing Mine
5202 333
Mike Leech: Managing Director
Telephone: 5203001 or 081 129 3129

Willem van Rooyen: General Manager Operations
Telephone: 52022316 or 081 122 5221

ISOS Emergency
400700
Appendix 4 Study Visit to Australia Itinerary

May 22  Minerals Down Under National Research Flagship, CSIRO, Queensland Centre for Advanced Technologies – meetings with Anna Littleboy and Paul Degnan
May 23  Minerals Down Under National Research Flagship, CSIRO, Queensland Centre for Advanced Technologies – meetings with Rhys Worrall and Paul Degnan
May 26/27  Olympic Dam
May 29  Meeting with Peter Woods, Heathgate (Beverley)
May 30  Meeting with Ian Gould; telephone with Greg Hall
June 1  Ian Hore-Lacy
June 2  ARPANSA – Melbourne
June 3  ARPANSA – Sydney
June 5  ANSTO – Sydney
June 11  Ranger Mine visit
June 12  Meetings with ERA in Darwin

Note: Dates in italics refer to proposed itinerary. Unfortunately my visit was curtailed because my father had a stroke and I had to return to the UK on June 1.
Appendix 5 Key References


Australian Government, Geoscience Australia, 2005 Why Australia has so much uranium. AUSGEO News, 80


Deloitte Touche Tohmatsu (Insight Economics) 2008 Outlook for the Uranium Industry: Evaluating the economic impact of the Australian uranium industry to 2030, Australian Uranium Association

Earthlife Africa Namibia Branch, 2005 Evaluation of selected aspects of the environmental assessment report for the Langer Heinrich Uranium Mining Project in Namibia.


House of Representatives, Standing Committee on Industry and Resources 2006 Australia’s uranium – greenhouse friendly fuel for an energy hungry world, The Parliament of the Commonwealth of Australia

Namibia Plains Farming and Tourism CC v Valencia Uranium (Pty) Ltd. Case No (P) A 70/78.


Quirk, T 2006 Nuclear waste management in Australia. Submission to the Uranium Mining, Processing and Nuclear Energy Review

Uranium Mining, Processing and Nuclear Energy Review Taskforce 2006 Uranium Mining, Processing and Nuclear Energy – Opportunities for Australia? Report to the Prime Minister, Commonwealth of Australia


Worrall, R 2008 In situ Leaching (ISL) and Heap Leaching. Literature Review for CSIRO
Appendix 6 A Small Selection of Photos of the Namibia Part of My Study Visit

1. Dressing up in Swakopmund Township
2. The Namib Desert looking East
3. Welwitschia mirabilis - a living fossil
4. Trilobite in Namib Desert
5. Nossing Mine, Namibia
6. Meeting the Hon. Governor
Appendix 7 A Small Selection of Photos of the Australian Part of My Study Visit

- Wallaby at Kangaroo Island
- Luxury Accommodation near Brisbane
- Tailing ponds at Olympic Dam
- Androocks fossicking
- Ore grading at Olympic Dam
- Australian Sea Lion