Dr Gavin M Mudd
Department of Civil Engineering
Monash University
Clayton, VIC
Ph 03 9905 1352 / Fax 03 9905 4944
Gavin.Mudd@eng.monash.edu.au

Friday, 6 May 2005

To : **Standing Committee on Industry & Resources**
House of Representatives
Parliament of Australia
Canberra, ACT 2600 **ir.reps@aph.gov.au**

RE : ***Inquiry Into the Development of the Non-Fossil Fuel Energy Industry in Australia***

Case Study Into the Strategic Importance of Australia's Uranium Resources

Dear Secretary,

Please find enclosed my complete submission on the above inquiry being undertaken by the House of Representatives Standing Committee on Industry and Resources into Australia's Uranium Resources.

I have been an analyst of the uranium mining industry in Australia (and globally) for some 9 years thus far, and specialise in the environmental impacts and legacies of such operations. To date I have had several papers accepted and presented at various international conferences as well as reputable international academic journals. I also appeared before the 2002 Australian Senate Inquiry into the Regulation of Uranium Mining as an expert witness.

My expertise includes :

- Groundwater flow and contaminant transport modelling, including groundwater resource assessment;
- Geochemistry of mine wastes, with a particular focus on long-term effectiveness of rehabilitation works;
- Water management and water quality impacts;
- Production history and trends, especially statistics of mining, milling and uranium resources.

As part of this ongoing research (and minor consulting) I maintain a detailed database of uranium production and resources. It has historically been published by SEA-US Inc. through the internet. The full reference is :

> Mudd, G M, 2005, ***Compilation of Uranium Production History and Uranium Deposit Data Across Australia***. Published by SEA-US Inc., Last Updated May 2005, Melbourne, VIC, 46 p.
>
> ***Attached in Appendix A.***

Hereafter this report shall be referred to as the "Production Compilation Report".

Without doubt, this report and the rich data it contains will be of prime interest to the deliberations of your Inquiry. It is presented in a personal capacity (not that of my employer).

Attached to this submission are the principal academic publications associated with the above research and consulting work. These works compile the currently known picture of environmental problems and impacts associated with uranium mining in Australia, and will be referred to throughout this submission.

Further publications are in preparation, including one detailed research report on the Ranger uranium project, another detailed research report on the environmental and radioactive impacts of uranium mining in Australia and a new bibliography covering all Australian uranium and nuclear related publications from 1894 to 2004. If the Inquiry feels that draft copies of this research could help in your deliberations I could happily make the draft manuscripts available for this purpose.

The main contents of this submission will provide an analysis of key data and issues related to the terms of reference for the Inquiry. It will be presented in a series of dot points.

If there is the opportunity, I would only be too happy to appear at any hearings that may be organised, whether they be in Canberra, Adelaide or elsewhere as the Committee approves.

Many thanks for this opportunity to provide this submission – I trust it will be well used and wisely guide the deliberations of your Inquiry.

Kind Regards,

Dr Gavin M Mudd

Primary Publications on the Impacts of Uranium Mining-Milling in Australia

Most are Attached in Appendix B.

Mudd, G M, 1998, **The Long Term Sustainability of Mound Springs in South Australia : Implications for Olympic Dam**. Proc. "Uranium Mining and Hydrogeology II (UMH-2) - 2ND International Conference and Workshop", Verlag Sven Von Loga, Freiberg, Germany, September 1998, Vol. 1, pp 575-584.

Mudd, G M, 2000, **Acid In Situ Leach Uranium Mining - 1. USA and Australia**. Proc. "Tailings & Mine Waste '00 - 7TH International Conference", A A Balkema, Fort Collins, Colorado, USA, January 2000, pp 517-526.

Mudd, G M, 2000, **Acid In Situ Leach Uranium Mining - 2. Soviet Block and Asia**. Proc. "Tailings & Mine Waste '00 - 7TH International Conference", A A Balkema, Fort Collins, Colorado, USA, January 2000, pp 527-536.

Mudd, G M, 2000, **Mound Springs of the Great Artesian Basin in South Australia : A Case Study From Olympic Dam**. *Environmental Geology*, March 2000, 39(5): pp 463-476.

Mudd, G M, 2000, **Uranium Mill Tailings Wastes In Australia : Past, Present and Future Management**. Proc. "MAPW National Conference on Nuclear Issues", Medical Association For the Prevention of War (MAPW), Canberra, ACT, August 2000, 16 p.

Mudd, G M, 2000, **Remediation of Uranium Mill Tailings Wastes In Australia : A Critical Review**. Proc. "2ND Conference on Contaminated Site Remediation : From Source Zones to Ecosystems", Centre For Groundwater Studies (CGS), Land & Water, Commonwealth Scientific & Industrial Research Organisation (CSIRO), Melbourne, VIC, December 2000, Vol. 2, pp 777-784.

Mudd, G M, 2001, **Critical Review of Acid In Situ Leach Uranium Mining : 1. USA and Australia**. *Environmental Geology*, December 2001, 41(3-4): pp 390-403.

Mudd, G M, 2001, **Critical Review of Acid In Situ Leach Uranium Mining : 2. Soviet Block and Asia**. *Environmental Geology*, December 2001, 41(3-4): pp 404-416.

Mudd, G M, 2001, **Review of Water Management At Jabiluka : Environmental Issues and Recommendations**. Consulting Report Prepared for Gundjehmi Aboriginal Corporation, December 2001, Jabiru, NT, 31 p.

Mudd, G M, 2002, **Uranium Mining In Australia : Environmental Impact, Radiation Releases and Rehabilitation**. Proc. "SPEIR 3 : 3RD International Symposium on the Protection of the Environment From Ionising Radiation", Waste Safety Section, International Atomic Energy Agency (IAEA), Darwin, NT, July 2002, pp 179-189.

Mudd, G M, 2002, **Environmental Hydrogeology of In Situ Leach Uranium Mining In Australia**. Proc. "Uranium in the Aquatic Environment : Uranium Mining and Hydrogeology III (UMH-3) - 3RD International Conference", Springer, Freiberg, Germany, September 2002, pp 49-58.

Mudd, G M, 2002, **Uranium Mill Tailings In the Pine Creek Geosyncline, Northern Australia : Past, Present and Future Hydrogeological Impacts**. Proc. "Uranium In the Aquatic Environment : Uranium Mining and Hydrogeology III (UMH-3) - 3RD International Conference", Springer, Freiberg, Germany, September 2002, pp 841-850.

Mudd, G M, 2004, **A Compendium of Radon Data For the Rehabilitation of Australian Uranium Projects**. Proc. "Tailings & Mine Waste '04 - 11TH International Conference", Taylor & Francis Group, Vail, Colorado, USA, October 2004, pp 247-260.

Mudd, G M, 2004, **One Australian Perspective On Sustainable Mining : Declining Ore Grades and Increasing Waste Volumes**. Proc. "Tailings & Mine Waste '04 - 11TH International Conference", Taylor & Francis Group, Vail, Colorado, USA, October 2004, pp 359-369.

Mudd, G M, 2005, **Compilation of Uranium Production History and Uranium Deposit Data Across Australia**. SEA-US Inc., Last Updated May 2005, Melbourne, VIC, 46 p. (see Appendix A).

Mudd, G M, 2005, **Early Uranium Efforts In Australia 1906 To 1945 : the Legacy From Radium Hill To the Manhattan Project**. *Historical Records of Australian Science* (Under Review - *provisionally accepted*).

(a) Global demand for Australia's uranium resources and associated supply issues

- *Uranium Supply-Demand*
  - At present, the global uranium supply is much less than demand. However, despite the (false) hype which currently surrounds the uranium market, there are a number of key elements which must be factored in for Australia's current and future supply of uranium to the global market :
    - Many nuclear power reactors in the western world, particularly Europe and the USA, will be decommissioned sometime over the next one to three decades. Although some reactors are having their operating licences extended, this is not without major risk : nuclear accidents, future economics causing financial failure of power companies, and the like. Thus, although these markets might be appealing at present, they do not present a long-term economic market with minimal risk to Australia.
    - Current Australian uranium is sold under secure long-term contracts with only minimal exposure to the global market spot price. Most western nuclear power companies procure their uranium requirements well in advance of actual needs. Combined this means that there is only very marginal room in the global market for new Australian uranium.
    - The present price of uranium, somewhat elevated over the average of the past two decades, is leading to exploration and potential developments not only in Australia but in many uranium mineralised provinces around the world. This will keep downward pressure on the uranium price. Thus there is only limited potential for new Australian uranium mines to compete in the global market, especially since secure long-term contracts are difficult to win. This fact is even acknowledged by Energy Resources of Australia (and therefore also Rio Tinto) in their long-term planning for their Ranger uranium mine.
    - The long-term energy mix for the western world and entire globe is anything from certain. The contribution of nuclear electricity has certainly slowed down and stabilised over recent years, and given the lack of extensive construction programmes in the western world, this situation is extremely unlikely to change for the forseeable future. This further limits demand for Australian uranium.
    - Given the strong historical community opposition to uranium mining and the nuclear cycle in Australia, there will be substantive political problems in attempting to develop any new uranium project in Australia.

- *Australian Uranium Production*
  - A graphical history of Australian uranium production is given in Figures 1 to 3.
  - As can be seen from these figures and the data in the Production Compilation Report, Australia's uranium production is mostly dominated by Ranger and Olympic Dam. In the medium term :
    - Average ore grade will continue to decline as Olympic Dam both moves to lower grade sectors of its resource and (potentially) expands further in the near future.
    - This leads to increased radioactive waste being generated per unit of uranium oxide production.

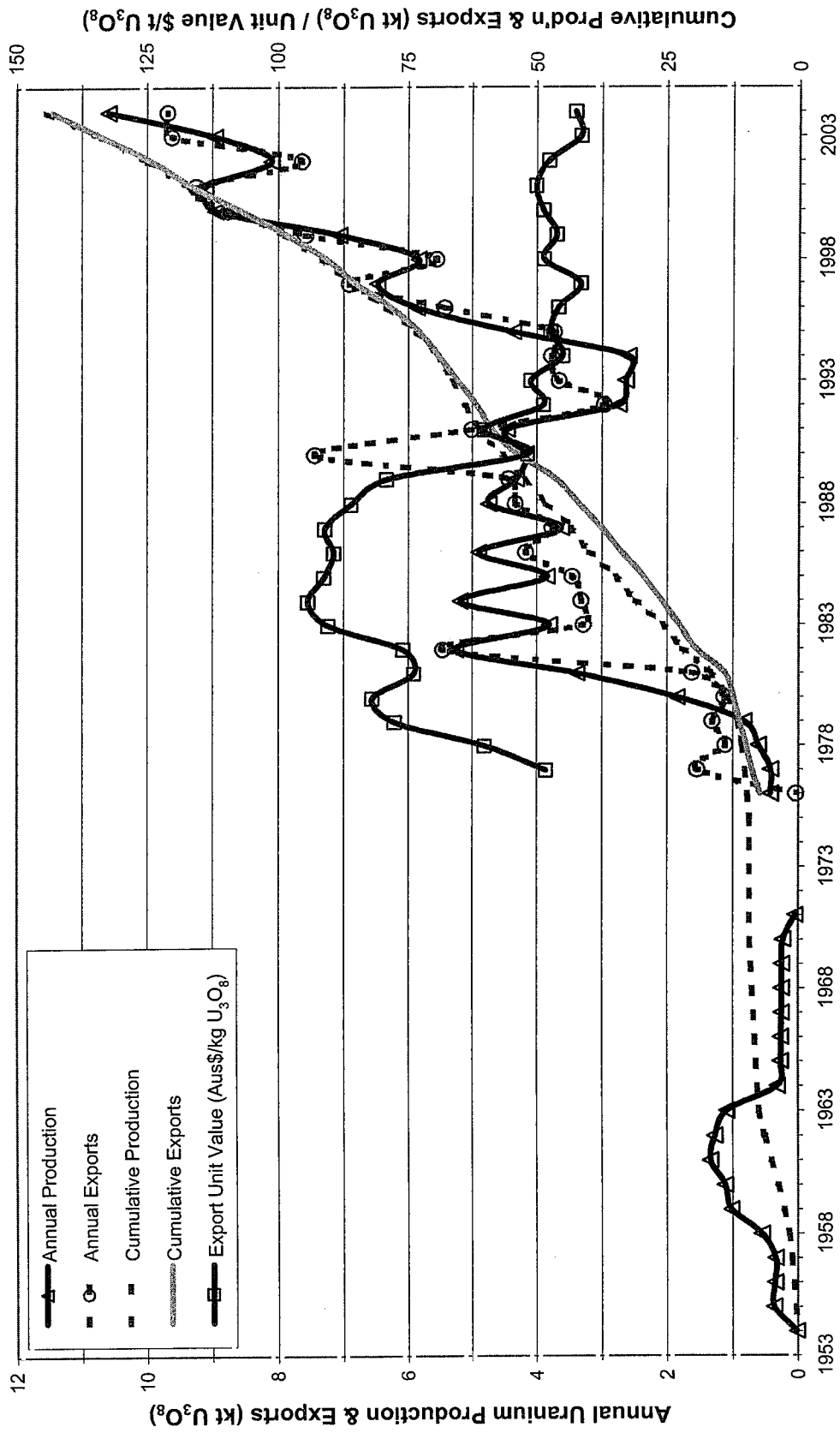

Figure 1 : Australian Uranium Production 1954-2004

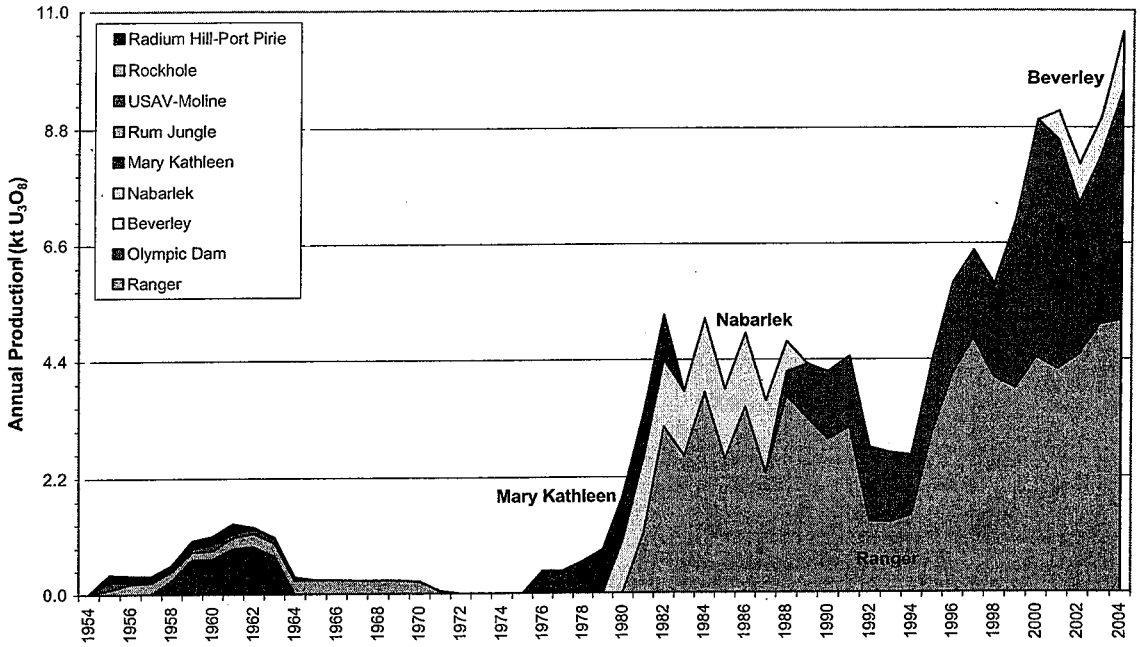

Figure 2 : Australian Uranium Production 1954-2004

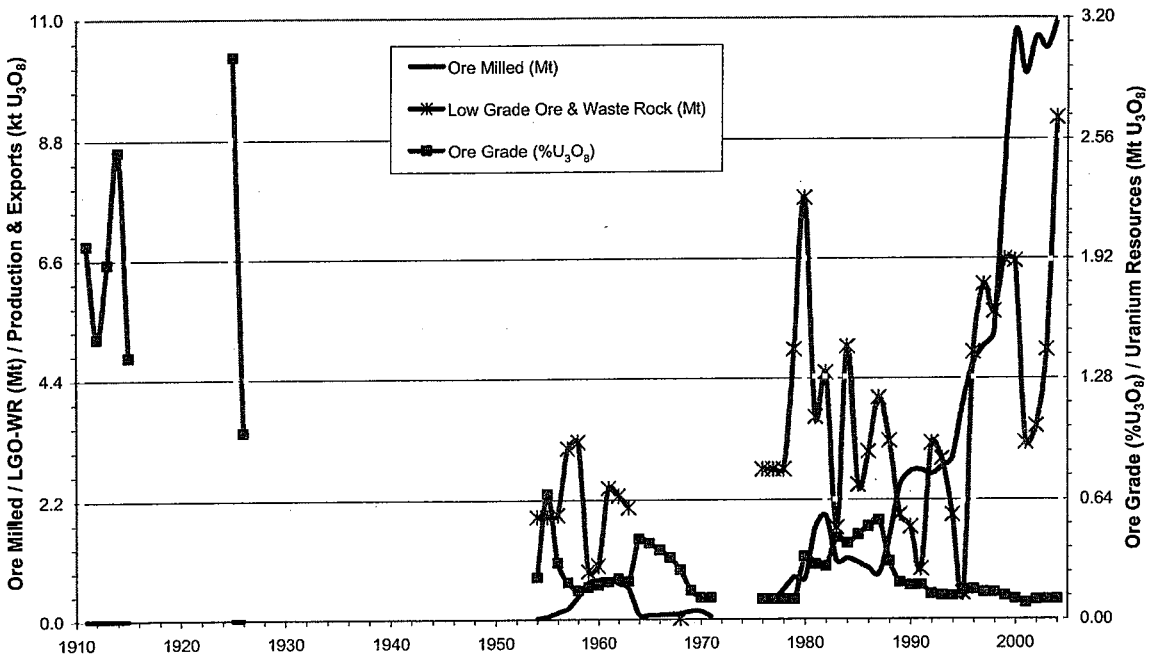

Figure 3 : Australian Uranium Mining-Milling 1954-2004

- *Australian Uranium Exports Value*
  - The export value and unit values for uranium oxide are given in Figure 4.
  - As can be seen, although the total export value is increasing with further production – the unit value, in Australian dollars per kilogram uranium oxide ($/kg U_3O_8). If converted to constant dollar terms (say 2004$), this long-term declining trend would be even more apparent and significant. Perhaps just as significantly the Australian dollar price is not very responsive to changes in the global spot price (again most likely due to the nature of the long-term contracts under which Australian uranium is currently exported).

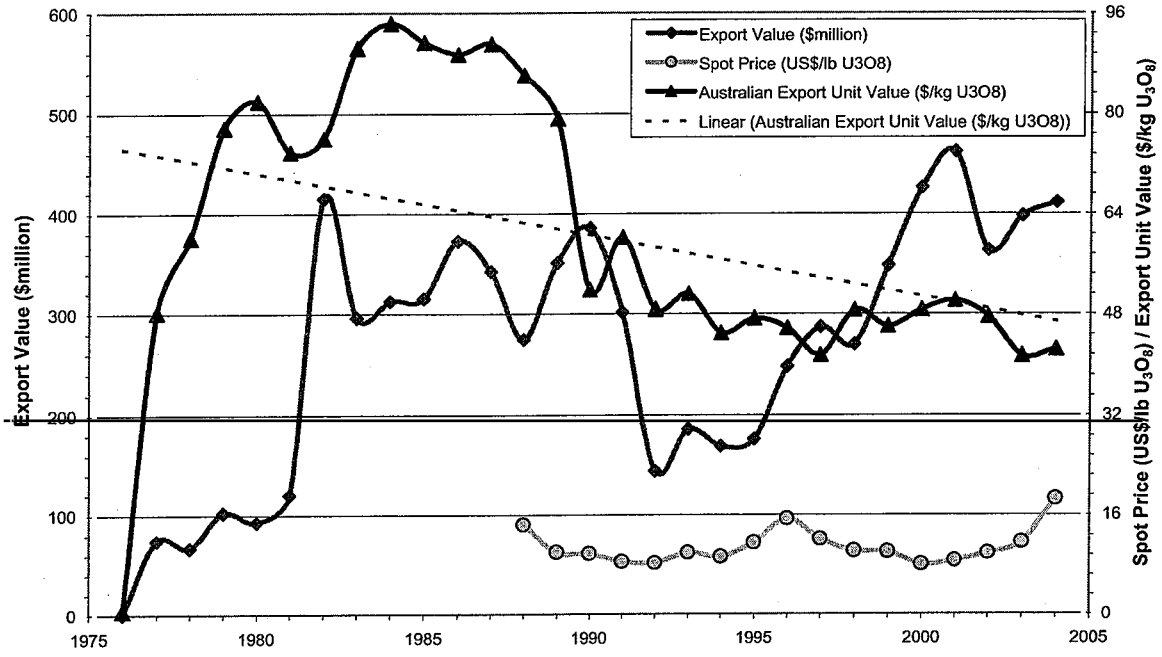

Figure 4 : Australian Uranium Exports 1976-2004

- *Australian Uranium and Nuclear Waste*
  - A key aspect of supplying Australian uranium is the high level nuclear waste issue : this involves the need to permanently manage such dangerous wastes and safeguard against the proliferation of nuclear weapons from such materials (eg. plutonium).
  - It is entirely ambiguous as to whether all Australian uranium is properly protected and prevented from entering nuclear weapons programmes (illicit or otherwise). At present we export significant amounts of uranium to many declared nuclear weapons states : the USA, UK and France. It is illogical to assume that there is no swapping between civilian and military nuclear regimes and that this ensures nuclear non-proliferation.
  - Detailed data on Australian obligated nuclear material (AONM) is found in the various tables of the Production Compilation Report.
  - The current inventory of plutonium in AONM high level nuclear wastes, if this waste was re-processed and the plutonium refined, is sufficient to build hundreds of nuclear weapons.

- A further issue is the long-term management of nuclear waste. As Australia has significant desert/arid regions, it has long been viewed with envy by some nuclear-dependent countries as ideal for the siting of high level nuclear waste dumps. Any future increase in uranium exports would re-ignite this issue and place Australia in a vulnerable position diplomatically : while advocating the alleged peaceful atom we would be facilitating more production of high level nuclear waste and the associated plutonium and pressure would increase for us to play our part.

- *Environmental Impacts of Australian Uranium Production*
  - The current state of knowledge of the legacy of environmental impacts at past and present Australian uranium projects is detailed in the attached papers and reports, as well as in the 2002 Senate Inquiry into the Regulation of Uranium Mining.
  - Based on these wide-ranging and extensive reviews (which have never been undertaken by government agencies or regulators as would be reasonably expected by the public), it is clear that accounting for the long-lasting environmental and radiological impacts has never been a feature of the uranium industry in Australia :
    - Rum Jungle – still polluting after all those years. Despite extensive acid mine drainage and pollution problems, as well as remaining uranium ore, the Commonwealth has recently not declared the new proposal to re-mine Rum Jungle a nuclear action under the EPBC Act. This seriously undermines the regulatory regime for uranium mining in Australia and its consistent application.
    - Mary Kathleen – although it was awarded an 'engineering excellence award' for its apparent standard of environmental rehabilitation in the early 1980's, recent research shows water pollution of the nearby creek due to ongoing seepage from the 'rehabilitated' tailings repository.
    - Beverley & Honeymoon – still no scientific evidence made public of claims of 'attenuation' of severe groundwater pollution caused by acid in situ leach mining. Despite my research being published at two international mining conferences and a well-respected international journal, the companies are yet to release peer-reviewed, independent research refuting my detailed analysis of the impacts of acid ISL mining.
    - South Alligator Valley – now part of southern Kakadu National Park and world-heriatge listed, these small former uranium mines and milles still litter and pollute the nearby area, including tailings and acid mine drainage. There has been little progress made towards any attempt at rehabilitation.
    - Ranger – the environmental problems of this project have been recalcitrant from the outset. The mine has a long history of significant spills and incidents, including numerous occasions where they breached environmental requirements and operating authorisations (as detailed in the 2002 Senate Inquiry).
    - Olympic Dam – already Australia's largest single radioactive waste dump, currently about 73 million tonnes and growing by some 9 million tonnes per year. This radioactive waste dump, the tailings left from milling and smelting, has leaked profusely in the past. If the full ore resource is ever mined at Olympic Dam, ***IF***, the tailings dump could reach some 4,000 million tonnes (or ***4 billion tonnes***).

(b) Strategic importance of Australia's uranium resources and any relevant industry developments

- *Australian versus Global Uranium Resources*
  - Australian and global economic uranium resources are shown in Figure 5 (based on OECD/IAEA data).
  - Further data on Australian uranium deposits is found in the various state tables of the Production Compilation Report.

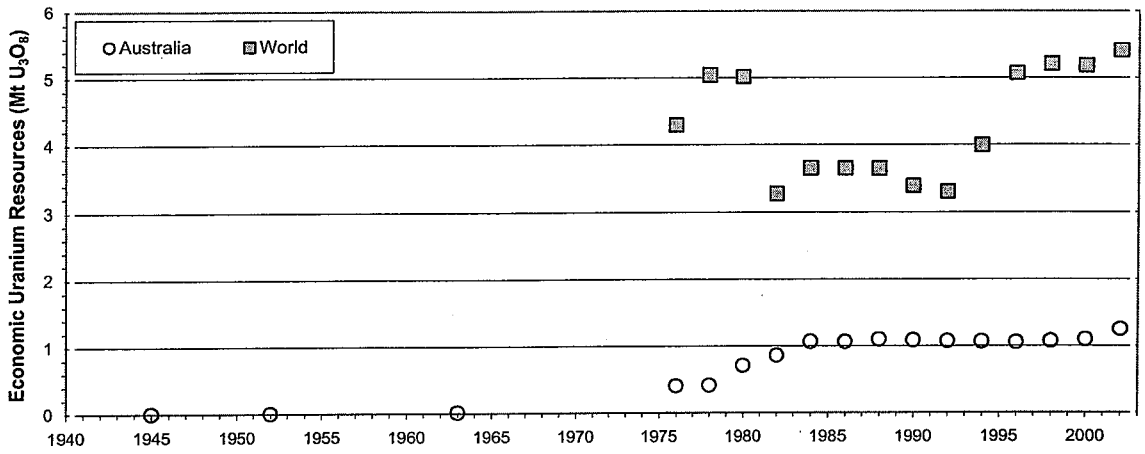

Figure 5 : Australian and Global Economic Uranium Resources Exports 1945-2002

  - Some general points need to be made with respect to known resources :
    - The bulk of Australian uranium is contained in Olympic Dam, with smaller but noteworthy resources at Ranger, Jabiluka and a series of second-tier deposits around Australia (Yeelirrie, Kintyre, etc).
    - The uranium grade at Olympic Dam is very low, averaging about 0.04% U_3O_8 for the full resource (as at March 2005). Given that it generally takes a minimum grade of about 0.01% U_3O_8 to ensure an overall positive energy return on uranium mining, Olympic Dam uranium is only returning a marginal energy payback (although there is the partial benefit of copper, gold and silver production also). This severely limits the alleged energy benefits of most of Australia's uranium resources.
    - A further issue with Olympic Dam is the brannerite problem. The uranium mineral brannerite is highly refractory and has historically been effectively dumped in tailings (the Olympic Dam metallurgical complex was never designed to dissolve brannerite, thereby explaining the poor extraction efficiency of 64.2% to date).

It is understood that as the ore is sourced from the broader resource, not only does the average uranium (and copper) grade decline by half but that the brannerite increases from its present one-third (hence the 64% extraction) to about one half. Thus any claims that uranium extraction efficiency can be increased in the present mill-metallurgical complex up to 85% or more is clearly questionable. Any future expansion will therefore most likely require more intensive processing and energy, limiting even further any alleged energy benefits from the uranium production.

- Other possible Australian uranium projects are also likely to require more intensive processing due to refractory or non-conventional ore mineralogy. This is especially the case for many Queensland uranium deposits (eg. Skal, Valhalla, Anderson's) as well as Western Australian calcrete uranium deposits (eg. Yeelirrie, Lake Way, Lake Maitland).

(c) potential implications for global greenhouse gas emission reductions from further development and export of Australia's uranium resources

- *Greenhouse Gas Releases : Australian Uranium Mines (Ranger, Olympic Dam)*
  - In recent years many mining companies have begun to publish sustanability or environmental-social performance reports, including for two of Australia's currently operating uranium mines. This is Energy Resources of Australia (ERA) for Ranger, NT, and WMC Resources (WMC) for their Olympic Dam project, SA.
  - At present Heathgate Resources do not publish similar report, though they do publicly release an annual formal environmental monitoring report (somewhat surprisingly given their historic recalcitrance at releasing public data).
  - Based on the ERA and WMC sustainability reports, the following analysis examines potential greenhouse gas impacts as available from this published data (available in Appendix A, or the Production Compilation Report). This includes carbon dioxide (CO_2), sulfur dioxide (SO_2) and energy standardised per tonne of ore milled and tonne of uranium oxide produced plus per tonne of copper for Olympic Dam.

- *Greenhouse Gas Releases : Ranger Uranium Mine*
  - The available data of the Ranger mine for carbon dioxide releases per unit uranium oxide production from 1995/96 to 2003 are shown in Figure 6. The data is plotted as an index relative to the first reported data (ie. 1995/96).
    - The data is somewhat difficult to generalise, however, a long-term trend of increasing CO_2 emissions per unit uranium oxide production is apparent (although this trend is clearly very dependent on the pending data for 2004).

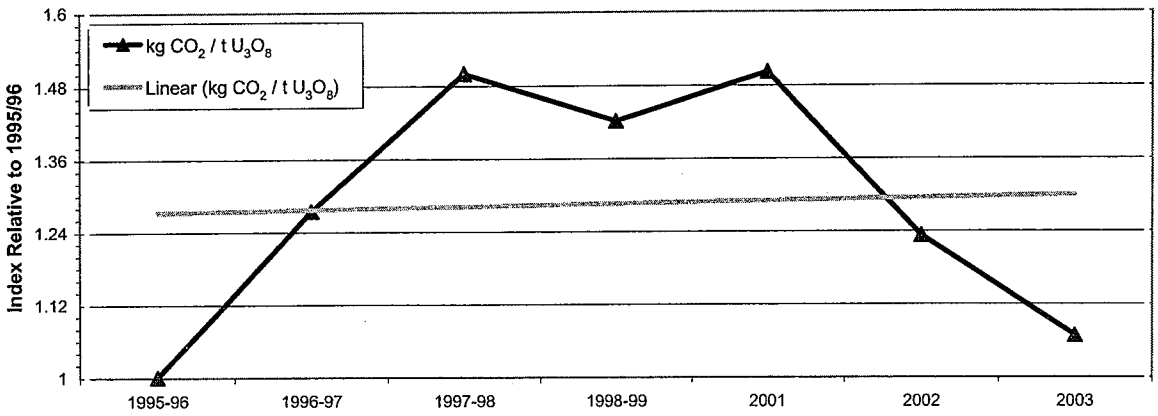

Figure 6 : Relative Carbon Dioxide Releases – Ranger Uranium Mine 1995/96 to 2003

- The available data of the Ranger mine for sulphur dioxide releases per unit uranium oxide production from 1995/96 to 2003 are shown in Figure 7. The data is plotted as an index relative to the first reported data (ie. 1995/96).
  - The data is somewhat difficult to generalise, however, a long-term trend of decreasing SO_2 emissions per unit uranium oxide production is apparent (although this trend is clearly very dependent on the pending data for 2004).

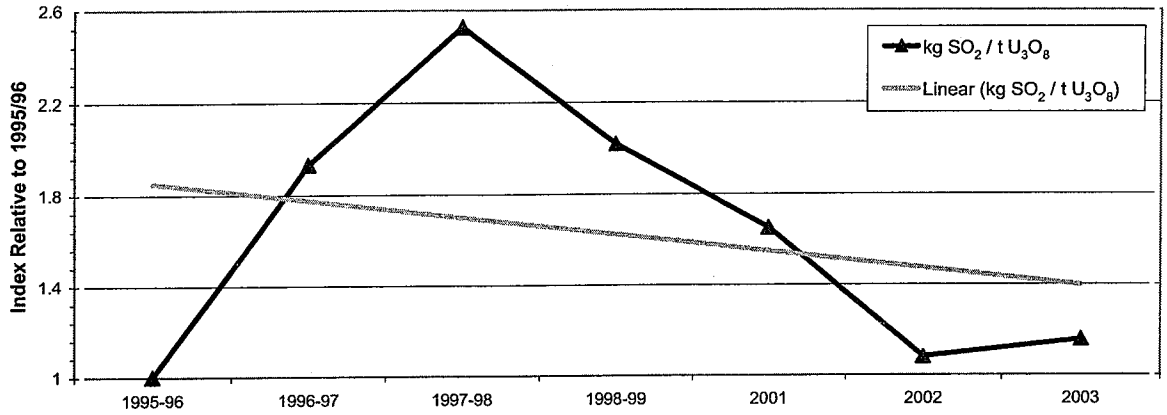

Figure 7 : Relative Sulphur Dioxide Releases – Ranger Uranium Mine 1995/96 to 2003

- The available data of the Ranger mine for energy consumption per unit uranium oxide production from 1995/96 to 2003 is shown in Figure 8. The data is plotted as an index relative to the first reported data (ie. 1995/96).
  - The data is somewhat difficult to generalise, however, a long-term trend of increasing energy consumption per unit uranium oxide production is apparent (although this trend is clearly very dependent on the pending data for 2004).

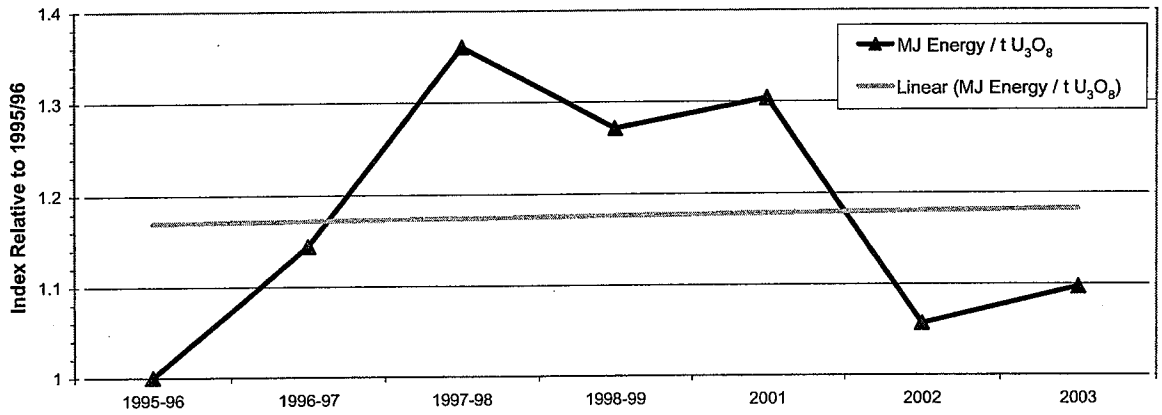

Figure 8 : Relative Energy Consumption – Ranger Uranium Mine 1995/96 to 2003

- Overall, the trends in energy consumption and greenhouse emissions are important to note on a unit production as well as a total basis. Given the limited extent of data published to date, however, it is difficult to predict future emissions, except to say that this needs to be accounted for properly in any assessment of uranium resources and potential exports.

- *Greenhouse Gas Releases : Olympic Dam Copper-Uranium Project*
  - The available data of the Olympic Dam project for carbon dioxide releases per unit copper or uranium oxide production from 1990/91 to 2004 are shown in Figure 9. The data is plotted as an index relative to the first reported data (ie. 1990/91).
    - The data clearly shows long-term trends of increasing CO_2 emissions per unit copper or uranium oxide production. As noted previously, given the forseeable metallurgical difficulties associated with milling the lower grade ore at Olympic Dam with higher brannerite, it is difficult to see this trend going down. This means that ***IF*** production expands further in the future, ***CO_2 emissions will most likely increase at a higher rate than just the ratio of increased mineral production***. As the scale of operations at Olympic Dam already lead to about one million tonnes of CO_2 emissions per year, any future expansion will therefore lock in emissions equivalent to some smaller fossil fuel-fired power stations.

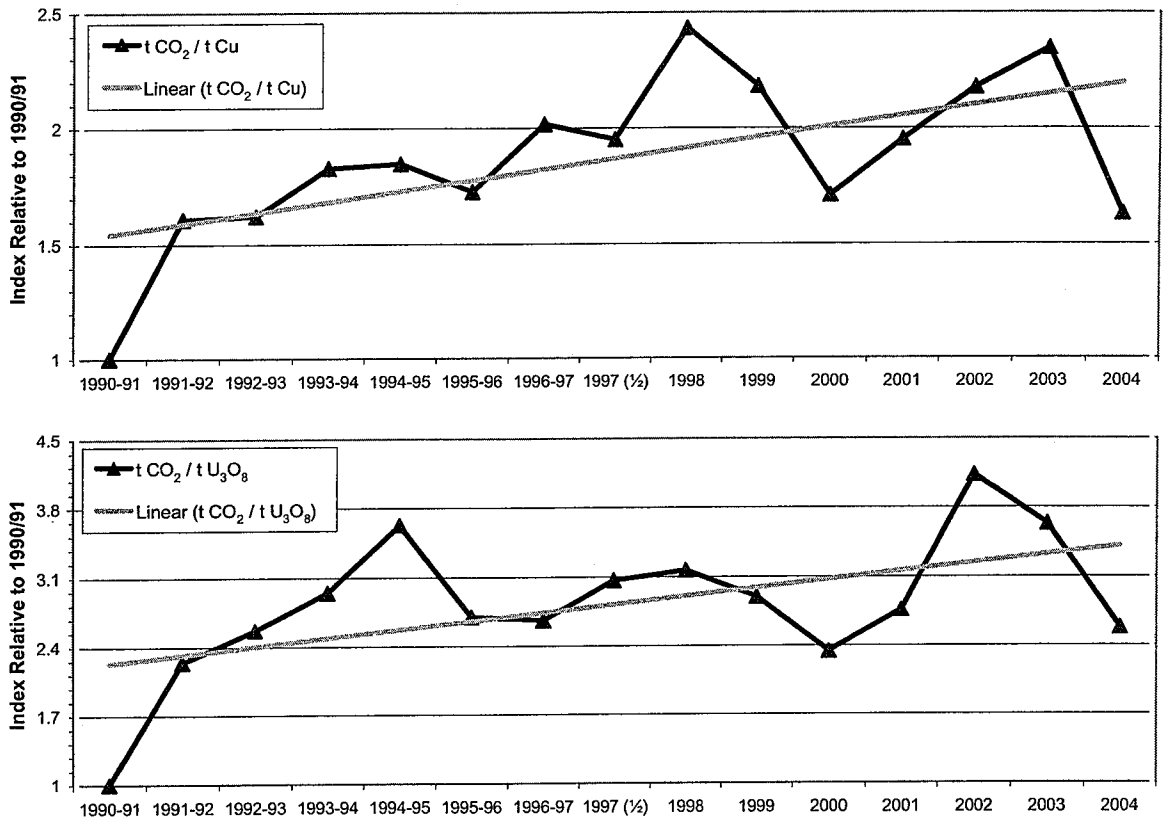

Figure 9 : Relative Carbon Dioxide Releases – Olympic Dam Copper-Uranium Project 1990/91 to 2004

  - The available data of the Olympic Dam project for sulphur dioxide releases per unit copper or uranium oxide production from 1990/91 to 2004 are shown in Figure 10. The data is plotted as an index relative to the first reported data (ie. 1990/91).
    - The data suggests a long-term trend of decreasing SO_2 emissions per unit copper or uranium oxide production.

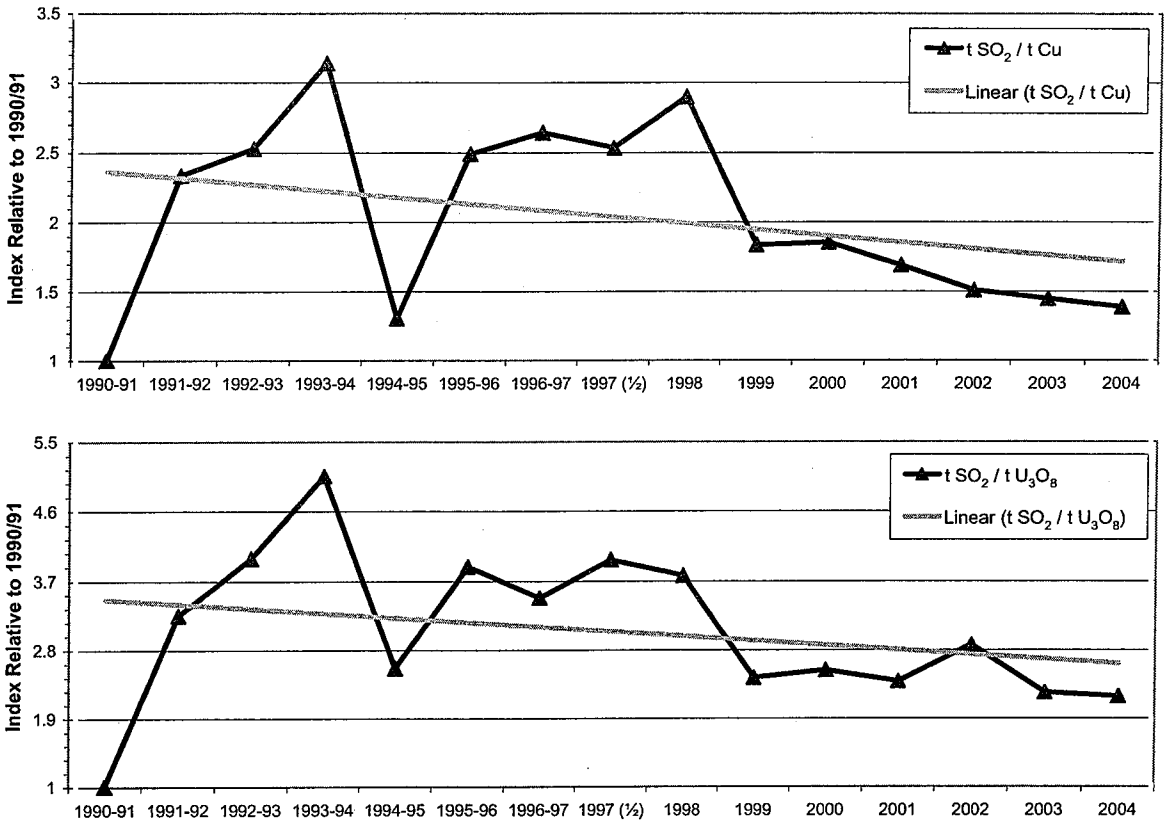

Figure 10 : Relative Sulphur Dioxide Releases – Olympic Dam Copper-Uranium Project 1990/91 to 2004

- The available data of the Olympic Dam mine for energy consumption per unit uranium oxide production from 1995/96 to 2003 is shown in Figure 11. The data is plotted as an index relative to the first reported data (ie. 1995/96).
  - The data suggests a long-term trend of increasing energy consumption per unit copper or uranium oxide production.

- **Overall, the trends in energy consumption and greenhouse emissions are important to note on a unit production as well as a total basis. Given the extent of data published to date, however, it is difficult to predict future emissions, except to say that this needs to be accounted for properly in any assessment of uranium (and copper) resources and potential exports.**

All future uranium production must consider full life-cycle accounting for actual emissions and energy and water consumption. The limited evidence to date from Ranger and Olympic Dam suggests that the environmental burden per unit production, in this regard, will increase in the future (primarily CO_2 and energy). This restricts any benefits of alleged reductions in greenhouse gas emissions from Australian uranium exports.

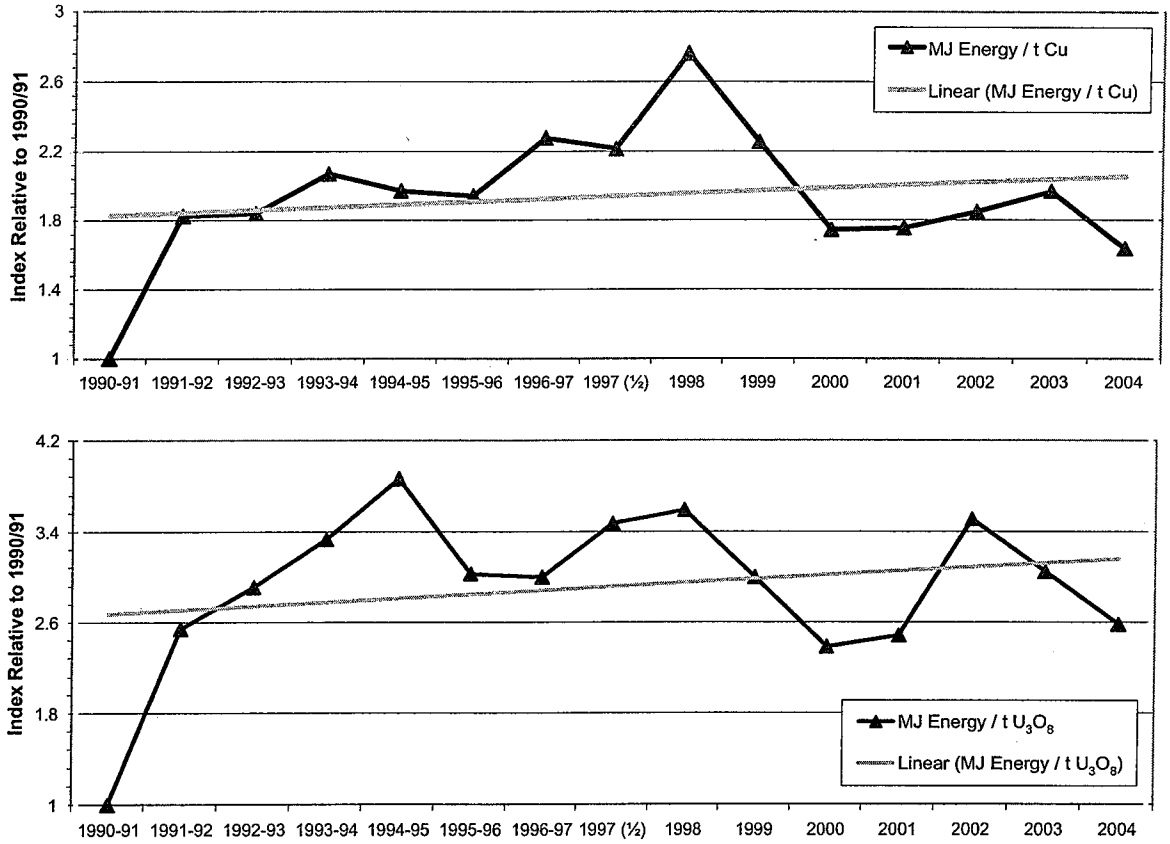

Figure 11 : Relative Energy Consumption – Olympic Dam Copper-Uranium Project 1990/91 to 2004

(d) current structure and regulatory environment of the uranium mining sector (noting the work that has been undertaken by other inquiries and reviews on these issues)

- At present the primary regulation of uranium mining is performed by agencies with a vested in promoting the sector. For example, in the Northern Territory and South Australia, the primary agencies with carriage of day-to-day regulation of uranium mining at Ranger, Olympic Dam and Beverley are the mining/resource agencies – ***NOT*** an independent, statutory environment authority (eg. EPA). This situation is particularly corrupted by the Roxby Downs (Indenture Ratification) Act 1982 (as amended), which makes strong SA Government support to subsidise the project in the medium term compulsory and removes many normal state regulatory agency functions to WMC (eg. indigenous heritage, radiation protection, etc).
- For such pro-uranium mining agencies to be controlling the environmental performance of the industry ***represents a fundamental conflict of interest*** – a situation which has yet to change despite the work of numerous previous inquiries by the Australian Parliament.
- ***Until a situation is developed whereby a statutory, independent regulatory body is established to regulate uranium mining and strictly enforce legitimate community expectations, there can and should be no confidence placed in existing state resource agencies regulating uranium mining.***