Studies of natural populations and communities of aquatic organisms provide the best information about the *ecological importance of impacts*. Advantages of this approach are the potentially wide range of sensitivities shown by different species to toxicants, and the provision of information about the biological diversity in the ecosystem. In the case of the ARR, this involves counting macroinvertebrate (eg insect larvae, molluscs, shrimps) and fish species in the creek systems, downstream of mine sites and in control locations unaffected by mining. The control locations are situated both upstream of mine sites and in separate streams.

In all these procedures, it is crucial to collect information on natural populations before any possible impact. These 'baseline' data enable comparisons to be made before and after possible impact and are the basis for testing whether future changes in aquatic ecosystems are the result of mining activities. So far, no observable changes have been detected in the structure of macroinvertebrate and fish communities between control and 'test' sites downstream of Ranger.

The approaches outlined above have been subjected to refinement and change. This has come about through an increasing information base at ***eriss***, international research into biological monitoring and external review of the ***eriss*** program. Modification to techniques to account for environmental change unrelated to mining have also been required. As an example, the nature of lowland billabongs has altered over the last 15 years with an increase in aquatic plant growth following the removal of feral buffalo from Kakadu. This demonstrates a major side benefit of the research at ***eriss*** in adding to the knowledge of the ecology of freshwater ecosystems of northern Australia and in documenting long-term environmental changes.

Biological monitoring programs should be supported by chemical monitoring programs to assess the extent and importance of any detected impacts effectively. Consequently, corresponding protocols for the sample collection, analysis and data management for water chemistry are being developed.

The principles and elements of the ***eriss*** program developed for aquatic ecosystems of the ARR are being used as a model for similar areas of high conservation in Australia, through the revision of national guidelines on water quality.

eriss *carries out scientific research for the protection of people and the environment in places that are highly valued by the Australian community.*

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eriss notes

MONITORING THE HEALTH OF KAKADU'S STREAMS

The Environmental Research Institute of the Supervising Scientist (***eriss***) conducts research into environmental issues relating to mining and wetland management. ***eriss*** is located at Jabiru in Kakadu National Park, in Australia's Northern Territory – a World Heritage area renowned for its rich cultural and natural values. Mining and milling of uranium in the Alligator Rivers Region (ARR), including Kakadu, have been under way since 1979.

Based upon its research program, eriss has recommended the adoption of a biological control regime to ensure protection of the aquatic ecosystems of the ARR from the operation of mines in the region. This was in recognition that in this highly-valued area, biological assessment would provide assurance that the highest standards of ecosystem protection would be met. In addition, such methods provide a model for environmental protection in other locations.

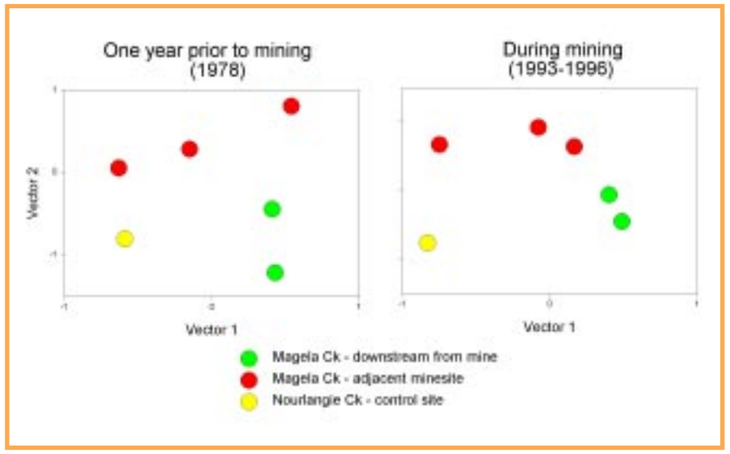
The first stage in the control regime involves the use of laboratory-based toxicity testing of any waters that are considered for discharge to streams. Animals tested include fish fry, waterfleas and hydra. These tests determine discharge rates of mine waste waters at which no harm should occur to animals in downstream ecosystems. The second stage consists of a biological monitoring program conducted in downstream ecosystems to demonstrate that the expected high level of environmental protection has been achieved. The biological monitoring program is the subject of this note.

The biological monitoring research program

Since 1987 we have trialed and refined various monitoring techniques to meet key targets for environmental protection. The biological 'indicators' used in the program satisfy two important needs of environmental protection:

- early detection of effects so that large and ecologically important impacts are avoided
- information on the ecological importance of any impact

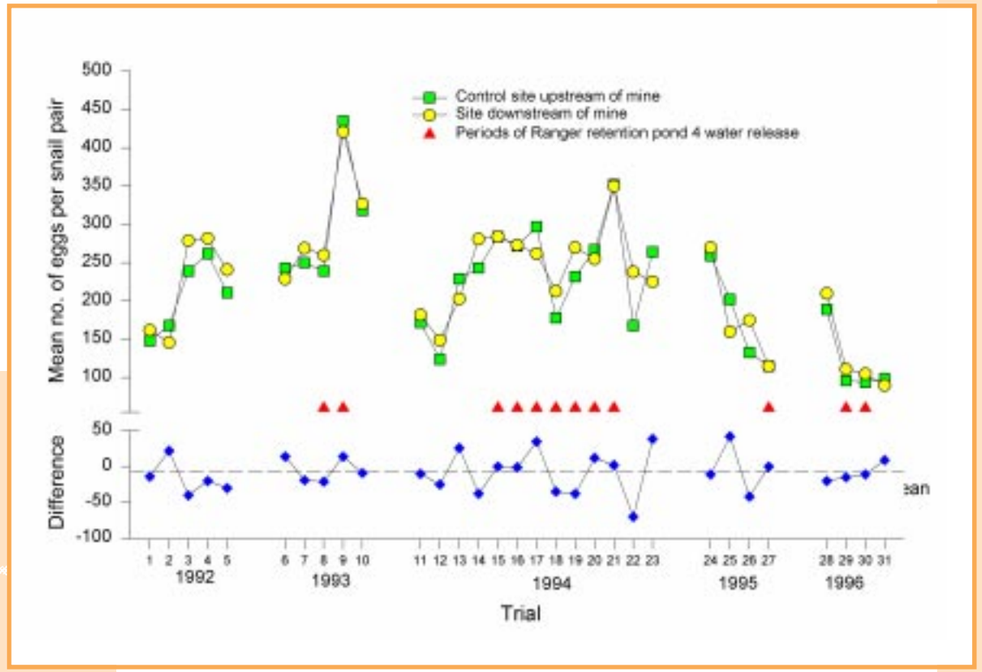
eriss *staff monitoring freshwater snails and fish fry at a creekside station on Magela Creek*



Relationships of fish communities in shallow lowland billabongs on Magela Creek (potentially affected by Ranger Uranium Mine) and a control billabong on Nourlangie Creek. The closer data points are together, the more similar are the corresponding fish communities.

In the field, creekside monitoring is used for *early detection* of effects in the creek arising from any release of mine waters during the wet season. Reproduction and survival of freshwater snails and survival of fish fry exposed to creek waters pumped to creekside shelters are measured during each wet season. These species have been shown to be particularly sensitive to mine waste waters. Responses of the test animals are measured at two sites, one located upstream of Ranger (a control) and the other several kilometres downstream. Information gathered for both species over past wet seasons shows that responses are very similar at the upstream and downstream sites, indicating no effects of mine water releases.

Freshwater snail egg production in creekside monitoring trials conducted in Magela Creek near the Ranger Uranium Mine. Some of the tests coincided with releases of low contamination mine runoff waters to the creek.



Putting the biological procedures into practice

The development of methods for biological monitoring in the ARR is near completion. A period of implementation is now beginning where core elements will be used in a demonstration model for biological monitoring of streams potentially affected by the uranium mining operations in the ARR. Protocols and procedures for data management and documentation used in the demonstration projects by ***eriss*** will be made available to mining companies, regulatory agencies and other interested groups. The demonstration model incorporates the following aspects:

Program design

All data collection procedures are subject to strict design criteria guided by internationally accepted practices. The design and documentation, including quality assurance, are crucial steps in the model.

Field procedures

Rigorous and novel experimental design is applied to collection of data. Quantitative sampling and sorting methods are used for the collection of macroinvertebrates from the beds of aquatic plants in the seasonally-flowing sections of Magela Creek and control streams. Fish data are gathered using non-destructive, quantitative procedures: visual counting of resident and migrating fish in the high clarity waters of the creek channels and billabongs, and 'pop-netting' procedures in billabongs containing high densities of aquatic plants.

Laboratory procedures

Laboratory procedures include sample registration, sorting and identification of macroinvertebrate samples, and chemical analyses. Streamlined processes supplying precise, accurate and rapid results are required for a monitoring program that will provide early warning of unacceptable impacts.

Data management, documentation and reporting

Critical to the success of a biological monitoring program is efficient storage of data and the appropriate reporting of results. To enable rapid feedback to management and interested stakeholders of monitoring results, data must be easily accessible and stored in a manner compatible for use in statistical software packages. Protocols are being prepared for all field and laboratory procedures.

eriss *staff and volunteers using the 'popnet' technique to collect and count fish in a densely vegetated lowland billabong*

Stakeholder involvement

Stakeholders include the Traditional Owners of the area, Commonwealth and Northern Territory governments, Energy Resources Australia (ERA) and the general public. Through groups such as the Alligator Rivers Region Advisory Committee (ARRAC), we will report on the development of the demonstration model for biological monitoring in the ARR. We also acknowledge the need for further consultation and reporting of monitoring results to other stakeholders and the wider community.