Trigger Release Mechanism for Release of Mine Water to Magela Creek

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ABSTRACT

The Ranger Uranium Mine is surrounded by a World Heritage National Park. The strict environmental controls under which the mine operates are based on scientific and social requirements. Release of non-process storm runoff water to the Magela Creek during flood discharge and under controlled conditions has been identified as Best Practicable Technology for the operation of the water management system. Social and political factors have limited this release to a wet season with an Annual Exceedance Probability of one in ten.

The first-generation trigger mechanism was based on a percentile analysis of monthly rainfall. The second-generation trigger is based on cumulative monthly volume increase in the retention ponds and is considered to be more applicable to the operation of the mine water management system.

1. INTRODUCTION

The possibility that controlled release of water from the Ranger Uranium Mine may result in an environmental impact which is socially unacceptable has been the main argument advanced against release of Retention Pond 2 (RP2) water to the Magela Creek. Release of excess waters to the creek in high-dilution conditions has been recognised as Best Practicable Technology (BPT) and offers a higher degree of environmental protection than providing additional long term storage.

The Ranger mine operates within a 78 square kilometer project area which is located near Jabiru some 250 km east of Darwin. The Ranger Project Area is surrounded by, but does not form part of, Kakadu National Park which is listed as a World Heritage Area.

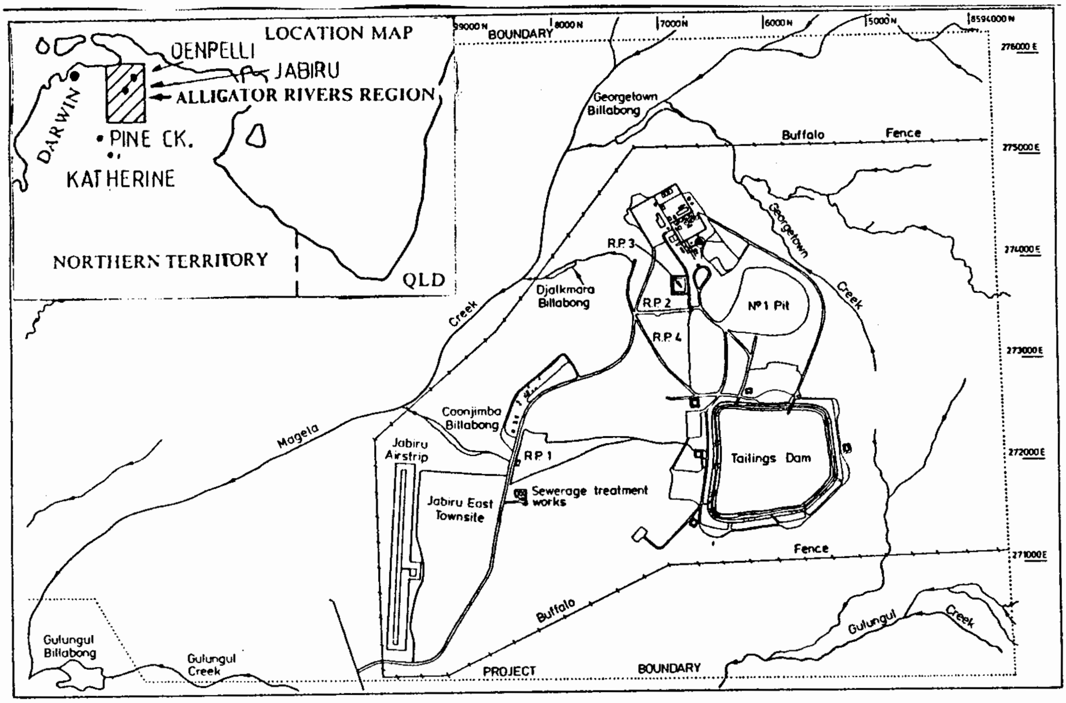


Figure 1 Location Map

The Magela Creek passes through the Project Area and feeds an adjacent wetland. The primary objective of the release control mechanism is to ensure that the biological environment is not harmed.

The region has a wet/dry tropical climate with the dry season lasting from about May to September. Ninety percent of the rain falls between December and March. The average annual rainfall recorded at Jabiru over the last 17 years is 1540 mm, the regional long- term average rainfall being 1360 mm. Pan evaporation is approximately 2600 mm per year. Prevailing winds are easterly to south easterly in the dry season and north-westerly in the wet season. The area is subject to cyclones and intense rain depressions.

2. HISTORICAL PERSPECTIVE

Due to the politically sensitive nature of the nuclear industry, a Royal Commission (Fox Inquiry) was established in 1975 to investigate and advise on Australia's potential role in the industry. The second Fox Report (Fox and others, 1977) dealt specifically with environmental aspects of the establishment, operation and rehabilitation of the Ranger Uranium Mine and its interaction with the local indigenous communities. It contained detailed recommendations for the design and initial operation of the mine and these were adopted in subsequent legislation. Many of these recommendations were of necessity conservative due to the limited understanding of the regional ecology.

The Water Management System was designed to permit efficient economic operation of the mine and to minimize environmental impact. Material with a uranium content greater than 0.02% U is contained within a Restricted Release Zone (RRZ) together with the mill operations. As the name implies, water in this zone may only be released in accordance with strict requirements. The waste rock stockpiles and two sediment control ponds are located outside the boundaries of the RRZ (Figure 2).

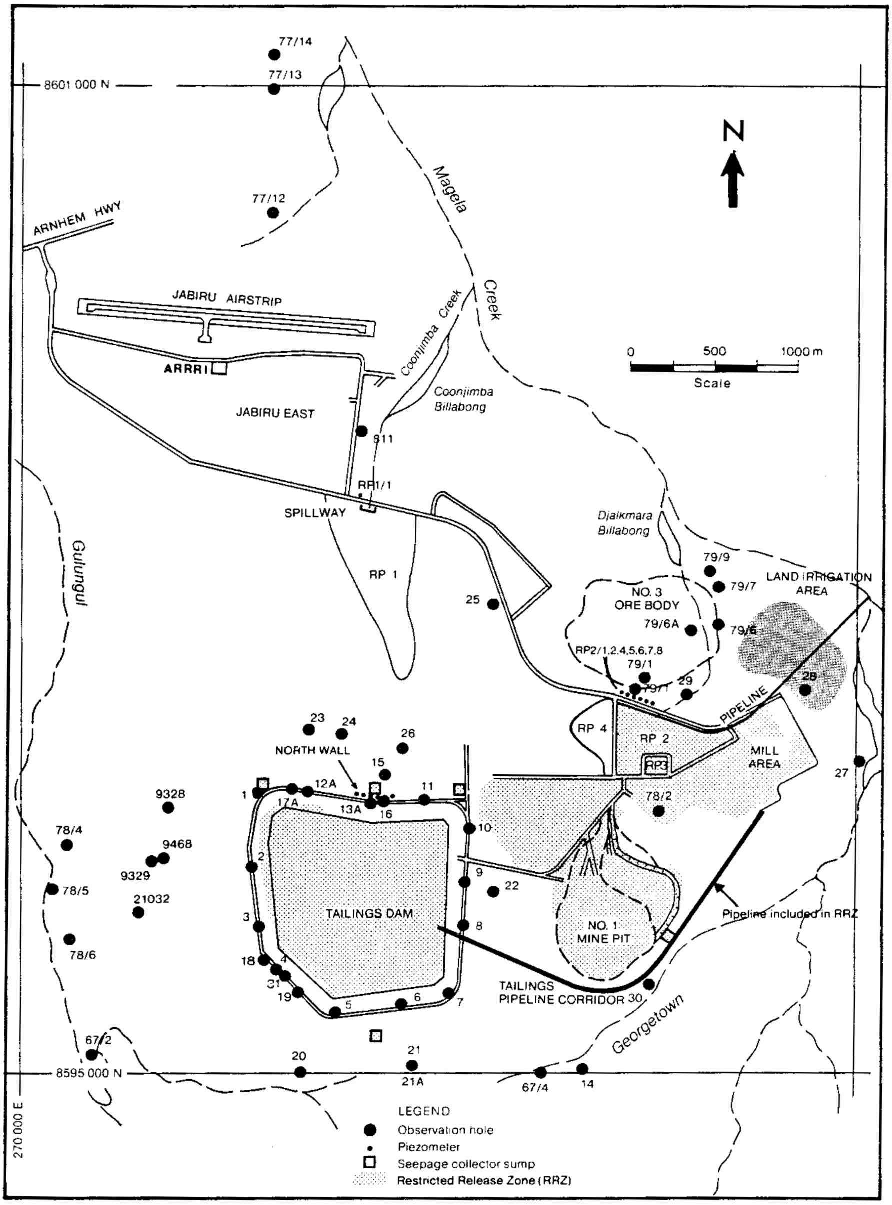


Figure 2 Restricted Release Zone

It is not proposed that any water should be released from the Tailings Dam or Retention Pond 3 (RP3) which contain the water with the highest concentration of solutes. Retention Pond 3 has a capacity of 50,000 m^3 and contains runoff water from the high-grade ore stockpile and from the relatively high contamination risk areas, such as the power house, the sulphur stockpile and the sulphuric acid plant. Water from RP3 and the Tailings Dam are used for mill supply.

RP2 has a volume capacity of 1.1 million m^3 and contains runoff water from the relatively low contamination risk areas, such as the stores yard, the engineering workshops, the administration and the low-grade ore stockpiles. It is this water which is proposed for release.
Retention Ponds 1 and 4 are sediment control structures. RP1 contains runoff from the catchment which contains the Tailings Dam. RP4 acts as a silt trap for waters derived from the waste rock stockpile.

3. WATER RELEASE AND ITS CONTROLS

The Water Management System was designed to include water release from the RRZ under wet season conditions. It was stated in the Fox report that approximately 400,000 m^3 of water would be released from the RRZ into the Magela system in an average year and 900,000 m^3 in a year with a 1-in-10 exceedance probability rainfall. The alternative is to build large evaporation basins to store and evaporate all possible excess water. These are expensive, require clearing of large areas of native vegetation which then must be rehabilitated. Fox recommended that release criteria should be developed and the following points considered:

- The total amount of contaminants to be released from the operations should be minimised. This means that all practicable modifications to the water management program which would result in less releases of contaminants, whether by runoff or by deliberate releases, both during and after mining, should be introduced.
- Deliberate releases should be permitted only under conditions of high flow in Magela Creek (flow at East Jabiru exceeding 20 cubic metres per second), and then only if there is a continuous flow between East Jabiru and the northern end of the Magela plains.
- Deliberate releases should not be permitted late in the wet season since there would be a greater risk then of contaminants being trapped in billabongs and swamps within the Magela system. The precise timing in any year would have to be determined by reference to a proposed hydrological/meteorological water-quality model.
- Release standards for toxic materials should be based on acute bio-assay tests and application factors.
- Release standards for other contaminants should be based on achieving the minimum practicable disturbance to the environment.
- Standards for deliberate releases should take account of the total amounts of each contaminant discharged, the concentrations in the retention ponds, the dilution actually achieved in Magela Creek and the length of time of each release. Where discharges are permitted directly into the flooded creek, a mixing zone, where initial rapid dilution of the effluent would take place, would need to be defined and the required dilution stated. Maximum contaminant levels in this zone should be restricted to below derived 'fish-avoidance' levels.

Release criteria have been established for water quality and flow conditions. Biological toxicity testing is being developed but has not proved to be a reliable regulatory tool nor is it reliable in assessing environmental impact. The water quality criteria for Magela Creek are included in Table 1.

In 1986 a technical working group was established by the Commonwealth to review Best Practicable Technology and its application to the Ranger Water Management System. The principal conclusion of the Working Group was that *"best practicable technology for water management at Ranger (if non technical considerations are excluded) is a water management system based upon the disposal of excess RRZ water by controlled release, as necessary, to the Magela Creek during the wet season supplemented by land application during the dry season."* The Commonwealth imposed an additional constraint of a maximum release frequency of 1 year in 10, to take into account political and social factors; the definition of these factors is obscure.

Table 1 AUTHORISED MAXIMUM ALLOWABLE ADDITIONS FOR RELEASE TO MAGELA CREEK

Parameter	Units	Category	Maximum Allowable Addition
Turbidity	NTU	Statistical	1.5
Suspended Solids	mg/L	Statistical	0.75
TOC	mg/L	Statistical	4
Calcium	mg/L	Ecological	1.3
Magnesium	mg/L	Ecological	1.0
Sulphate	mg/L	Drinking water	19.0
NH^3 (ammonia)	mg/L	Toxicological	0.015
Nitrate and Nitrite	mg/L	Drinking water	0.6
Nitrate	tonnes/yr	Ecological	4.4
Fluoride	mg/L	Statistical	0.02
Phosphate	mg/L	Statistical	0.01
Phosphate	tonnes/yr	Ecological	2.8
Iron	mg/L	Statistical	1.1
Copper	ug/L	Statistical	0.6
Copper	tonnes/yr	Human Health	90
Lead	ug/L	Statistical	0.7
Lead	tonnes/yr	Human Health	8
Zinc	ug/L	Human Health	5
Zinc	tonnes/yr	Human Health	200
Cadmium	ug/L	Statistical	0.1
Cadmium	tonnes/yr	Human Health	1.3
Chromium	ug/L	Statistical	1.4
Manganese	ug/L	Human Health	24
Manganese	tonnes/yr	Human Health	6
Uranium	ug/L	Toxicological	3.8
Uranium (238+234)	GBq/yr	Human Health	88
Thorium 230	GBq/yr	Human Health	170
Radium 226	GBq/yr	Human Health	13
Lead 210	GBq/yr	Human Health	8
Polonium 210	GBq/yr	Human Health	7

4. TRIGGER RELEASE MECHANISM

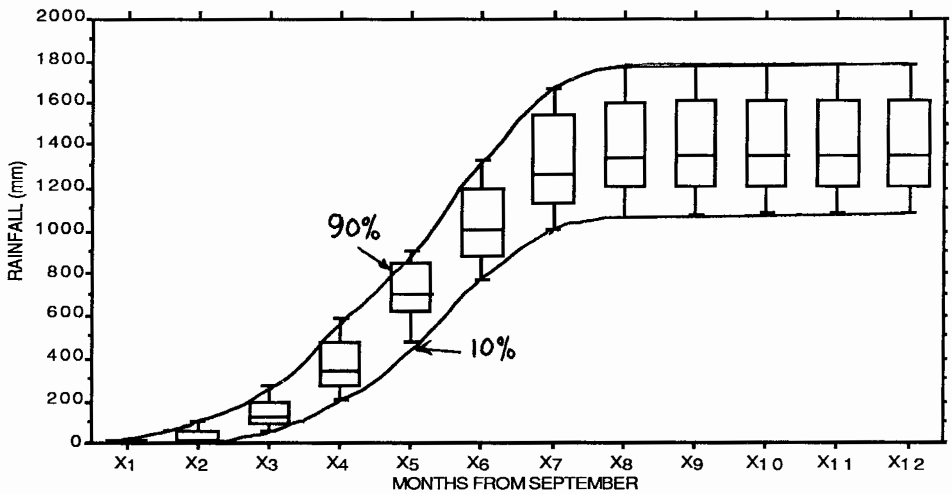
For operational and regulatory purposes a trigger mechanism was required which should satisfy certain criteria:

- it must be capable of specifing the timing and frequency of the release
- it must be clear and unambiguous
- it must be unchanging from year to year, and
- it must be easily verifiable.

Ideally, operational decisions which relate to mining and milling should reside with the Company.

The first-generation trigger was based on a percentile analysis of monthly rainfall (Figure 3). The accuracy of this technique is dependent upon the number of years for which records are available. The sixteen years of record at Jabiru were considered to be inadequate. When the Jabiru rainfall data were compared with those of three regional stations, the regression equations between them were found to be similar and synthetic data generated from these stations produced a similar result (Figure 4). Rather than carrying out weighted averaging of the three derived data sets, it was considered to be reasonable to use the larger data set derived from the Oenpelli records. A comparison of the Jabiru data with this synthetic data set shows that this choice is conservative in the upper percentile range (Figure 5).

Figure 3 Percentile analysis of Cumulative Monthly Rainfall



The decision to release would have been based upon the condition that the cumulative rainfall was greater than that which was read from the trigger curve for that day, and that the release criteria were met.

A trigger mechanism based upon the volume being stored at any time was considered to be more applicable to the operational needs of the Water Management System.

Two options for developing a rainfall/volume relationship for the Water Management System were studied. These were a physical process model and an empirical model. The physical process model required parameters such as runoff coefficients for the various sub-catchments and pan factors for each pond. These are generally not well understood. A trigger based on this type of model would therefore depend to some extent upon the Company's estimation of the magnitude of each parameter.

The empirical alternative is based upon the observed relationship between monthly rainfall and pond-volume increase. The relationship is strongly linear. The estimated volume in RP2 is calculated by subtracting the monthly volume increase in the Tailings Dam from the total monthly volume increase in the Water Management System (Table 2). The 90th percentile volume curve is then derived by applying the rainfall volume relationship to the 90th percentile rainfall curve (Figure 6).

When the volume accumulated in RP2 exceeds the trigger value for that day and the other release criteria are met then release could occur and this should happen on average one year in ten.

Figure 5. Comparison of Jabiru synthetic data generated from Katherine, Oenpelli and Pine Creek rainfall records

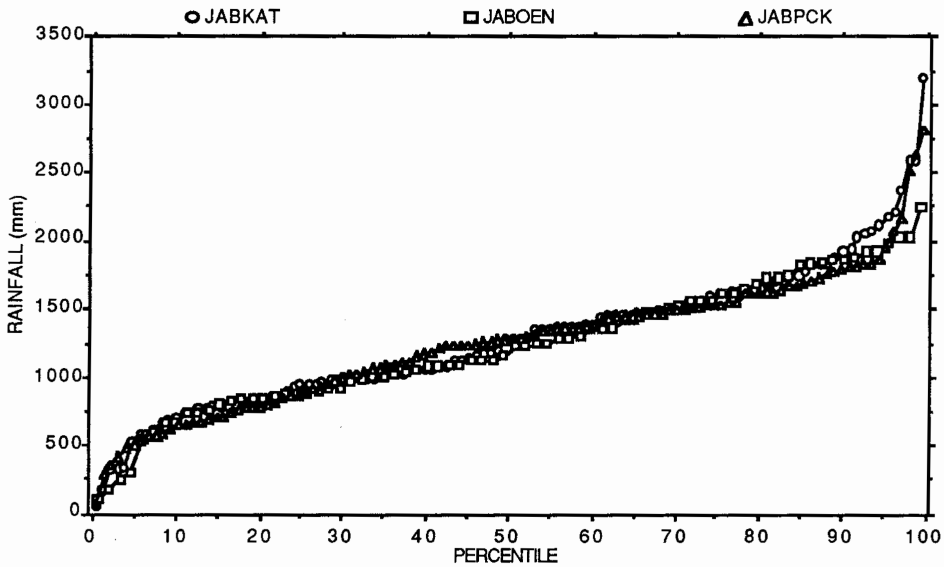


Figure 4

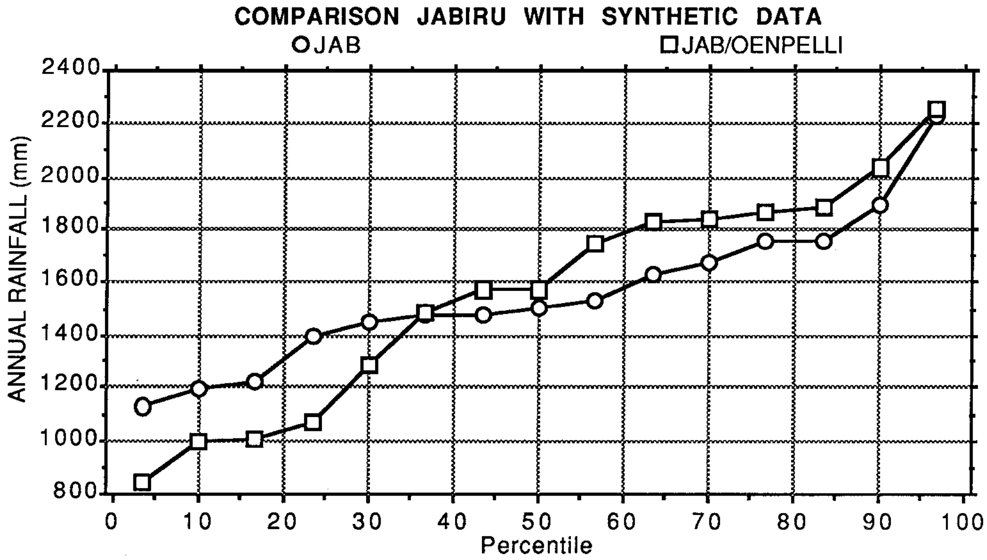


Figure 5

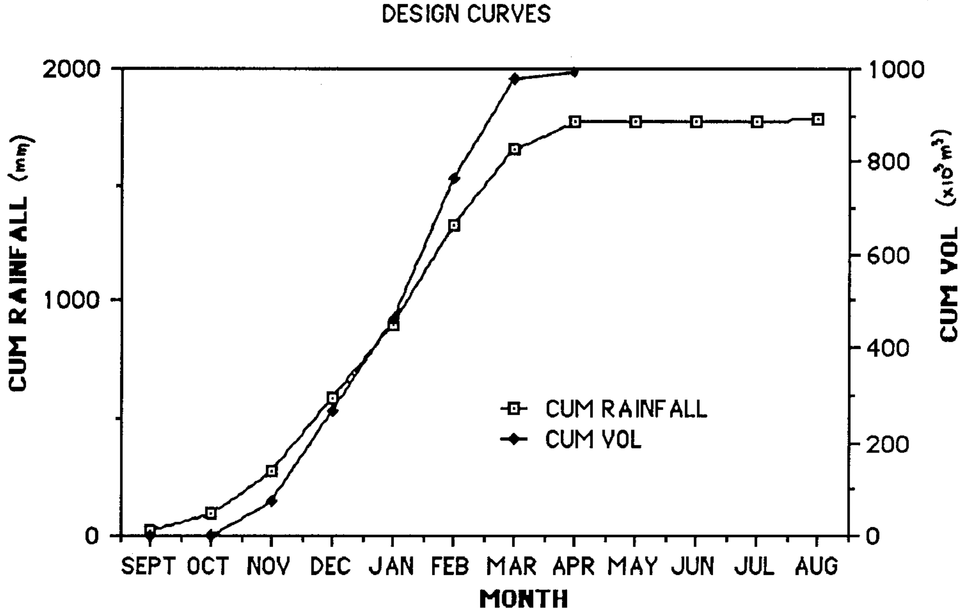


Table 2 Monthly Volume Increase

	CUM. 90th %ILE	RAINFALL (mm)	VOLUME INCR. (*1000m^3)	RP2 VOL. INCR. (*1000m^3)
SEPTEMBER	17	17	LOSS	LOSS
OCTOBER	98	81	LOSS	LOSS
NOVEMBER	280	182	186	74
DECEMBER	588	308	536	192
JANUARY	898	309	538	193
FEBRUARY	1327	430	872	305
MARCH	1663	336	612	217
APRIL	1774	110	LOSS	8
MAY	1776	2	LOSS	LOSS
JUNE	1776	0	LOSS	LOSS
JULY	1777	1	LOSS	LOSS
AUGUST	1782	5	LOSS	LOSS
TOTAL	1782		2745	989

5. ENGINEERING CONSIDERATIONS

The Magela creek is ephemeral. Flow begins between December and February and lasts up to five months. During this period discharge rate will vary from less than five cumecs to more than five hundred cumecs. Typically, the greater part of the seasonal discharge occurs in less than five flood events. The optimum release period is between February and March when the likelihood of flood flow in the Magela is high.

Release of water to the Magela Creek involves controlled volume discharge which is necessary to maintain strict dilution (volume and solute) criteria. Presently a pump and pipe system is the only permissible method of discharge. The installed system allows up to 18 thousand m^3 per day to be released to the Magela Creek, which is approximately a 1:80 volume dilution at the minimum allowable flow in the creek for release.

This system does not allow maximum environmental protection as the mine cannot fully utilise the immense dilution of flood discharge. The most practical method to maximise the release rate is by the use of a controlled outlet structure releasing through a minor stream channel into the Magela Creek. This technique offers the requirements of release control and the ability to maximise release during flood events.

6. DISCUSSION

The Water Management System at Ranger was designed to release the best quality runoff water falling within the RRZ. The system cannot reasonably be adapted to operate as a "no release" system under all forseeable circumstances. The most likely alternative to release would be periodic or permanent mine closure. The frequency of closure would be a function of the extremely variable climatic patterns which are a characteristic of this region. The huge retention ponds required to retain infrequent and extreme annual rainfalls do not represent a cost-effective solution to the problem and would also impose a major additional impact on the environment. In most years additional ponds are not required to balance the existing system.

Scientific investigations to date have not identified any potential or unacceptable environmental impact due to release of RRZ water under controlled conditions. The comprehensive monitoring program covering solute analysis and biological toxicity testing before, during and after release offers an additional safeguard to the ecosystem. The proposed second-generation release trigger combined with flexible release rates is a simple workable method for release timing.

7. REFERENCE

FOX, R. W., KELLEHER, G. G., and KERR, C. B. 1977. Ranger uranium environmental enquiry. Second Report. (Canberra: Australian Government Publishing Service).