Geomorphic research to determine the off-site impacts of the Jabiluka Mine on Swift (Ngarradj) Creek, Northern Territory

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1 Introduction

In October 1996 Energy Resources of Australia (ERA) submitted a Draft Environmental Impact Statement (Kinhill Engineers & ERA Environmental Services 1996) for the mining of uranium at Jabiluka. The Commonwealth Government approved the Ranger Mill Alternative in October 1997 subject to a broad range of requirements on environmental protection (Johnston & Prendergast 1999). The Ranger Mill Alternative involved the mining of the Jabiluka orebody by underground methods and the milling of the ore at the existing mill at Ranger (Kinhill Engineers & ERA Environmental Services 1996). However, following the refusal of the traditional land owners to permit the trucking of ore from Jabiluka to Ranger, the Jabiluka Mill Alternative was further developed and approved by the Commonwealth Government in August 1998, subject to a number of environmental requirements (Johnston & Prendergast 1999). This alternative involved the construction of a new mill at Jabiluka and was outlined in a Public Environment Report (Kinhill & Energy Resources of Australia Ltd 1998). Environmental requirements stipulated that all mill tailings had to be returned to the underground mine void and to specially constructed stopes or silos instead of tailings pits, as proposed by ERA (Johnston & Prendergast 1999). Work on the mine began immediately after government approval. Despite criticisms of the Jabiluka Mill Alternative by Wasson et al (1998) which were also raised by the World Heritage Committee, the Supervising Scientist found that development of the Jabiluka uranium mine will not threaten the natural values of Kakadu National Park (Johnston & Prendergast 1999). The Jabiluka Mining Lease is surrounded on three sides by Kakadu National Park and by the Ranger Mining Lease on the fourth.

As outlined below, there are limited data on catchment geomorphology, channel stability/instability, sediment movement and hydrology of the Swift Creek[1] catchment, which contains the portal, retention pond and other head works for the Jabiluka Mine (fig 1). There was an urgent need to establish baseline channel, sediment and hydrological conditions to assess changes caused by the commencement of mining before the first flush of the 1998/99 Wet season. Furthermore, two small creeks were at least partly diverted from their natural course through sections of artificial channel to enable the construction of mine infrastructure. Therefore, baseline conditions had to be determined before the start of streamflow for the 1998/99 Wet season to avoid measuring any impacts of the mine. The channel network is the conduit for runoff, sediment and pollutants leaving the mine site, and the mine site tributaries (fig 1) will be the first part of the catchment to experience off-site environmental impacts. It is

[1] The name Swift Creek is used in this report for the river that drains the catchment in which the Jabiluka Mine is located and that flows into the Magela Creek wetlands. Ngarradj is the Aboriginal name for this stream system. The full term is Ngarradj Warde Djobkeng and is the site where the cockatoo vomited on and split the rocks to form the creek known as Ngarradj. It is one of several dreaming (Djang) sites on or adjacent to the Jabiluka mine lease (A Ralph, Gundjehmi Aboriginal Corporation, 2001).

also necessary to characterise the catchment, channels and hillslopes so as to establish a temporal and spatial data base as part of a Geographical Information System (GIS) on sediment movement for long-term land and water management. Research by the Environmental Impact of Mining Section of ***eriss*** should address the incorporation of modelling techniques into the GIS which can use catchment, channel, hydrological and sediment data for the calibration of landform evolution and sediment transport models (SIBERIA).

These models are needed for:

1 Prediction of the long-term impacts of mining; and

2 Selection of stable post-mining landforms as part of mine decommissioning and rehabilitation.

It is essential that data for model calibration are collected so that alternative mine rehabilitation plans can be reliably evaluated before mine decommissioning.

This report outlines 13 sub-projects that were developed at short notice in 1998 to determine the off-site geomorphic impacts of the Jabiluka uranium mine on Swift Creek. Pickup et al (1987) noted that their feasibility study of geomorphic research for the long-term management of uranium mill tailings at Ranger uranium mine discussed many issues that could equally apply to Jabiluka. Some of these have been modified below in their application to Jabiluka. Erskine and Saynor (2000) also concluded that the geomorphic behaviour and sediment dynamics of the Ranger Mine site tributaries were not well understood, despite being the initial storages and pathways for mine-derived particulates. The projects proposed below address these issues for the Jabiluka Mine.

2 Aims

The aims of this project are threefold, namely:

1 To review existing literature on the geomorphology, geology, soils, climate and hydrology of the Swift Creek catchment;

2 To develop projects for obtaining baseline data on the channel network, channel stability/instability, channel boundary sediments, sediment storages, sediment fluxes and hydrology of the Swift Creek catchment; and

3 To outline projects for determining temporal changes in channel morphology and aquatic habitat, sediment storages, sediment fluxes and hydrology due to mining.

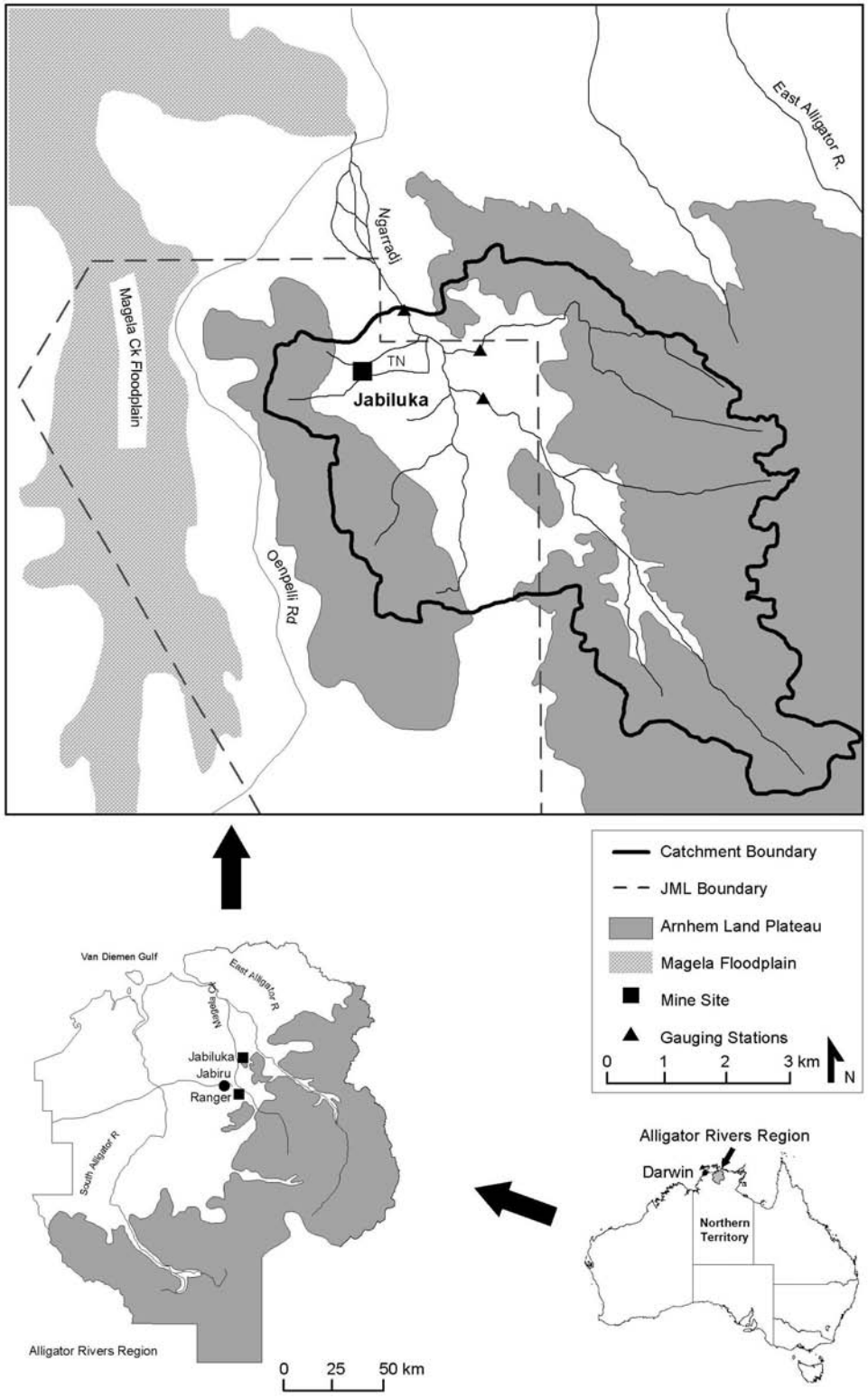

Figure 1 The Swift Creek catchment showing the Jabiluka Mineral Lease (JML), gauging stations and local creek names. SC refers to Swift Creek gauging station, TN Tributary North, ET East Tributary gauging station, TC Tributary Central, TS Tributary South, TW Tributary West and UM upper Swift Creek gauging station.

3 Outline

To determine the baseline characteristics of catchments in the Jabiluka Mineral Lease and the hydrologic and geomorphic impacts of uranium mining, the following 13 sub-projects were proposed for implementation:

1 A detailed geomorphic map of the catchment;

2 Mapping and description of morphologically homogeneous channel reaches throughout the Swift Creek catchment;

3 Assessment of historical stability/instability of each channel reach from all available vertical air photographs;

4 Determination of the grain size of channel boundary and floodplain sediments for each channel reach;

5 Construction of a digital elevation model (DEM) of the whole Swift Creek catchment;

6 Installation and operation of at least four river gauging stations and pluviometers (two on control rivers and two on mine-impacted rivers);

7 Detailed suspended sediment and turbidity measurements at each river gauging station;

8 Detailed bedload measurements at each river gauging station;

9 Installation and measurement annually of scour chains at each gauging station and on mine site tributaries;

10 Selective measurement of bank erosion and knickpoint migration rates;

11 Installation of permanently marked cross sections throughout the channel network;

12 Mapping and measurement of the volume of sediment in discrete sediment storages downstream of the mine site;

13 Evaluation of the significance of riparian forests and large woody debris for stabilising sandy channels and storing bed material on Swift Creek and Tributary East.

Each of these sub-projects is outlined in detail with appropriate methodologies in section 6.

The available background information on Swift Creek is outlined below. Each of the activities required to establish the baseline characteristics of the catchment, as well as the impact of uranium mining, is detailed along with the observations and data collected during field work. The purpose of this report is to outline the purpose, design and methodology for each sub-project. Results for any project that is implemented will be published in subsequent Supervising Scientist Reports.

4 Background information

There is limited background information on the environmental characteristics of the Swift Creek catchment. The available information is contained in the following sources:

- **Topographic maps**: The largest scale available are two 1:50 000 maps ('Mount Brockman' 5472 1; 'Canon Hill' 5473 2) that were printed in 1997 by Army Topographic Support Establishment. There are also two 1:100 000 maps ('East Alligator' Sheet 5473 1st Edition produced by Division of National Mapping in 1971 and 'Cahill' Sheet 5472 2nd Edition produced by Royal Australian Survey Corps in 1976) and one 1:250 000 map

('Alligator River' SD 53-1 1st Edition compiled by Royal Australian Survey Corps in 1984) that cover the Swift Creek catchment.

- **Vertical aerial photographs**: ***eriss*** has copies of aerial photography (contact prints) flown at the times detailed in table 1. In addition, copies of Energy Resources of Australia Ltd 1:5000 Rectified Photomap Ranger-Jabiluka Sheets 1 and 2 derived from air photographs flown in August 1997 have also been obtained. Digital copies are being sought for input into Arcview to provide a base map for a GIS. Data obtained using a differential Global Positioning System (dGPS) will be superimposed on the rectified photomaps.

  Available vertical air photographs need to be obtained as part of the baseline characterisation, provided they are at an appropriate scale of 1:15 000 to 1:40 000. Needham (1984) lists vertical air photographs flown by various authorities in 1968, 1969 and 1972 that may cover the Swift Creek catchment. Flight diagrams of all runs should be obtained to determine whether they cover the Swift Creek catchment. There are also photographs held by Auslig, which were flown on 20 May 1984.

Table 1 Aerial photography of the Swift Creek catchment held by ***eriss***

Date	Run	Photographs
16 May 1950	7	5012–5015, inclusive
	8	5060–5063, inclusive
27 June 1964	20	5090–5095, inclusive
	21	5117–5122, inclusive
	22	5109–5115, inclusive
16 July 1964	22AE	5060–5066, inclusive
22 June 1975	13	3124–3127, inclusive
	14	3135–3140, inclusive
8 July 1975	15	5219–5224, inclusive
5 June 1981	12E	165–169, inclusive
5 July 1981	11	70–73, inclusive
13 July 1987	2	75
	3	27–30, inclusive
20 August 1991	3	37–38, inclusive
	4	57–62, inclusive
15 June 1996	4	35–39, inclusive
	5	22–29, inclusive

- **Other remotely sensed data**: Landsat, SPOT and other remotely sensed data have been used in various land management projects in Kakadu National Park. ***eriss*** has access to a comprehensive satellite imagery archive stored at the Environmental Resources Information Network (ERIN) in Canberra. These images include the Swift Creek catchment.
- **Geological maps**: The Swift Creek catchment is covered by:

  i) The 1:500 000 Pine Creek geosyncline map of Needham and Stuart-Smith (1984);

  ii) The 1:250 000 geology maps of Needham (1984, 1988); and

  iii) The 'East Alligator' and 'Cahill' 100 000 geology maps.

Kinhill Engineers and ERA Environmental Services (1996) repeat the 1:100 000 geology maps.

- **Land resources maps and data**: Land systems and associated climatic conditions, vegetation, soils and landforms of the Swift Creek catchment have been presented and/or mapped at various scales by Christian and Stewart (1953) and Story et al (1969, 1976).

Additional land resources information is contained in the various environmental studies prepared for the mining companies (Pancontinental Mining Ltd 1977, 1979, 1981, Bettenay et al 1981, Kinhill Engineers & ERA Environmental Services 1996, Unger et al 1996, Kinhill & Energy Resources of Australia Ltd 1998) and by Wells (1979).

As a result of limited available data, it is necessary to collect basic climatic, hydrological, sediment transport, stratigraphic and geomorphic information for the following sub-projects. ERA maintains a climate station at the Jabiluka mine site and other neighbouring stations should be sourced and all relevant data obtained. Rainfall stations located within the region are listed in table 2 with the custodian of the information. At some stations, further instrumentation was installed to measure additional climate parameters. In particular, the Australian Bureau of Meteorology usually installs automatic weather stations (AWS) that measure other climatic parameters such as temperature, wind speed and direction, air pressure and humidity.

5 Swift Creek catchment characteristics

5.1 Climate

The Swift Creek catchment is located in the summer rainfall-tropical climatic zone, characterised by heavy periodic rains and generally hot and humid conditions from November to March and essentially dry and mild to warm conditions from April to October (McQuade et al 1996). At Jabiru, 92% of the average annual rainfall (1460 mm for the period 1971–92) is recorded during the Wet season months of November to March (McQuade et al 1996). More recent work by Chiew and Wang (1999) found that the mean annual rainfall for the period 1971–1998 was 1500 mm at Oenpelli and 1480 mm at Jabiru. For the complete period of record at each site, the mean annual rainfall was 1397 mm and 1483 mm at Oenpelli (1911–1998) and Jabiru Airport (1972–1998), respectively (Bureau of Meteorology 1999). Rainfall variability in the summer rainfall-tropical climatic zone is low to moderate but high daily totals are recorded during tropical cyclones. On average, one cyclone per year affects the Northern Territory coast (McDonald & McAlpine 1991).

5.2 Landforms

The north west part of the Swift Creek catchment comprises the Arnhem Land plateau, which is an exhumed, essentially sandstone, tabular upland (East 1996). A deeply incised, trellised drainage pattern has developed along the closely spaced joints and faults. The scenically striking Arnhem escarpment marks the edge of the plateau and forms the northeastern rim of the Swift Creek valley. Rivers leaving the plateau flow either over steep bedrock falls (East Tributary) or dissect the scarp by long narrow deep sandstone valleys which follow joints and faults (Swift Creek). Steep sandstone slopes with lower scarps, part of the Jabiluka outlier, characterise the southern side of the valley. A low saddle, from which the sandstone has been totally eroded, separates Swift Creek from the adjoining 7J Creek catchment to the south.