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A methodology for the assessment of rehabilitation success of post mining landscapes—sediment and radionuclide transport at the former Nabarlek uranium mine, Northern Territory, Australia

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Abstract

Protection of the environment post-mining is an important issue, especially where runoff and erosion can lead to undesirable material leaving post-mining landscapes and contaminating surrounding land and watercourses. Methods for assessment of the environmental impact and long-term behaviour of post-mining landforms based on scientific methodology are needed especially where field data are absent or poor. An appraisal of the former Nabarlek uranium mine was conducted to assess the site from a soil erosion perspective as part of an independent evaluation of overall rehabilitation success. Determination of the gross erosion occurring, sediment discharge to Cooper Creek and the resultant sediment associated radionuclide load in Cooper Creek were the primary objectives of the study. These objectives were achieved through the application of several models using parameter values collected from the site. The study found that the area containing the mill tailings repository is extremely stable and meets the guidelines established for long-term storage of uranium mill tailings. Most other areas on the site are stable; however there are some areas with a high sediment loss. Sediment concentration in Cooper Creek, which drains the site, was found to be within the Australian water quality guidelines for fresh water, however sediment concentrations in tributaries were found to exceed recommended levels. Radionuclide determinations on soil samples showed that the highest specific activities (Bq kg^{-1}) were present on a small (0.44 ha) area with a relatively high erosion rate. This small area contributed the majority of the estimated flux to Cooper Creek of uranium-series radionuclides sorbed or structurally incorporated to eroded soil particles sourced from the mine site. This study provides a methodology for assessment of the erosional stability of such a landscape and consequent impact on water quality, using extensive field data and readily available and well known models and methodologies.

Keywords: Erosion modelling; Sediment transport; Minesite rehabilitation; Water quality; Radionuclide transport; Rehabilitation assessment

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1. Introduction

Successful rehabilitation of the Nabarlek uranium mine site in the Northern Territory, Australia, is a priority issue given its location within the Alligator Rivers Region (ARR)—an area containing the World Heritage Listed Kakadu National Park. Monitoring and surveillance of the site are continuing as the stakeholders work towards final approval of the rehabilitated site and its return to the Aboriginal Traditional Owners of the area (Waggitt, 2000).

The assessment of post-mining landscapes as case studies is an important part of the evaluation of current rehabilitation practices (Willgoose and Riley, 1998; Hancock et al., 2000, 2002; Evans, 2000). Although there are several abandoned, one operating and two proposed uranium mines in the ARR, Nabarlek is the first such mine to be rehabilitated in the modern era under strict regulatory environmental controls. Consequently, several related environmental research projects are being undertaken, both to assist with assessment of the Nabarlek site itself and also to provide information of use in rehabilitation works at other mine sites in the ARR and elsewhere, and the work presented here is a part of this process (Martin, 2000; Evans et al., 2001).

Successful mine rehabilitation is dependent on many factors, two of the major issues being the short- and long-term stability of the rehabilitated landform. In the short-term, erosion can lead to increased sediment loads and transport of other contaminants in downstream waterways. In the case of uranium mines, radionuclides represent one set of contaminants of particular concern. Long-term landform stability is also important for uranium mines given the level of containment required for the radioactive mill tailings (Schumm et al., 1984). Australian guidelines recommend a design life for a tailings cap of 200 years and a structural life of at least 1000 years (Commonwealth of Australia, 1987). This means the structure must be built to maintain its integrity in a 1 in 50 000 year rainfall event. The ARR has the second highest erosivity index in Australia (after Cape York Peninsula) and, as a result, fluvial erosion is a significant process (Williams, 1976; Duggan, 1988).

The objectives of this research were to quantify the gross erosion and radionuclide flux from the rehabilitated surface of the Nabarlek mine site, and to estimate the degree to which sediment loads and radionuclide concentrations in the waters draining the mine site. A further objective was to develop scientifically based methodologies for the assessment of rehabilitated post-mining landscapes. Such assessments are extremely difficult in the case of mines, such as Nabarlek, which are in remote locations. In such cases, there are often few field monitoring data available, and the cost of post-rehabilitation monitoring is high. This study provides a methodology for assessment of the erosional stability of such a landscape and consequent impact on water quality, using extensive field data and readily available and well known models and methodologies.

2. Site description

The Nabarlek mine site is located 270 km east of Darwin near the western edge of Arnhem Land (Fig. 1). Queensland Mines (QML) discovered the Nabarlek ore body in 1970 during an aerial spectrometer and magnetometer survey. The uranium deposit was completely exploited by open cut mining in 143 days during the dry season of 1979 by removal of 606 700 tonnes of ore (Riley, 1995). Ore was stockpiled and covered with a 400 mm ferricrete and gunnite (sand–cement mortar) cap on a purpose built ore stockpile area (Waggitt, 1998). Processing of the stockpiled ore was completed in 1989.

All tailings from the processing plant were returned to the open pit and the site rehabilitated in 1995. This involved backfilling the tailings within the pit, inserting drainage wicks into the tailings material to remove excess water, removing all surface structures, such as evaporation ponds and plant equipment, covering the area with waste rock mulch, deep ripping with tynes pulled by a bulldozer to a depth of approximately 0.9 m and finally seeding the area with shrub and tree species (Riley, 1995; Waggitt, 1998).

The site is located in the seasonally wet/dry tropical environment of northern Australia, with an annual rainfall of 1389 mm, mostly falling in the wet season months from October to April. Short, high intensity storms are common and consequently fluvial erosion is the primary erosion process (Waggitt and