Chapter 6 Conclusions

6.1 Summary

The major aim of this project has been to investigate the current environmental status of the historic Mary Kathleen mine site including the open pit; D Stockpile, Crusher, Goldings West, West Tip, Southern Tip and North Waste Tip pile; evaporation ponds and tailings dams area; and Cameron Creek. This study has provided a thorough dry season data set than has been integrated with current guidelines to suggest appropriate environmental management responses for the area.

From this study the main objectives have been achieved,

Objective 1

1. Detecting and measuring the levels and causes of radiation in the open pit, on and near selected waste rock piles, on the tailings dam surface, at the tailings dam seepage point, and in Cameron Creek.

Radiation levels on the eastern pit face exceed Australian occupational health standards (NH&MRC, 1995). Exposure rate maximums correspond with exposed ore lenses. Localised radiometric highs occur on the waste rock dump at the base of the pit. The remainder of the pit is at background levels.

Radiation levels on non-vegetated waste rock pile surfaces exceed Australian occupational health standards of 20mSv/yr (NH&MRC, 1995). Localised radiometric contamination also occurs on the bare waste rock pile slopes and bases, which are above background level. However, areas covered by soil and vegetation are at background levels.

Radiation levels do not exceed background on the tailings dam surface, evaporation pond areas or Cameron Creek (except for three discrete tailings spills). Low radiation levels indicate that the tailings dam cover, spillways and walls are intact. Seepage waters have elevated total count (1300 cps) readings indicating the mobilisation of radionuclides into surface waters.

Cameron Creek radiation levels are within background levels (<2 mSv/yr) except for elevated dose readings at the base of the sump (5 mSv/yr). Total count readings are highest in the drainage area from the former plant site and waste rock piles.

Objective 2

2. Determining characteristics of contamination from existing waste repositories such as waste rock piles and the tailings dam.

Active weathering of the pit walls runoff, and dissolution of the mineral efflorescences are the main source of contamination in the pit water. Concentrations of U, Mn, Ni and Cu exceed water safety limits for domestic, industrial, recreational and agricultural use (ANZECC 1992, ANZECC 2000). Metal concentrations of Cu and U exceed low risk livestock drinking values. The hardness-modified trigger value for 80% level of protection in the pit lake was also exceeded for Cu and Ni. Uranium (460 μg/L or approx 3.8 Bq/L) in particular is considered excessive both chemically and radiologically and requires monitoring.

Metals, uranium and rare earth metals are eroded into the local drainage system from waste rock piles. Soil concentrations for As, Cu, Mn and Ni exceed the environmental soil quality guidelines (ANZECC, 2000). The sediment quality guidelines (ANZECC, 2000) high trigger values have been exceeded for five stream sediment samples for Cu and Ni. Low ISQG trigger values for the above mentioned elements and As (>20 ppm) and Zn (>200 ppm) have been exceeded (ANZECC, 2000).

There are no signs of erosion or tailings dam failure. Acid, saline, conductive and radioactive tailings water seeps from the base of the dam and flows into the former evaporation ponds. Downstream these waters have higher pH, conductivity, hardness, total dissolved oxygen, and salinity values than the seepage waters.

Objective 3

3. Investigating the dispersal of contaminants into the local soils as well as Cameron Creek sediments and waters.

Weathering of waste rocks is the main source of contamination to soils, stream sediments and vegetation in and around the waste rock piles. Elevated levels of Ce, La, Mn, S, U and Zn in stream sediments below waste rock areas indicated these elements are being transported from waste rock piles into local drainage basins.

Metals (e.g. Fe, Mn, Pb, U and Y) metalloids (As) rare earth elements (Ce, La), alkalis (Ca, Mg, Na,K) radionuclides and sulphate are mobilised from the tailings dam into surface water, by seepages emanating at the toe of the tailings dam. This study highlights dry capping of Mary Kathleen uranium mill tailings did not prevent the mobilisation of numerous contaminants in particular radionuclides into the surface environment.

Co-precipitation and adsorption are likely processes responsible for metal (U,Y) metalloid (As) and rare earth element (Ce, La) enrichment out of solution within Cameron Creek stream sediments. Evaporation during the dry season promotes the precipitation of sulphate rich evaporative sediments within the drainage system. Cameron Creek acts like a uranium sink with regular flushing events distributing low levels of uranium further downstream.

Minor objectives include:

1. Biogeochemical characterisation of vegetation species providing limited information on the bioavailability of uranium at the mine site.

Acacia chisholmii (wattle), Aerva javanica (kapok bush), Triodia longiceps (porcupine spinifex) and other species of grass colonise chemically hostile areas within the pit. The identification of these species tolerant to high levels of U and other metal contaminants (Ni, REE's, Mn) may be useful in the revegetation of contaminated ground to prevent erosion and dampen gamma-radiation. *Cymbopogon bombycinus* bioaccumulates up to 226ppm U in ashed material and appears to be a stress-tolerant plant, that could be used to build up a population for replanting barren waste rock areas.

2. Defining significant problems, which may warrant future attention and additional rehabilitation or the planning of long-term remediation strategies

Due to the location of the mine, ground water and local geology, a viable end use option for the open pit is as a heritage park. Safety concerns can be met by preventing public access to high radiation areas and the pit lake by constructing an educational walk way.

Waste rock pile upper surfaces should be covered with non-radioactive material to attenuate radioactivity. A thicker upper surface layer would reduce oxygen and water infiltration and in turn reduce AMD potential. Metal tolerant species should be encouraged to grow on this new surface to reduce erosion. Due to the plants uptake of toxic elements (U, Mn) grazing animals should be excluded from waste rock areas.

This project has resulted in a major improvement in the amount of data available about water, soil, and stream sediment quality at the Mary Kathleen mine. This data set has applications including its use by statutory authorities for monitoring purposes.

6.2 Directions for future research

This thesis has provided detailed examination into the environmental status of the Mary Kathleen uranium minesite. This section briefly highlights some of the implications of the findings from this thesis for directions in future research.

Data were collected during the dry season and this research focused on these results. It is apparent from a brief of historical data that major differences in water quality and soil and stream sediment geochemistry exist during the wet season. These differences should be examined in detail by sampling during both wet and dry seasons.

The bioaccumulation pathways for on-site vegetation is of particular interest in an environmental sense. The finer details of the accumulation pathways of various metals in plant structure could provide valuable information for other minesite rehabilitation areas. Also beef cattle grazing at the minesite could be tested for heavy metals and compared to beef cattle grown on farm land.

Air quality at the site should be investigated to characterise and source radionuclide contaminants in the air at the minesite. Atmospheric fine particles (<2 μm) produced by mining activities may be present in the atmosphere and have the potential to affect population health over wide areas. Coarse particles, on the other hand, are generally produced by natural environmental processes (wind-blown dust) and are not as easily taken in through the lungs. However, these coarse particles may still present a health risk close to their source because of their chemical composition. The accelerator based ion analysis techniques at ANSTO are ideally suited to investigating this problem.

Inexpensive monitoring of the tailings dam seepage into Cameron Creek could be achieved by high resolution ground geophysics. A multi-channel system including self potential, direct current resistivity, induced polarisation and transient electromagnetic methods that detect near surface groundwater contamination and resolve geological structures relevant to hydrological processes could be used to map contamination.

Longer term detailed groundwater monitoring to ascertain the chemical stability of the surrounding groundwater is another future research option. Waste rock piles and tailings at this site have elevated heavy metal concentrations. Infiltration of rainwater through the tailings dam site, the evaporation pond, the mill site and other areas gives rise to the potential for chemical toxicity from further groundwater contamination by heavy metals.

There is a lack of extensive radiological data prior to mining to allow a full evaluation of rehabilitation standards and effectiveness, especially for radon (which is critical) and other radionuclides. Radon behaviour is complex and radon is a major contributor to radiation dose.