

Radiation Advice & Solutions Pty Ltd

ABN 31 891 761 435

Principal: Mark Sonter MAppSc (Med Phys), MARPS, ARPAB, MAIOH.

116 Pennine Drive
South Maclean Qld 4280

phone / fax: (07) 3297 7653

mobile: 0447 755598

email: sontermj@tpg.com.au; sonterw@tpg.com.au

Dose Calculations for RJCS Access Scenarios - Figtree Short-term visits and Camping

Introduction:

The Rum Jungle Creek South Recreation Reserve is the location of the old Rum Jungle Creek South Uranium Mine, which was mined out (i.e., depleted of economically recoverable uranium) in the early 1960s.

The Environmental Research Institute of the Supervising Scientist (ERISS) performed a comprehensive assessment of radiation dose estimations for DME to assess risks to recreational visitors to the Rum Jungle Creek South Site, in 2011. These estimations included the following dose delivery pathways: (i) gamma; (ii) inhalation of radon decay products (RDP); (iii) inhalation of radionuclides in dust (LLAA); (iv) ingestion of radionuclides in water; (v) ingestion of radionuclides in bush tucker.

Two 'access scenarios' were chosen for study, being (i) 14 short-term visits, 12 noon to 6 pm each, no bush foods consumed; and (ii) overnight camping for 14 days per year, bushtucker foods consumed.

The ERISS report was an exhaustive review of the doses which might be accrued via the various dose delivery pathways for these visit scenarios, and showed that doses to the public are well within international standards for radiation protection and subsequently there is no unacceptable radiological risk to recreational users of the site".

This present exercise is intended to review the specific information provided, and the methodologies used, in the ERISS study and apply them for the specific cases where the visit and camping location is held to be the 'Figtree Site' (more restricted than 'picnic area', see ERISS Report, Fig. 3, attached).



Overview:

As an overview statement, it is important to state that the restriction of location to the Figtree Site will affect only the gamma component of the doses, as the dose components arising from inhalation of radon decay products, and from inhalation of activity in dust, and from ingestion of local foods, are not closely localised, but arise from extended sources and will be relatively consistent across the whole of the picnic area. Therefore the calculations given by ERISS for doses to persons visiting or camping at the picnic area remain realistic as regards the other dose components, viz, RDP, LLAA, and ingestion.

Details of Review:

We reviewed the ERISS dose estimation methods and calculations in light of the request for further advice on doses localized to the 'Figtree Site'. This review was not at the level of detail of the ERISS study, but was intended to gain an understanding of what they had done, so as to be able to apply the same approach to estimations for the Figtree site.

The significance of restricting dose calculations to the Figtree Site is that it is likely that the only component which will change is the gamma component, as the radon decay product and dust inhalation doses will not be so site-specific. Radon source is essentially all ground within 30 minutes air transit time from the Figtree site, but is somewhat weighted by the presence of the waste rock dump. This means that the radon dose will not be different from what was described for the site in

general. Dust doses are from breathing dust stirred up by camping activities, and these also are more dependent on activity in soil throughout the site rather than specifically at the Figtree. Doses from ingestion of food will not be changed from the ERISS assessment because the food collection area will remain the same, distributed over the site and beyond.

Standard for assessment.

It is important to be clear about the appropriate standard for assessing doses in 'existing situations'. '*Existing situations*' includes situations of historically impacted environments, such as environments where ambient doses have been increased by past industrial activities (as here), or by past military testing activity (eg Maralinga), or by accident or spill events, or indeed, situations where there is an unusually high natural background. In all these circumstances, the International Commission on Radiological Protection (ICRP) refers to an 'acceptability band' which is in the range 1 to 20 mSv per year (ICRP Publication 103).

To expand this discussion, ICRP in Publication 103, discusses 'existing exposure situations' in Section 6.3, as follows:

"There are many types of existing exposure situations that may cause exposures high enough to warrant radiological protective actions, or at least their consideration. Radon in dwellings or the workplace, and naturally occurring radioactive material (NORM) are well-known examples. It may be necessary to take radiological protection decisions concerning existing man-made exposure situations such as residues in the environment resulting from radiological emissions from operations that were not conducted within the Commission's system of protection... There are also existing exposure situations for which it will be obvious that action to reduce exposures is not warranted.

"Existing exposure situations can be complex in that they may involve several exposure pathways and (can) give rise to doses ranging from very low to, in rare cases, several tens of millisieverts. ... in many cases the behaviour of the individual determines the level of exposure. ... The multiplicity of exposure pathways and the importance of individual behaviour (particularly dietary) may result in exposure situations that are difficult to control."

(All being relevant to the RJCS situation, in which a major component of the estimated dose is from ingestion of bush foods)

The Commission then recommends setting of 'reference levels' to aid in decision making as regards 'implementation of an optimization process' for control of exposures. It reminds that exposures below the reference level should not be ignored. It points out that an 'endpoint for the optimization process should not be fixed 'a priori'.

Then, clause (287) says:

“Reference levels for existing situations should be set typically in the 1 mSv to 20 mSv band of projected dose as presented in Sections 5.9.2 and 5.9.3 and (as described in) Table 5. The individuals should receive general information on the exposure situation and the means of reducing their doses.”
*In all of the above, it is clear that it is NOT the intent of ICRP to apply as a criterion for any sort of control (being eg further cleanup, blanket exclusion from area, education, or other), the oft-quoted annual dose limit for members of the public, namely 1 mSv, **which is explicitly intended as a limit on doses arising from licenced operations.***

This (existing) situation is quite explicitly different from that which applies when a *current, licenceable, industrial ‘practice’ is operating*, where the dose is clearly ‘controllable’ by the operator, and enforceable by a regulator, in which case there is an obligation on the operator to ensure that members of the public living nearby must not be allowed to incur more than 1 mSv per year.

This, the normally quoted Annual Dose Limit for Members of the Public, of 1 mSv/year, is a dose limit which is applied to an existing operation, or a ‘practice’, (eg a radiopharmacy lab, a uranium or mineral sands operation, a radiography practice, etc) and which if exceeded, can be responded to by legal sanctions against the operator,

The **non-applicability** of the Member of Public Limit of 1 mSv/yr for this situation cannot be sufficiently emphasised.

The difference in philosophy between (a) setting a dose limit and using it to regulate a ‘practice’, and (b) providing advice to health authorities about desirability or otherwise of remediation or restriction of access to control doses in ‘existing situations’, is most completely explained in ICRP 82 (in which the acceptability band was proposed as ‘10 to 100 mSv/year, noting that this band is now superceded by the advice in Publ 103 which points generally to a band of ‘1 to 20 mSv’).

Short-term visits:

Gamma:

Gamma doserate was reported as 0.58 $\mu\text{Gy/hr}$ for the general picnic area by the ERISS study (see Table 1). However, the area around the Figtree site is in the range ‘1 to 2 $\mu\text{Gy/hr}$ ’ according to Fig 7 and Fig 8, in the ERISS Report, and furthermore the dose rate at the figtree itself is reported in the ERISS Report (p43) to be 1.98 $\mu\text{Gy/hr}$ (round to 2.0 $\mu\text{Gy/hr}$).

The estimated total annual gamma dose to a person engaging in 14 daytime visits of 6 hours each, ranging throughout the picnic area, will be $(14 \times 6 \times 0.58 =) 49 \mu\text{Gy}$ (i.e 34 μSv) per year. If one restricts location specifically to the figtree itself, however, then this total dose will be in the order of 170 μGy (or 120 μSv) per year.

This result is higher than the 'picnic area' scenario given in ERISS, but is still very small compared with the acceptability band of 1,000 to 20,000 μSv per year, which is ICRP's guidance for acceptable doses to members of the public in 'existing situations'.

Radon decay products:

ERISS reported a two-day daytime average figure of $0.044 \mu\text{J}/\text{m}^3$. On this basis, the above access scenario and a breathing rate of $1.2 \text{ m}^3/\text{hr}$, gives a time integrated exposure of $(14 \times 6 \times 0.044 \times 1.2 =) 18.4 \mu\text{J}\cdot\text{hr}/\text{m}^3$, which with a dose conversion factor of $1.1 \mu\text{Sv}$ per $\mu\text{J}\cdot\text{hr}/\text{m}^3$, delivers $20 \mu\text{Sv}$ per year. This is comparable with the ERISS Report, Table 29, which reports $29 \mu\text{Sv}$ per year, the difference between their calculation and this one being due to slight differences in assumptions, mainly with breathing rates.)

The restriction of location to the Figtree, rather than the whole of the picnic site, will have *no effect* on the radon decay product dose: it will be the same. This is because the radon decay product concentration in air is not determined by the radon emissions at the specific site, but from an extended area around the location, being at least the distance that air will move in about 30 minutes.

Long-lived alpha emitters in dust:

If we apply the figure for dust raised by camping activities, measured by ERISS, of $0.289 \text{ mBq}/\text{m}^3$, and assume two extreme alternative breathing rates of 0.5 and $1 \text{ m}^3/\text{hr}$, for sedentary sitting and for active playing, then we get 0.42 and $0.84 \mu\text{Sv}$ for the 14 days of short visits. ERISS reported estimates (Table 29) of 0.28 to $0.56 \mu\text{Sv}$ for various scenarios, again, showing minor differences with my estimates but similar in general magnitude. It is noteworthy that the general picnic area average, in the *absence* of dust-raising activities, was reported by ERISS as $0.181 \text{ mBq}/\text{m}^3$, about 30% higher than what was measured at the Batchelor Bushfire Council site, which, was in different periods, 0.138 and $0.142 \text{ mBq}/\text{m}^3$. (pp26 and 46)

As in the case of radon decay products in air, the airborne dust concentration is also likely to be determined by the ground activity averaged or distributed over an extended area rather than just the precise figtree location.

Long-stay (camping) visits:

Gamma:

Assume gamma dose rate at Figtree is $2 \mu\text{Gy}/\text{hr}$. For long-stay camping, for 14 days, total time is 336 hours, so total gamma will be $672 \mu\text{Gy}$ (i.e., $470 \mu\text{Sv}$).

The gamma dose for camping using 'whole of picnic area', for comparison, is $(0.58 \times 336 =) 195 \mu\text{Gy}$, or $136 \mu\text{Sv}$. ERISS reported $101 \mu\text{Sv}$ for adults and $125 \mu\text{Sv}$ for children. So, restricting location to precisely the site of the Figtree has the effect of increasing the gamma dose about 4 fold.

However, these results are still low compared with the acceptability band of 1 to 20 mSv per year, which is ICRP's guidance for 'existing situations'.

As discussed above in 'Standards', the usually-quoted 'Member of Public annual Dose Limit' of 1 mSv does not apply, as the doses to be assessed are not subject to control by application of rules upon an operator, rather, they are doses which are more like background, albeit a background which has been modified by past activities.

The interpretation of the ICRP guidance in this case is that *only in the scenarios which suggest members of the public might accrue doses above 20 mSv per year* should the health authorities definitely contemplate specific actions to restrict access.

Radon decay products:

Will not change from ERISS estimates.

Long-lived alpha emitters in dust:

To take into account the dust raised by camping activities, ERISS specifically took an air sample for the 2-day period when they camped at the site. This filter gave a result of 0.289 mBq α /m³, compared to the figure when no activities were happening, of 0.142 mBq α /m³. Natural background, however, was stated to be 0.14 mBq α /m³, as measured at Batchelor Bushfire Station.

The total dose that inhalation of this dust incurs, for an adult or for a child, for a 14 day camping stay, with an assumed breathing rate of 0.5 m³/hr for resting / sitting, is:

(14 x 24 x 0.5 x 0.289 x 10⁻³ x 6 =) 585 uSv. This supports the general validity of the ERISS estimates.

Ingestion of local foods:

Will not change from ERISS estimates.

Summary Table, total for year, each scenario:

The following table has been constructed by taking Table 29 of the ERISS Report, multiplying out for 14 days for each scenario and pathway, and then adding a new column to reflect the increased gamma dose from restricting location of activities to Figtree.

	Gamma, ERISS	Gamma, figtree*	RDP	LLAA	Ingestion	Total, ERISS	Total, figtree
Adult, short	31	118	29	0.28	0	60	147
Adult, camping	101	470	214	0.42	336	651	1020
Child, short	35	118	29	0.28	0	64	147
Child, camping	125	407	179	0.56	406	710	992

* Note we have not sought to calculate children's gamma doses separately from adults, as the error bars are likely to be higher than any minor differences between them. As shown in the ERISS report, they are similar, with children's doses being about 15 to 20% higher. It may even be that in a 'figtree' scenario, children's doses would be lower because they will be more likely to play away from the 'figtree' location, throughout the more general camping area.

Summary comments:

I have reviewed the ERISS Report and have calculated dose estimates (from each dose delivery pathway) based on the ERISS raw data. The numbers which have been generated are not identical to those generated by ERISS, but are similar, and thus confirm my understanding of and agreement with their results. These have then been reviewed with a view to judging the change which comes from restricting activities and location to the Figtree site.

The only dose component which changes when one restricts activities to the immediate vicinity of the Figtree, is the gamma dose.

All dose delivery pathways other than external gamma remain unaffected: inhalation of radon products and of dust will give doses which are unchanged (and as discussed in the ERISS Report). This is because they are driven by the area-distributed source, not localised. In the case of radon decay products, the generating area is at least that which air has traversed over a period of 30 minutes prior to passage past the figtree location. In the case of airborne dust, the source will be surface dust stirred up throughout the 'camping area', hence the validity of the ERISS estimate still holds. For doses from consumption of bush foods, because these foods are collected from a wider range, these doses are also not localised, and the doses from these foods are already discussed and assessed in the ERISS Report.

The gamma dose to adults and to children when localised to the figtree, will be about 4 times higher than the gamma doses assessed in the ERISS Report. *But these estimates still result in quite low*

total doses. They still fall below, or at, the minimum end of the range for which ICRP suggests consideration of active control to avert existing doses (1 to 20 mSv/year). (See ICRP Publ 103, pp111, 117.)

The doses estimated by ERISS for the short-term and long-term (e.g. camping) scenarios discussed, and the higher doses incurred by staying specifically at the figtree, despite the higher gamma dose rate component, are also well within the range that you can get elsewhere in the world from natural background.

It should be noted that the ERISS Report was quite comprehensive, and as discussed above, I am in general agreement with the estimates of doses which they have arrived at.

What does not come through clearly enough in the ERISS Report, is that the overall calculated doses, and specifically the 'radon' doses and the 'dust' doses, are really quite low. This may seem counter-intuitive, or even unbelievable, as the recreation area is the site of an old uranium mine. However, (i) the dust activity levels reported at the recreation area are only about twice what was found at Batchelor, (and are about one two-thousandth of what would apply at a well-controlled operating uranium mine); (ii) the nearby waste dump which is the main source of radon, has average uranium content between about 60 and about 240 ppm U, which is far below the grade of the ore which was mined, which was about 3000 ppm. (Historically, 200 ppm was regarded as the lower cutoff of what was regulated as radioactive ore, material which was required to be under 'regulatory control'.)

Warning on Remediation:

Whilst consideration of remediation of the Figtree site by excavation of local surface material may well reduce the local gamma field, that is not a foregone conclusion: it may be that excavation could uncover a higher-gamma emitting layer at depth, and if remediation is to be contemplated then this eventuality would have to be tested for, and if found likely then this would require backfill with inert material.

Further Discussion:

It should be recognised that social activities at this site including picnicking and camping, and the associated formal and informal educational activities which take place there, including storytelling and learning craftwork and bush lore including food gathering and hunting, are socially beneficial.

The question is, 'is there any hazard associated with carrying out these activities at the Rum Jungle Creek South recreation area, and specifically at the Figtree?'

The radiation dose figures for the access scenarios calculated by ERISS, and checked in this report, and the further dose assessment done in this report specifically taking into account localized time spent at the Figtree (including camping), are doses which are well within the range of 'existing doses'

which ICRP advises as acceptable without the need for controls. They are also well within the range of natural doses found elsewhere in the world.

ICRP has always been anxious to remind assessors of the importance of including consideration of social values when assessing acceptable doses (see eg, ref 2). The assessed potential doses for the scenarios under discussion are small, in the order of 0.5 or so milliSieverts per year. It would be a terrible pity to forego the benefits of social interaction, generational bonding, and environmental, bushcraft, and lifestyle learning experiences, simply to avert such small and unthreatening doses.

It is crucial however that the stakeholders be adequately informed of the doses they may incur. It is important that the doses incurred by their activities be placed in context with (similar) background doses here and elsewhere in the world.

ICRP advice insists that the individuals who may enter and use the area should know in general terms the (small) doses which they incur, and should particularly know that they can further reduce those doses by limiting their consumption of bush foods, particularly mussels.

Mark Sonter, 11-04-2016, amended 1-05-2016, 16-05-2016

References

ERISS: Assessment of the Radiological Exposure Pathways at Rum Jungle Creek South Lake Reserve, Batchelor, May 2012

ICRP Publication 82: Protection of the Public in Situations of Prolonged Radiation Exposure, The Application of the Commission's System of Radiological Protection to Controllable Radiation Exposure Due to Natural Sources and Long-Lived Radioactive Residues, ICRP, 2000.

ICRP Publication 103: The 2007 Recommendations of the International Commission on Radiological Protection (see Section 6.3 pp111-112, pp 116-117).