# Radiation dose models *for people*

Nuclear Africa

*Produced by Nuclear Africa (Pty) Ltd for general public information.*

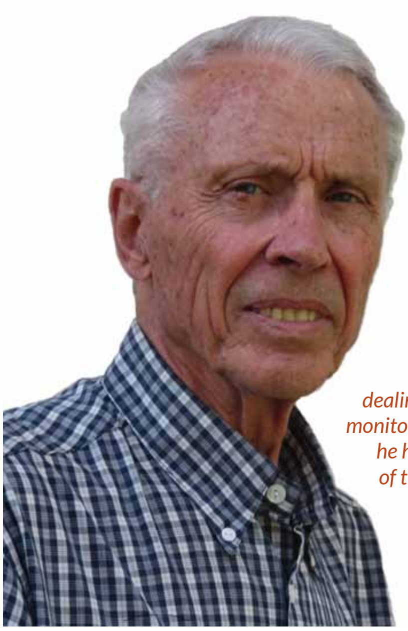
*Koeberg Nuclear Power Station*

*By Dr Cairns Bain*

*At the dawn of the nuclear power age it was realised that nuclear power plant workers could potentially be exposed to nuclear radiation from the operating plant. As a result, extensive studies were carried out concerning possible radiation absorption, and what such radiation could then do to the people.*
*These international studies were not confined to the workers at nuclear plants, but were extended to consider any people living anywhere near nuclear plants.*

In principle, very small amounts of radiation can be released from nuclear power stations via gaseous or liquid effluent. These paths are known as 'discharge pathways.' A discharge pathway can, in principle, lead to multiple exposure pathways for humans.

For example; for a discharge into the air, the dispersed cloud of gas, or fine particulates, could directly irradiate people or be inhaled as the cloud passes. Furthermore, the cloud could interact with dust and moisture in the air and could then fall mixed into the rain. This is known as radioactive fallout.



*Dr Cairns Bain has an MSc in nuclear physics and a PhD in coastal oceanography. Before retiring from the South African Nuclear Energy Corporation (Necsa) he was chief scientist dealing with environmental radiation monitoring and the public. Since retiring he has carried out reviews of aspects of the radiological assessment of the new nuclear power station sites in South Africa.*

This radioactive fallout varies depending on a number of factors such as; the chemicals and the type of the radioactive materials; the weather conditions and the topography (such as the hills and terrain type).

The fallout can build up on the soil to root to plants, or from plant leaf directly to fruit or vegetable etc. For certain radio chemicals such as iodine, deposition on grass can lead to cows and so into milk and then to humans who drink milk.

For liquid discharges there is a need first to distinguish between fresh water and sea water routes. For fresh water this includes drinking water and using water to irrigate crops. For both fresh and sea water discharges their pathways include eating fish, swimming, boating and sunbathing on contaminated beaches.

A member of the public can incur a dose from the sum of all these multiple pathways, but the dose is also dependent on factors relating to that person's lifestyle. This includes factors such as person's age group, distance from the discharge point, sports like boating or swimming, and the consumption rate of different foods. All of this needs to be known, to be able to determine the potential dose incurred.

However there is a further complication in estimating the dose to a human body, since the different chemical species of the radioisotopes can travel to different body organs. A well-known example is that iodine goes mainly to the thyroid, caesium to the bone, uranium to the kidneys etc.

There are several hundred radioactive radioisotopes, each with differing nuclear properties. With all this complexity, a number of computer dose assessment models have been developed, to estimate the possible dose received. These are models which take all the variables into account.

*Beach near Koeberg Power Station*

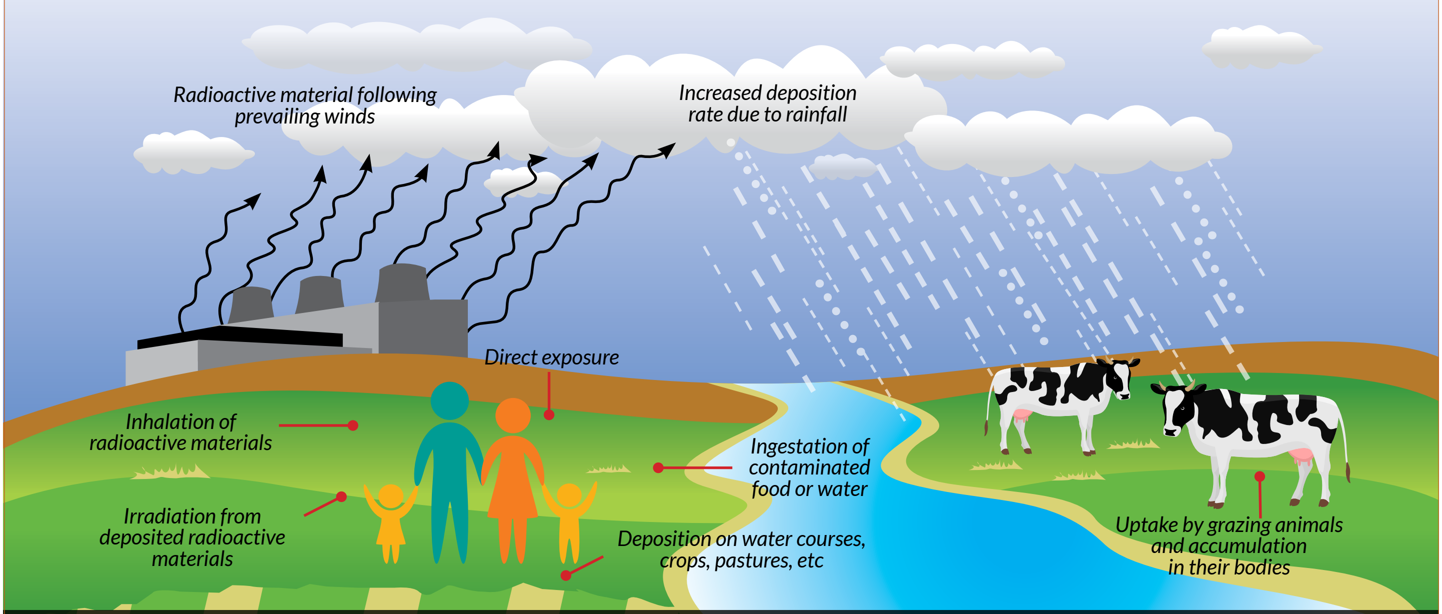
## Very Small Doses

*It is important to note that because nuclear radiation is actually an energy source in itself it is very easy to detect using the correct scientific equipment.*

One can make the comparison that if you had a couple of dozen closed cardboard boxes lying on the lawn and one box contained a chirping cricket, it would be very easy to find the cricket without opening any of the boxes....just listen for the chirp.

So, nuclear radiation can be detected in incredibly small quantities. For example, in the study of ocean currents off the South African coast , two or three litres of mildly radioactive liquid has been poured into the ocean off Richards Bay, and a few days later this liquid was tracked flowing past Durban, hundereds kilometres away.

So when a newspaper states that nuclear radiation was detected, tens of kilometres away for some individuals, it is usually the case that the radiation detected was of an insignificantly small amount. So do not overreact to stories about nuclear radiation being detected.




*Potential radiation release pathways*

## Monitoring to Confirm Dose Impacts

*The first stage of monitoring a nuclear facility is to measure the discharge which comes out of ventilation stacks and liquid pipelines, in order to determine the amounts that in principle could be released over various time intervals. The next stage is to monitor for any possible impacts detected in the environment surrounding the facility. One can measure direct radiation and take various samples. For example; air filter samples, dry fallout, rain, soil, vegetation, crops, milk and so on, are all easily measured.*

*It must be pointed out that the annual legal dose limits for people are already very small.*

Annual legal dose limits are made up of a sum of many contributing exposure pathways, so when a sample is taken over a week or a month, on a sub part of a pathway, it represents a valid part of the whole view.

Specific radioisotopes are measured on such samples. The measurements are often on the edge of analytical detection ability. The measurements are then interpereted, via the dose model. Measurement of environmental dose can also be done directly, using small thermo-luminescent dosimeters. These are generally positioned one metre above ground level, at boundary points and at various distances, for a one month exposure. They of course, measure all the radiation from the soil and air, plus cosmic radiation from outer space, with the potential nuclear facility contribution being added.

*Potential nuclear pathways to rivers and the sea are constantly monitored.* *Beach near Oyster Bay*

## Dose Models and Site Specific Data

Of importance in any use of these computer-based models is the dose path assessment, which is dependent on the knowledge of the site-specific data. At both the Koeberg nuclear power station and the SAFARI-1 research reactor on the Pelindaba site, specific environmental data was collected before the commissioning of the nuclear facilities.

For the Koeberg site , extensive air dispersion and marine studies were started in the 1970's and a meteorological tower was established. Air dispersion models are needed to determine patterns of meteorological dispersion, averaged over a distance of 50km, over a period of a year. Koeberg and Pelindaba continue to operate their own weather stations to provide relevant data for air dispersion modeling.

A marine discharge does not have as complicated a dispersion model as an atmospheric discharge. However of critical importance is the large variation in the accumulation rate of the different chemicals, in the different marine food chains. So for example, various correction factors are used such as the Biological Accumulation Factor (BAF) which is the ratio between the concentration of a given chemical element in the edible part of a fish, lobster or mussel and it's concentration in sea water. This varies by factors of 10 to 10 000. The BAFs were determined in the late 1970's, some years before the Koeberg nuclear plant was operational. This demonstrated the thoroughness that was shown in preparing to conform to legal nuclear limits for discharges into the sea.

For each site, a special set of specific data are examined. Site-specific data include: wind and rain data, topography, population demography, BAFs, plus a survey of public habits and food consumption patterns. Generic assumptions include: the breathing rate of children and adults, the food plants; grass to cow to milk etc. One of the main choices in the models is people. Specific measuring factors are things like: the closest public boundary, or a critical group of people who have habits that result in a higher potential dose than an average person.

The philosophy of the model design is to be very conservative in considering the different steps leading towards the dose result. This means that an overestimate of the total estimated dose incurred is always achieved.

*All of this analysis means that certain radioisotopes can be targeted for specific control and limitation, before any discharge occurs. The results are also used for nuclear license purposes to set dose limits, and to determine the scope of radioactive quantities which may be discharged per facility per day, week or year.*

Dose models concentrate on the dose to humans, since people are considered the most vulnerable to radiation exposure. However, with growing environmental awareness, and from mankind's impact on the biosphere, newer models such as the ERICA model have been developed internationally to identify non-human indicator species and organisms in various areas.

Although a national standard for such non-human dose assessment is not yet available, the ERICA model is being used in the initial assessment of the proposed sites for future nuclear power stations.

# ERICA | Assessment Model

The ERICA model is a mathematical model used to assess potential nuclear radiation threats to people, in the event of an accidental release of nuclear radiation. The name ERICA comes from; the integrated Environmental Risk from Ionising Contaminates Assessment and management approach.

It uses a selected group of Representitave Animals and Plants (RAP's), which collectively can be used to assess potential radiation absorbed by humans in the same area.

*Wildlife on the beach at the new nuclear power station site at Oyster Bay*

The RAP'S are selected for different areas around nuclear installations, and are defined like this:

*"A series of entities that provide a basis for the estimation of radiation dose rate to a range of organisms, which are typical, or representative, of a contaminated environment. These estimates, in turn, would provide a basis for assessing the likehood and degree of radiation effects."*

Nuclear Africa

*Produced by:*
*Nuclear Africa (Pty) Ltd*
*Pretoria, South Africa*
*Tel: +27 (0) 12 807 3920*
*Email: exec@nuclearafrica.co.za*
***www. nuclearafrica.co.za***

www.facebook.com/www.nuclearafrica.co.za/