NATIONAL DOSE ASSESSMENT WORKING GROUP

PAPER 14-03: THE RADIOACTIVELY CONTAMINATED LAND EXPOSURE ASSESSMENT MODEL

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1 Introduction

In August 2006 the "Part 2A" Contaminated Land regime was extended to address land that is contaminated by virtue of radioactivity (Defra, 2006a). In addition, new regulations came into force in December 2007 which extended the scope of the regime for non-nuclear radioactive contamination to contamination caused by nuclear occurrences (Defra, 2007a).

The Radioactively Contaminated Land Exposure Assessment (RCLEA) methodology is Defra's recommended approach for the exposure assessment of contaminated land on sites that fall under the new regime. It is designed to be applied at the first stage of the tiered approach for assessing radioactively contaminated land, and uses the same scenarios as the Contaminated Land Exposure Assessment (CLEA) methodology for non-radioactive contaminated land. RCLEA is primarily designed for screening assessments. However, where the scenarios and assumptions are sufficiently representative of the actual situation, calculations made using RCLEA can support determination decisions.

This paper describes the process of developing the RCLEA model, the model itself, and its application. Further details can be gained from the RCLEA documentation available from the Environment Agency and Defra (Defra 2006b, 2006c, 2007b).

2 Developing RCLEA

The RCLEA methodology was developed between February 2005 and the end of 2006. The technical work was undertaken by Quintessa, supported by URS, through a project commissioned by Defra. A sub-group of Defra's Radioactively Contaminated Land Steering Group (RCLSG) was set up to oversee the development of RCLEA and a wide range of stakeholders was consulted on the proposals as the project progressed.

The objective was to develop, in an open and consultative way, an assessment model for radioactively contaminated land that complemented the CLEA model. The model is designed to be used to derive the concentrations of various radionuclides in soil that would lead to specified levels of radiation dose and/or risk.

The work consisted of five phases which are summarised below.

2.1 Phase I: Development of Proposed Approach

The first phase of the project involved defining the overall scope and requirements of RCLEA.

The scope was largely formed by the characteristics and needs of the regime in which RCLEA was to be applied, and the desire for consistency with CLEA. It is summarised in Box 1.

Box 1: Scope of RCLEA

S1	RCLEA is intended for screening radioactively contaminated land and will calculate concentrations in soil that indicate the need to consider intervention as well as potential radiation doses for given concentrations of radionuclides in soil.
S2	The methodology will enable 'site-specific' calculations by allowing the user to modify some exposure pathways and parameter values, although detailed assessments are beyond the scope of RCLEA.
S3	The methodology will be restricted to the assessment of existing (historic) radioactive contamination, i.e. 'intervention' situations.
S4	The RCLSG will specify health protection criteria in terms of effective and equivalent radiation dose to an individual below which no further consideration of the contamination is required.
S5	A set of radionuclides, defined by the RCLSG and representing those most likely to be found in radioactively contaminated land in the UK, will be considered. These can be considered individually or as mixtures of radionuclides.
S6	RCLEA will be consistent with the CLEA methodology, as far as appropriate.
S7	The methodology will be aimed at 'practitioners' with some specialist knowledge of radioactively contaminated land and the assessment of human health risks.

The specific requirements for RCLEA were informed by a review of the CLEA approach (by URS) and the work of the Soil Guideline Value Taskforce, which has since reported (Defra, 2006d) and resulted in a new version of CLEA (Environment Agency, 2008). Quintessa also undertook a review of methodologies for the assessment of radioactively contaminated soil. This drew on a preceding literature review (Oatway et al., 2004) and examined in detail the assessment methodologies developed by the Environment Agency (EA, 1999), by the National Radiological Protection Board* (Oatway and Mobbs, 2003) and by the US National Council on Radiation Protection and Measurements (NCRP, 1999). Whilst these assessment methodologies differ in scope, they show a consensus on the

* now the Radiation Protection Division of the Heath Protection Agency (HPA-RPD)

assessment approach most suitable for screening calculations for radioactively contaminated land. This provided a basis for defining specific requirements for RCLEA.

It was also recognised that some assumptions were necessary to allow RCLEA to be developed in a clear and consistent way. These covered aspects such as the size and depth of contamination to be assessed, key aspects of exposure scenarios and exposure pathways (e.g. radon and groundwater were excluded), and the level of ambition for the methodology.

The outcome was a series of technical requirements for the RCLEA methodology, which are summarised in Box 2. A further six requirements dealt with the functionality of the software and seven requirements were defined in relation to the structure, format and style of accompanying documentation.

Box 2: Technical Requirements for the RCLEA Methodology

R1	Contamination is assumed to be at the surface, extend to a depth of 1 m and to cover a large areal extent. Patchy contamination will be assessed with simple assumptions.
R2	47 specified radionuclides will be considered.
R3	RCLEA will calculate annual effective individual doses, for both total dose and contributions from individual radionuclides and exposure pathways.
R4	RCLEA will calculate concentrations of radionuclides (for a specified mixture of radionuclides in the contamination) corresponding to a specified dose criterion for intervention.
R5	The same soil types considered by CLEA will be assessed.
R6	RCLEA will consider the same exposure pathways as CLEA, with the exception of exposure to volatile gases and with the addition of external irradiation.
R7	RCLEA will consider the same land uses as those addressed in CLEA (residential, allotment and commercial/industrial).
R8	RCLEA will enable simplistic representation of shielding from external irradiation provided by building walls and floors.
R9	The age groups will cover the range of ages considered in CLEA in a manner consistent with those age groups typically considered in radiological assessments.
R10	Parameter values used in the models will be consistent with CLEA, where possible. In cases of significant discrepancies with established radiological assessments, parameter values will be taken from the latter and the difference highlighted.
R11	Uncertainty will be considered in the development of RCLEA, although it will adopt a deterministic approach, using cautious but realistic parameter values.

2.2 Phase II: Consultation on Proposed Approach

The proposed approach was reviewed and endorsed by the RCLSG. Phase II of the project then involved consulting with a wide range of stakeholders on the proposals. A report was issued that included a series of questions and points for which feedback was requested.

The consultation took place in May and June 2005. It was publicised by Defra and through industry fora such as the SAFEGROUNDS Learning Network. Feedback was received from the Ministry of Defence, Nexia Solutions and the Health Protection Agency and the (conventional) contaminated land branch of Defra. All supported the overall approach. Comments mainly related to detailed aspects of the scope and requirements. These were reported to Defra and a revised version of the proposed approach was developed.

2.3 Phase III: Development of Draft RCLEA

Phase III involved using the proposed approach to derive a detailed specification for RCLEA followed by the development of the draft RCLEA documents and software.

As RCLEA is intended to be consistent with CLEA (as far as possible) much of its specification was drawn from the CLEA technical documentation. In particular, the main technical report, 'CLR 10' (Defra and Environment Agency, 2002), and subsequent CLEA briefing notes, were used. Where the RCLEA approach needed to differ from CLEA because of the particular characteristics of radioactive contaminants, the specification drew on established approaches for assessing radioactively contaminated land. This included work by the HPA-RPD, the US NCRP and the International Commission on Radiological Protection (ICRP).

The resulting technical specification describes conceptual models, mathematical models and data for calculating human health risks from an area of radioactively contaminated land under various types of use. A complementary functional specification was also developed to describe the basic requirements for the RCLEA software application to implement the models.

The technical specification was used to develop a draft technical report describing the proposed model and its application. The key elements of the model are described in the Section 3.

The draft software application was implemented in Microsoft® Excel. It was organised around a series of worksheets which present the data used in calculations and the calculated results. The sheets were password-protected, with the exception of clearly indicated user-editable values and options. This is also described in Section 4.

2.4 Phase IV: Consultation on Draft RCLEA

Draft RCLEA documents and the software application were reviewed by the RCLSG and issued in a second round of consultation in January and February of 2006. The technical report, software application (and software user guide), and a non-technical summary were published on Defra's website with an invitation to comment. Once again,

SAFEGROUNDS assisted in publicising the opportunity to comment. A limited number of comments were received and none proposed any significant changes to the RCLEA methodology and/or software.

2.5 Phase V: Finalisation of RCLEA

The RCLEA methodology, software and documentation were updated in the light of the consultation comments. The structure of the regulatory regime continued to develop with the result that the updated versions of the RCLEA documents and software were published in the autumn of 2006. The main differences were modifications in terminology to accord with that used in regulatory guides and the incorporation of ideas from Defra (such as a worked example) into the summary report and user guide.

The documents were incorporated into the "CLR" series of reports providing technical guidance on contaminated land. The final versions were published at the end of 2006 and are freely available through the Environment Agency website as a summary report, technical report, and Microsoft® Excel application.

3 The RCLEA Model

As the RCLEA methodology complements CLEA, the same generic exposure situations are considered. The detailed derivation of the CLEA models is presented in the main technical report, 'CLR 10' (Defra and Environment Agency, 2002), and subsequent briefing notes. However, some modifications and additions were needed due to the nature of radioactive contamination. The main differences between CLEA and RCLEA models are shown in Box 3.

3.1 Characteristics of Contaminated Soil

RCLEA includes data for 47 different radionuclides, which can be assessed separately or in combination. The radionuclides, shown in Box 4, have been selected to include those most likely to be encountered in practice.

RCLEA very cautiously assumes radionuclides to be uniformly distributed in the whole area of land occupied by the exposed individual and to extend to a depth of 1 m from the surface. Exposure to patchy contamination is approximated simplistically, assuming that the radiation dose is linearly related to the proportion of the area that is contaminated. More complex treatment of geometry is beyond the scope of RCLEA. Likewise, buried contamination is not considered. More detailed modelling would be required in order to properly assess the risks of such situations.

3.2 Land Uses

CLEA uses to the concept of "land uses" to define the conditions in which people are assumed to be exposed, and RCLEA uses the same approach. Land uses are represented through permitted combinations of exposure pathways and age groups, and with parameter value assumptions that describe the nature of human exposure to the contamination. Reference land uses are defined in CLEA and implemented in RCLEA (see Table 1). The RCLEA methodology (and Microsoft® Excel application) also permit user-

defined land uses to be created, although these are constrained by the exposure pathways that can be modelled.

Box 3: Key Differences between RCLEA and CLEA

RCLEA enables calculations in which multiple contaminants contribute to the human health risk.

The RCLEA methodology is deterministic in nature in comparison to CLEA's probabilistic approach. This is because the adoption of the probabilistic parameters from CLEA would lead to inconsistencies in the internationally recommended radiation dosimetry used in RCLEA. It also recognises that there are other (possibly larger) sources of uncertainty than those represented explicitly in CLEA.

The CLEA methodology includes data for 18 different age groups, whilst RCLEA includes only three (Infant, Child and Adult) consistent with internationally recommended radiation dosimetry.

RCLEA includes exposure pathways for whole body external irradiation from contamination at a distance; and irradiation of the skin from direct contact with contaminated material.

Absorption through skin is excluded from the RCLEA methodology as it is considered not to be a significant pathway for radioactive contamination.

The RCLEA methodology adopts a single soil type, as a key characteristic (the equilibrium soil solid:liquid distribution coefficient, Kd) is considerably uncertain across soil types.

Volatilisation is excluded from RCLEA on the basis that it is considered as an insignificant pathway for the historic contamination considered by the methodology.

A higher concentration of atmospheric respirable particulates is adopted for RCLEA in comparison with the CLEA methodology. The value used in RCLEA is in line with assumptions for typical radiological assessments.

Box 4: Radionuclides Considered in RCLEA

H-3, C-14, K-40, Fe-55, Co-60, Ni-63, Se-79, Sr-90*, Nb-93m, Nb-94, Mo-93, Tc-99, Ag-108m*, Sn-121m*, Sn-126, Sb-125, I-129, Cs-134, Cs-137*, Pm-147, Sm-147, Sm-151, Eu-152, Eu-154, Eu-155, Pb-210*, Ra-226*, Ra-228*, Ac-227*, Th-228*, Th-229*, Th-230, Th-232, Natural Th~, Pa-231, U-233, U- 234, U-235*, U-236, U-238*, Natural U+, Np-237*, Pu-238, Pu-239, Pu-240, Pu-241*, Am-241

Note: * Includes contribution from short-lived daughters; ~ natural thorium is assumed to contain 0.333 Bq of Th-232, 0.333 Bq of Th-230 and 0.333 Bq of Th-228 as well as 0.333 Bq of Ra-228 that has ingrown; + natural uranium is assumed to contain 0.483 Bq U-238, 0.022 Bq U 235 and 0.495 Bq U-234.

Table 1: Reference Land Uses

Land Use	Permitted Age Groups	Permitted Exposure Pathways
Residential	▲ Infant; ▲ Child; and ▲ Adult.	▲ Whole body external irradiation (indoor and outdoor); ▲ Soil ingestion (indoor and outdoor); ▲ Dust ingestion (indoor and outdoor); ▲ External irradiation of the skin from dermal contact (indoor and outdoor); ▲ Dust inhalation (indoor and outdoor); △ Consumption of home grown produce; and △ Consumption of soil associated with home grown produce.
Allotments	▲ Infant; ▲ Child; and ▲ Adult.	▲ Whole body external irradiation (indoor and outdoor); ▲ Soil ingestion (indoor and outdoor); ▲ Dust ingestion (indoor and outdoor); ▲ External irradiation of the skin from dermal contact (indoor and outdoor); ▲ Dust inhalation (indoor and outdoor); ▲ Consumption of home grown produce; and ▲ Consumption of soil associated with home grown produce.
Commercial/ Industrial	▲ Adult.	▲ Whole body external irradiation (indoor and outdoor); ▲ Soil ingestion (indoor and outdoor); ▲ Dust ingestion (indoor and outdoor); ▲ External irradiation of the skin from dermal contact (indoor and outdoor); and ▲ Dust inhalation (indoor and outdoor).

Notes: Different building types can be considered for all reference land uses. ▲ Included in the default assumptions; △ Permitted as optional.

The residential land use scenario considers a two-storey property with a private garden, occupying 0.2 hectares. Infants and adults are assumed to spend most of their time at home, whilst children spend time away from the home at school. Part of the garden can be assumed to be used as a vegetable patch, and potentially contaminated vegetables may be eaten.

The allotment land use scenario assumes a plot of 0.8 hectares in size. Adults are assumed to visit the allotment site four days a week for four hours per visit, sometimes accompanied by infants and/or children. The vegetables are assumed to be consumed by the allotment gardener and his/her household.

The commercial/industrial land use scenario is intended to reflect shops, offices, or a small light industrial park. The whole site is assumed to be 2 hectares in size, with

buildings occupying 5% of the area. It is assumed that workers spend about 38 hours a week on the site, the majority of their time being indoors.

The RCLEA methodology considers three age groups: 1 year old ('infant'); 10 year old ('child'); and >17 year old ('adult'). Both males and females can be considered for any specified age. Age and sex-dependent data include exposure durations, consumption rates and human characteristics such as body weight.

The RCLEA methodology considers a single generic soil type (a loamy soil is adopted). It allows (in a simple way) for the differing level of shielding that could be offered by different types of building. Two reference building types are considered: timber walls and floors and concrete/brick walls and floors.

3.3 Exposure Models

The exposure models used in RCLEA are consistent with those used in CLEA but have been supplemented with additional models for external irradiation of the whole body and of the skin.

Whole Body External Irradiation

Individuals are assumed to be subject to external irradiation for the whole time they are present at the contaminated site. External dose conversion factors relate to irradiation of an adult by an infinite depth of contamination. Some degree of shielding can be assumed when the person is inside, depending on the building type. A simple energy-independent shielding factor is applied.

Soil Ingestion

Inadvertent ingestion can occur both indoors as well as outdoors, as contaminated soil may be deliberately or inadvertently brought into a building. Age-dependent ingestion rates are combined with the duration spent in a particular location to determine the total intake of contaminated soil by this route by a given individual. Consistent with the CLEA methodology, deliberate ingestion of soil is not considered.

Dust ingestion is modelled in a similar way.

Dermal Contact

Dermal contact with contaminated soil can result in direct irradiation of the skin. This is assessed by considering the radiation dose rate from skin surface contamination at the depth at which sensitive cells are present. This is combined with the exposure duration and concentration of radionuclides on the skin. It is also necessary to determine the fraction of skin that is irradiated and apply a factor for the sensitivity of the skin to irradiation to calculate the annual effective dose.

Dust Inhalation

Dust from contaminated soil can be suspended in the atmosphere and inhaled by individuals occupying a contaminated area both indoors as well as outdoors. The assumed airborne dust concentration of particles of a respirable size is combined with the

exposure duration and age dependent inhalation rate to determine the total annual intake of contaminated soil by this route.

Consumption of Home Grown Produce

A range of plant types is considered to be suitable for growing in allotments or gardens: brussels sprouts, cabbage, carrot, leafy salads, onions and potatoes. In each case a radionuclide-dependent equilibrium soil-plant transfer factor is applied to determine the concentration of the radionuclide in the edible portions of the plant. It is also assumed that vegetables retain external soil contamination. Some is considered to remain and can be ingested with the produce. The total annual intake of contaminants by this route is then determined with the application of an assumed ingestion rate (which is age- and sex-dependent).

3.5 Data

Contaminant-independent data for the three reference land uses is based on values used in CLEA. However, as RCLEA does not adopt a partially probabilistic approach like CLEA, suitably cautious deterministic values have been selected. For example, consumption rates of vegetables are the 95th percentile values of the distributions used in CLEA.

Reference radionuclide-dependent data have been obtained from well-established databases. For example, many equilibrium soil solid-liquid distribution coefficients and soil-plant concentration factors are based on values used in the Food Standards Agency PRISM foodchain modelling application (Thorne et al., 2005).

For ingestion and inhalation pathways, the radiation dose is the product of the exposure rates (i.e. from Bq ingested or inhaled per year) and a radionuclide-dependent dose coefficient. RCLEA uses dose coefficients recommended by ICRP (1996). For whole body external irradiation and contact irradiation of the skin, doses are the product of the duration of exposure to a given concentration of radionuclides at a given distance, and a radionuclide and geometry-dependent dose factor. ICRP does not recommend external dose factors; therefore, RCLEA adopts other well established dose factors (Eckerman and Ryman, 1993).

All data are presented clearly in the technical report (Defra, 2007b) and the software application (Defra, 2006c). The software application permits most of the default values to be modified, however it is for the assessor to justify any changes.

3.6 Implementation in Microsoft® Excel

A software application has been developed to accompany the RCLEA methodology. This provides a convenient implementation of the RCLEA models and data that can be used for generic and site-specific calculations. It has been implemented in Microsoft Excel® and is freely available as CLR 15 from the Environment Agency website.

The application was developed by Quintessa's software development team under ISO9001 registered procedures that have since been accredited to the "TickIT" standard for software development and testing. The application went through a full testing and verification process prior to release.

The RCLEA software application operates with Excel 2000 or later versions running on a typical Microsoft Windows® operating system. It requires macros to be enabled in Excel. The file size is less than 1 MB and has no special memory, disk space or processor requirements.

The RCLEA application consists of a single workbook (.xls file) with a collection of worksheets (pages) that contain all input data and results (see Table 2). For every parameter, a default library value is given (on a grey background), presented next to the user value (on a white background) which is initially set to the default. All library values are protected against change. The underlying calculations are also hidden and protected.

It is recommended that a copy be made of the RCLEA.xls file for each assessment. This copy should be renamed and saved regularly to capture any user defined input data.

4 Application of RCLEA

4.1 Use of RCLEA in Determining Radioactively Contaminated Land

The RCLEA methodology is intended for application during the investigation of a contaminated site. If site information is known, its details can be used to modify the default model data and assumptions. If there is limited information, reference land use scenarios can be assessed and will give suitably conservative results.

If the concentration of radionuclides in soil is known, the annual dose to an exposed person can be estimated using RCLEA for comparison with the criteria for the determination of radioactively contaminated land (Box 5). RCLEA can also calculate 'guideline values' of radionuclide concentrations in soil that correspond to these criteria.

If, during any part of the investigation process, the dose calculated with RCLEA is markedly below the criteria in Box 5 then the site can be eliminated (screened out) from the contaminated land regime - provided that the RCLEA scenarios and assumptions are appropriate for the particular site. Furthermore, it must be recognised that the determination of contaminated land requires more information than an assessment using the RCLEA methodology.

If the calculated dose is close to or above one or more of the criteria, then there are three possible courses of action.

- Further investigation and data refinement (which might draw on the results of site investigation), followed by additional calculations using RCLEA;
- Determination of the site as radioactive contaminated land (subject to all the requirements of the statutory guidance being fully met); or
- Should the results of a RCLEA calculation with suitably refined assumptions remain close to the dose criteria, further advice should be sought from a suitable expert (perhaps involving additional calculations with different models) before a decision is made.

RCLEA will not be universally applicable. Although many parameter values can be modified to reflect site-specific conditions, in some cases the underlying models will not be able to adequately represent the particular circumstances, and alternatives may need to be considered. In such cases an assessment method tailored to the specific site will need to be developed. Users should therefore look critically at the suitability of RCLEA and its assumptions before either making a determination or deciding that no further consideration need be given to the site.

Table 2: Pages in the Microsoft® Excel RCLEA Application

Name	Description
Intro	Gives RCLEA version information and space for application-specific information.
Instructions	General instructions for using RCLEA.
Main	The main calculation control page, which also presents a summary of results from the 'Doses' and 'GuidelineValues' pages.
Contamination	Allows the radionuclides of interest, average activity concentrations in contaminated soil and the fraction of soil that is contaminated to be specified.
Doses	Presents calculated doses for the scenario conditions that result in the highest total dose. Doses are presented for each radionuclide and pathway
All Doses	Presents a summary of total doses calculated for all combinations of calculation options considered. (Only displayed for a worst case calculation.)
Guideline Values	Presents Guideline Values - the radionuclide concentrations that would result in a dose criterion being reached.
Calculation Parameters	Summary of the parameter values used in the calculation of the highest radiation dose for the assessment.
Soil And Plant	Data describing soil properties relevant to contaminant behaviour.
Land Use	Land use specific data including exposure characteristics such as receptor occupancy, dust concentrations and skin contamination.
Building Type	Information on the assumed reduction in external irradiation dose rates due to shielding by building materials.
Human	Information describing human anatomical and physiological characteristics used in assessment calculations.
Consumption	Data on food ingestion rates and amount of soil on home grown foods.
Effective Dose	Reference values that convert radionuclide intake into committed effective dose, or external irradiation by a given concentration to effective dose rate.
Equiv Dose	Reference values that convert an irradiation duration into equivalent dose to the skin.
New Land Use	Allows the user to define the basic characteristics of a user defined land use. (Only displayed when adding a new land use.)
Intermediate Calculations	Intermediate calculations undertaken by RCLEA.
Side Calcs	A spare page for any side calculations that are required.

Note: RCLEA contains pages of three types: **Control and Information** pages are coloured green; **Data Input** pages, which are coloured yellow; and **Calculation and Results** pages, which are coloured blue.

Box 5: Criteria for the Determination of Radioactively Contaminated Land

Land is determined as contaminated land by virtue of radioactivity if 'harm' is being caused or if there is a significant possibility of 'harm' being caused. Statutory Guidance says that the local authority should regard 'harm' as being caused where lasting exposure gives rise to doses that exceed one or more of the following criteria:

An effective dose of 3 millisieverts per annum;

An equivalent dose to the lens of the eye of 15 millisieverts per annum; or

An equivalent dose to the skin of 50 millisieverts per annum.

4.2 Using the Methodology

Initial Calculations with RCLEA

Initially, a generic assessment can be undertaken with the RCLEA application using limited site-specific data. Generic calculations can be made even when there is no reliable information about the site other than the radionuclide(s) suspected to be present. The user need only specify the radionuclide(s) of interest and other optional information, including:

- Land use;
- Building type;
- Receptor age group; and
- The fraction of the land that is contaminated.

If this optional information is not specified the RCLEA application will automatically use worst-case assumptions. When using the RCLEA application, all this information can be entered through the main page (shown in Figure 1). The concentrations of the radionuclides are entered on a separate page. If concentrations are uncertain, estimates or unit values can be entered and RCLEA will calculate Guideline Values (corresponding to the criteria in Box 5) that can be used as a point of reference in further investigations.

Refining Calculations with RCLEA

If the results of initial calculations indicate that more realistic site-specific information should be considered users can modify the parameters used in RCLEA. All such changes should be carefully considered and fully justified.

The method by which most key parameters can be changed in the RCLEA application is to define a new Land Use. This option becomes enabled by selecting the site-specific calculation option on the RCLEA Main Page. The new Land Use can be based on an existing one to avoid the need to re-enter every single parameter value. Once a new Land Use is created, the user can specify:

- the age groups;

- the exposure pathways;
- the basic characteristics of the site (e.g. the concentration of dust in air);
- the occupancy of the contaminated site by exposed individuals;
- the inadvertent soil ingestion rate; and
- the amount of soil contamination present on the skin.

Other parameters can also be modified as required, but caution should be exercised as the default parameter values have been selected on the basis of considerable research. Figure 2 shows the modification of parameter values for a new user-defined Land Use called “parkland”.

Figure 1: The Main Page of the RCLEA Application

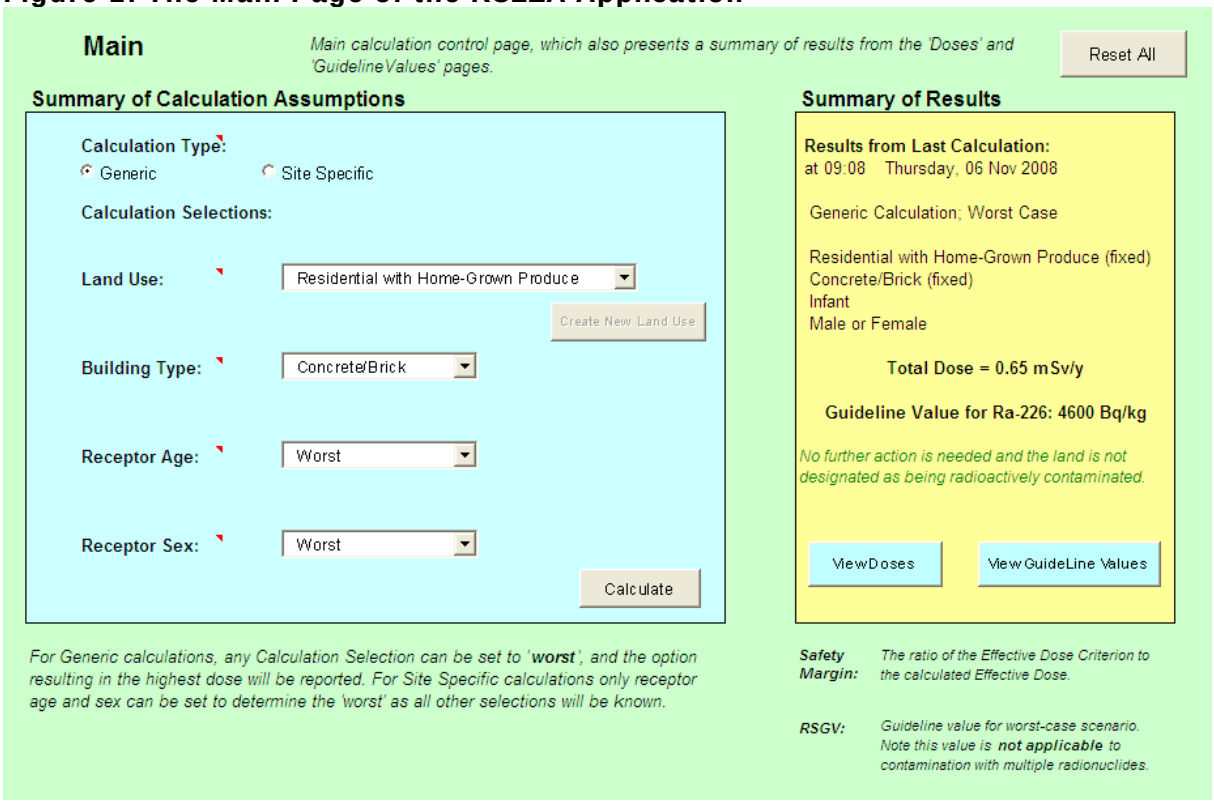

Figure 2: The Land Use Page of the RCLEA Application, Showing a New Land Use ('Parkland') and User-defined Parameter Values

	Fraction of Indoor Dust Comprising of Locally Derived Soil (-)		Annual Average Air Concentration of Respirable Particles (kg/m3)		
Land Use	Library	User	Library	User	Comment
Residential with Home-Grown Produce	0.75	0.75	5.E-08	5.E-08	
Residential without Home-Grown Produce	0.75	0.75	5.E-08	5.E-08	
Allotments	0.375	0.375	5.E-08	5.E-08	
Commercial/Industrial	0.75	0.75	5.E-08	5.E-08	
Parkland	0.75	0	5.E-08	5.E-08	No houses so no indoor dust is considered.

Soil Ingestion and Occupancy of Contaminated Land *Editable data for user defined land uses appears at the end of the table.*

		Inadvertent Ingestion Rate for Soil and Dust (kg (dry soil) /y)		Fractional Indoor Occupancy Over Contaminated Land (-)		Fractional Outdoor Occupancy on Contaminated Land (-)		
Land Use	Age	Library	User	Library	User	Library	User	Comment
Residential with Home-Grown Produce	Infant	5.5E-02	5.5E-02	0.875	0.875	0.125	0.125	
Residential with Home-Grown Produce	Child	3.7E-02	3.7E-02	0.750	0.750	0.083	0.083	
Residential with Home-Grown Produce	Adult	2.2E-02	2.2E-02	0.833	0.833	0.104	0.104	
Residential without Home-Grown Produce	Infant	5.5E-02	5.5E-02	0.875	0.875	0.125	0.125	
Residential without Home-Grown Produce	Child	3.7E-02	3.7E-02	0.750	0.750	0.083	0.083	
Residential without Home-Grown Produce	Adult	2.2E-02	2.2E-02	0.833	0.833	0.104	0.104	
Allotments	Infant	5.5E-02	5.5E-02	0.875	0.875	0.036	0.036	
Allotments	Child	3.7E-02	3.7E-02	0.750	0.750	0.024	0.024	
Allotments	Adult	2.6E-02	2.6E-02	0.833	0.833	0.095	0.095	
Commercial/Industrial	Adult	9.2E-03	9.2E-03	0.197	0.197	0.019	0.019	
Parkland	Infant	5.5E-02	5.5E-02	0.875	0.000	0.125	0.003	1 h a day playing
Parkland	Child	3.7E-02	3.7E-02	0.750	0.000	0.083	0.003	1 h a day playing
Parkland	Adult	2.2E-02	2.2E-02	0.833	0.000	0.104	0.230	Park-keeper

Fraction of Time Spent Indoors *Editable data for user defined land uses appears at the end of the table*

5 Discussion

Defra's project management and the oversight of the RCLSG led to RCLEA being developed very efficiently and effectively. The opportunity for consultation (aided by publicity through the SAFEGROUNDS Learning Network) improved the methodology and ensured awareness. The result is a robust tool, which is easy to use and meets Defra's specification. Nevertheless, the development of RCLEA, and developments since its publication, have raised a number of issues that are discussed below.

Update of CLEA

RCLEA was intended to be consistent (as far as possible) with the approach adopted for non-radioactive contaminants under Part IIA. However, the timescales were such that RCLEA had to be developed during a period when the approach to calculating Soil Guideline Values was under review. The CLEA model has since been updated (Environment Agency, 2008). Some of the important developments of CLEA were anticipated in RLCEA (for example, the transition to a deterministic approach).

Nevertheless, there remains a need to review the changes if there remains a desire for a high degree of consistency between the approach to assessing radioactive and non-radioactive contaminants. The nature of the RCLEA models is such that updating them should not be a significant challenge. A similar sentiment applies to the RCLEA software, which was designed and built with a view to being modified easily.

Appropriate Application

RCLEA has not been used extensively, although there is a good degree of awareness of the tool amongst potential users. Informal feedback has indicated that – whilst there is generally a sound appreciation of the scope and applicability of RCLEA, some misconceptions may remain.

Firstly, it is not universally appreciated that RCLEA is intentionally limited in scope and detail. The fact that users can modify a wide range of parameters does not necessarily mean that the underlying models and calculational methods are suitable for detailed assessments. There is also limited guidance on undertaking more detailed assessments in relation to the extended Part IIA regime.

Secondly, there remains a concern that RCLEA may be applied to contaminated land situations for which it was not designed. The RCLEA documentation seeks to make it clear that the methodology is aimed at situations in which there are existing chronic exposures of the public to radioactive contamination. The scenarios, in particular, are not appropriate for the assessment of other situations, such as contamination on nuclear sites. Although other models have been developed for this purpose there remains the potential for inappropriate use of RCLEA.

Other Aspects of Modelling Radioactively Contaminated Land

The limited scope of RCLEA means that it does not address some pathways that may be important in some contaminated land situations.

RCLEA does not permit the assessment of groundwater migration of contaminants. In most circumstances, this process will result in a reduction of the concentration as the contamination is diluted and dispersed. However, bioaccumulation may occur, or the contaminants may migrate to a location that offers greater potential for human exposure. The pathway could therefore require consideration in relation to human health risks. Groundwater protection objectives may also need to be considered.

The possible contamination of animals used for meat is also excluded from the RCLEA model. This is because the Land Use scenarios do not include agricultural use of land (other than in gardens or allotments which are not considered to be sufficient to support animals). It may be the case that some situations that fall under the extended Part IIA regime could involve such uses, in which case separate calculations would be required to assess the pathway.

Finally, although RCLEA and CLEA have many similarities, there is limited guidance on dealing with situations in which mixed radioactive and non-radioactive contamination is present. SAFEGROUNDS has produced some guidance on the subject (Smith, 2005) but this is relatively high level.

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