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D9.59 - Radiological state database of sites

Report describing the TERRITORIES Library Database (TLD) – a repository for radiological measurements made at selected sites

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Abstract

Sub-subtask 9.3.1.1 of the CONCERT work programme (Task 1.1 of the TERRITORIES project) considered the development of guidance for the design of environmental monitoring for dose assessment and for support to remediation. In support of this task the TERRITORIES Library Database (TLD) was developed. This report gives details of the structure of the TLD, describes the data held in the TLD and the process by which these data are entered into the database. The purpose of the TLD is to provide a repository for measurements of environmental activity concentrations and dose rates that have been made at sites contaminated with radioactive material. The intention is to use these measurements to investigate the effectiveness of different monitoring strategies for characterising the contamination at a site and if possible to show the impact of any attempted remediation. In addition, the data held in the TLD can be used to validate models and to investigate the improvements in predictive power obtained through model development.

The TLD was created using the Firebird open source database developer software (http://firebirdsql.org/en/start/) and a user interface, called the TLD Reader, was created using Delphi™. The TLD Reader enables the user to interrogate the TLD using pre-programmed queries or by building bespoke queries using SQL.

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1 Introduction

This document describes the TERRITORIES Library Database (TLD) developed under Task 1.1 of the TERRITORIES project. The purpose of the TLD is to provide a repository for measurements of environmental activity concentrations and dose rates that have been made at sites contaminated with radioactive material. The intention is to use these measurements to investigate the effectiveness of different monitoring strategies for characterising the contamination at a site and if possible to show the impact of any attempted remediation. In addition, the data held in the TLD can be used to validate models and to investigate the improvements in predictive power obtained through model development.

The TLD will be made available as a resource to future studies beyond the lifetime of the TERRITORIES project both as a source of existing data and as a repository for new data. Therefore, this report gives details of how the current data can be accessed and how new data can be added.

2 Design of the TLD

The TLD was created using the Firebird open source database developer software; a user interface to facilitate data entry was written using Delphi™. The SQL code used to create the TLD tables is given in Annex 1. When designing the TLD a number of factors were taken into consideration:

- Intended use of the data
- Convenience of data entry
- Transparent and repeatable process for data entry
- Segregation of data eg by site and survey
- Convenience of data extraction
- Security of data
- Version control

The intended use of the data means that the priority was to include measurements of environmental activity concentrations in the TLD. Additional information describing the physical characteristics of a site were available for some cases and could be added to the TLD in future. However, such data should be reasonably generic and not tailored towards the requirements of a specific model as it is the responsibility of the modellers to extract the data required and interpret them for their needs.

3 Populating the TLD

The method for entering data into the TLD was designed to be convenient and, where possible, automated to reduce effort and the chance of introducing errors. Several organisations are responsible for the datasets that are held in the TLD. In some cases these datasets include many thousands of values. The first step in populating the TLD is for the data owners to enter their data into a template Excel workbook. This workbook is read by a Python script to generate the necessary SQL for entering the data into the TLD. The structure of the TLD is similar in form to the template workbook but with some additional fields. This approach enables a visual inspection to be made of the supplied data to ensure that it is in the appropriate format for input to the TLD. This inspection is carried out by the reviewer, currently Public Health England (PHE) in the UK, and any changes are made in consultation with the data owners before being recorded.

3.1 Description of template workbook

Data used to populate the TLD are first entered into a template Microsoft Excel™ workbook (TemplateFormat_v8.xlsx). The workbook includes a set of worksheets to collect measurements and worksheets that give additional information regarding the environment being monitored. These are summarised in Tables 3.1-1 to 3.1-10. It is important to note that each dataset may include data from many surveys (Table 3.1-3) which are all associated with a single site (Table 3.1-2). The surveys may have taken place in very different locations but are all linked to a common site which is the primary contaminating source. Seven categories of measurements were defined, each with their own worksheet: Air, Ambient, Animal, Particle, Plant, Soil and Water (Table 3.1-4). For each category, there are some common data fields such as SampleReference, Latitude, Longitude and Result, and some fields that are specific to a particular category such as Size in the case of Particle. Tables 3.1-5 to 3.1-8 describe the worksheets used to hold environmental data relating to measurements made in soil, water, plants and animals. These worksheets allow for additional data describing the physical characteristics of the environment or sample to be included. Similarly, Table 3.1-9 gives details of the database table that can be used to hold meteorological data. Tables 3.1-5 to 3.1-9 are used to a greater or lesser extent depending on the data available from each survey. Finally, a table is provided which acts as a checklist for all the user entered identifiers of sample, measurement, quantity and nuclide, to ensure consistency throughout the dataset and with other datasets (Table 3.1-10).

Throughout the tables 'NotNull' indicates where null values may not be entered. All units should be SI units unless agreed otherwise and specifically recorded in the database.

To ensure that database queries return all relevant entries two important rules were followed when setting up the TLD. The first was to ensure that measurements were entered into the correct sample worksheet; for example, all measured activity concentrations in soil were entered into the Soil worksheet so that the TLD reader would identify them as soil measurements. Secondly, a consistent naming scheme was adopted for the terms used to describe the data in each dataset. For example, consistency in names used for the fields SampleName, MeasurementName, QuantityName and NuclideElementName was achieved where possible. However, the diverse types of measurements meant that some variation was inevitable, for example, one survey in the TLD collected 'pine needles' while another collected 'pine needles and twigs', and hence the SampleName used in each case was different.

Table 3.1-1: VersionInfo worksheet

Field	**Details**
DataVersion	For version control of this dataset within TLD **NotNull**
DataDescript	Description of this dataset **NotNull**
IssueDate	Date of issue of this dataset by data owner **NotNull**
DataReferences	Reference to relevant literature

Table 3.1-2: Site worksheet

Field	**Details**
SiteName	Name of site (single site per dataset) **NotNull**
Country	Country name **NotNull**

Table 3.1-3: Surveys worksheet

Field	Details
SurveyName	Name of survey (can have multiple instances per site) **NotNull**
DataStatus	Public (available outside TERRITORIES) or Private (only within TERRITORIES) **NotNull**

Table 3.1-4: Air, Ambient, Animal, Particle, Plant, Soil, Water worksheets

Field		Details
SampleReference		User reference from survey
Latitude		Latitude of sample location in decimal degrees
Longitude		Longitude of sample location in decimal degrees
SampleDate		Date measurement was made **NotNull**
SampleName		Defines sample type and as described in CheckLists worksheet **NotNull**. A new one can be added but avoid duplication. These are grouped depending on what part of the environment they relate to. Examples include: **Worksheet** – **SampleName (examples)** **Air** – {Air} **Ambient** – {Ambient} **Animal** – {Animal – *ie whole animal*, Muscle, Skin} **Particle** – {Particle, Object} **Plant** – {Bark, Branch, Foliage, Throughfall, Stemflow, Litterfall, Biomas fall, Plant – *ie whole plant*} **Soil** – {Additional details of sample but may just be Soil. Could be Soil Gas, Bed sediment} **Water** – {Surface water, Seawater, Freshwater}
Air	-	No additional fields
Ambient	**Altitude_1** **Altitude_2** **CollectionTime**	Height above the ellipsoid from GPS receiver (m) (airborne sampling) Height above ground level (m) Sampling duration (s)
Animal	**AnimalName**	Needs to be selected from AnimalType worksheet. A new one can be added but avoid duplication. **NotNull** Eg: Woodlouse, fungi, D.rubidus, cod
Particle	**Size** **Depth** **Description**	Size of particle or object (m) Depth of particle or object (m) Eg: Particles are classified as beta rich or alpha rich
Plant	**PlantName**	Needs to be selected from PlantType worksheet. A new one can be added but avoid duplication. **NotNull** Eg: Broad Leaf Deciduous, Evergreen Coniferous, Birch.
Soil	**SoilName** **DepthBottom** **DepthTop**	Needs to be selected from SoilType worksheet. A new one can be added but avoid duplication. **NotNull** Eg: SoilDBL – *soil for deciduous broad leaf trees*, silt, sand, sediment, leachate. (ie a medium to which eg a density and porosity can be ascribed, see table 3.1-5) Depth to bottom of soil sample (m) Depth to top of soil sample (m)
Water	**WaterBodyName**	Needs to be selected from WaterBodyType worksheet. A new one can be added but avoid duplication. **NotNull** Eg: '*Name1* River', '*Name2* Lake', '*Name3* Sea'

Field		Details
	DepthBottom DepthTop	Depth to bottom of water sample (m) Depth to top of water sample (m) (these could be the same)
MeasurementName		Defines method of measurement and as described in CheckLists worksheet. A new one can be added but avoid duplication.
NuclideElelementName		Name of nuclide in format "Cs137" as described in CheckLists worksheet. **NotNull**
Result		Measurement result **NotNull**
LimitOfDetect		If below limit of detection then Y otherwise N
QuantityName		Measurement quantity as described in CheckLists worksheet. A new one can be added but avoid duplication. **NotNull**
Units		SI units as described in CheckLists worksheet. **NotNull**
UncertaintyValue		Uncertainty on measured quantity
UncertaintyType		Type of uncertainty (eg one standard deviation)
SurveyName		As defined in Surveys worksheet. **NotNull**

Table 3.1-5: Worksheet of environmental data relating to SoilType

Field	Details
SoilName	Identifier for a type of soil. This should be the same as SoilName in Soil worksheet. **NotNull**
Density (kg m-3)	Density of dry soil
Porosity	Porosity of soil
CEC (cmol(+) kg-1)	Cation exchange capacity of soil
OrganicCarbon	Organic carbon content % by mass
pH	Acidity / alkalinity

Table 3.1-6: Worksheet of environmental data relating to WaterBodyType

Field	Details
WaterBodyName	Identifier for a body of water. This should be the same as WaterBodyName in Water worksheet. **NotNull**
Flowrate (m s-1)	Mean annual flow rate
Depth (m)	Mean annual depth
Width (m)	Mean annual width
Volume (m3)	Mean annual volume

Table 3.1-7: Worksheet of environmental data relating to PlantType

Field	Details
PlantName	Identifier for a type of plant. This should be the same as PlantName in Plant worksheet. **NotNull**
RootDepth (m)	Mean root depth
Mass (kg d.w. m-2)	Plant mass dry weight
Height (m)	Mean height
Age (y)	Mean age (units of years agreed)
StandDensity (m-2)	Number of trees per unit area over region of interest
TrunkDiameter (m)	Mean trunk diameter at breast height

Table 3.1-8: Worksheet of environmental data relating to AnimalType

Field	Details
AnimalName	Identifier for a type of animal. This should be the same as AnimalName in Animal worksheet. **NotNull**
Mass (kg)	Mean mass of animal
PopDensity (m-2)	Number of animals per unit area over region of interest

Table 3.1-9: Worksheet of meteorological data - Metdata

Field	Details
SurveyName	Survey to which this meteorological data is related. This should be the same as SurveyName in Surveys worksheet **NotNull**
Temperature (°C)	Mean daily temperature
MetDate	Date of measurement
RainfallRate (mm d-1)	Mean daily rainfall rate (units of mm d^{-1} agreed)
PasquillCategory	Pasquill Stability Category

Table 3.1-10: CheckLists worksheet

Field	Details
SampleName* **Description**	Name of samples being analysed. This must be consistent with SampleName used elsewhere. **NotNull** Description of sample
MeasurementName **Description**	Name of measurement technique used. This must be consistent with MeasurementName used elsewhere. Description of sample
QuantityName **Units** **Description**	Measurement quantity. This must be consistent with QuantitiyName used elsewhere. Units of this quantity (SI units unless otherwise agreed) Description of this quantity
NuclideElementName **Description**	Name of the nuclide or group of nuclides. This must be consistent with NuclideElementName used elsewhere. Details of nuclide group

3.2 Process for entering data into the TLD

It is possible that in the future additional data will be added to the TLD and therefore the process to do this is described here. A schematic diagram of the steps that need to be taken to populate the TLD is given in Figure 3.2-1. The main steps are:

1. User enters data into workbook TemplateFormat_v8.xlsx and send to reviewer.
2. Reviewer reviews user data to ensure that
    a. All ‘NotNull’ fields are complete and any blank fields where nulls are permitted are replaced with ‘Null’
    b. Instances of names are consistent throughout.
    c. Units are SI or agreed deviations
    d. Radionuclide/element names are in agreed format
    e. Data generally looks sensible

3. If any name is a duplication of what is already in the TLD then the reviewer must determine if the new name really refers to the same thing as the existing name or if it should be modified. Differences in data associated with the duplicated name need to be considered, e.g. details describing soil density, porosity etc. may be different for apparently the same type of soil.
4. Reviewer increments site_id and survey_id in Python script on basis of what is already in the TLD and then runs this script to generate SQL for populating the TLD.
5. Reviewer creates the TLD and populates it using Firebird interface tool and SQL created in step 4. New data can be added to an existing TLD but modifications to data already in the TLD generally require the database to be recreated. The TLD name 'TLD DD-MM-YY.FDB' includes the creation date in days, months and years e.g. 1st March 2019: 'TLD 01-03-19.FDB'.

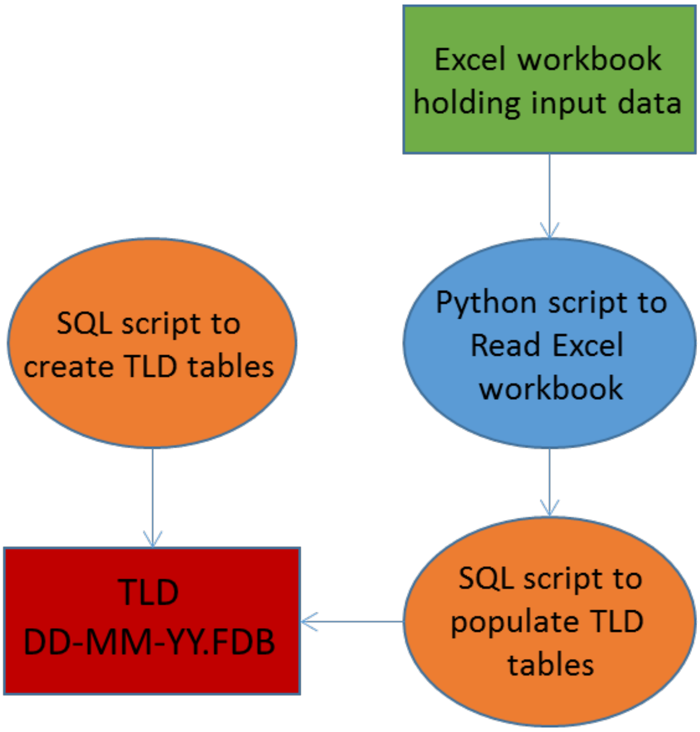

Fig. 3.2-1: Schematic of process for entering data into the TLD

4 How to use the TLD

The TLD reader can be used to view and extract data from the TLD. This can be achieved using menu options or by writing bespoke SQL. Extracted data can be saved in TSV format.

The link https://extranet.sckcen.be/sites/concert/_layouts/15/start.aspx#/WP9/Forms/AllItems.aspx is the current web address where TERRITORIES partners can access the TLD. Details of the future web location from which the TLD will be made available to the public have not yet been agreed.

The link above can be used to logon to the CONCERT website and gain access to the sub-directory 'WP9/TERRITORIES/WP1/TLD/DatabaseAndViewer' and the file 'TLD and Reader.7z'. To install the TLD, download this zip file and unpack the contents to a local drive or USB stick. The unpacked files include the TLD reader 'TLDReader.exe', the TLD database 'TLD DD-MM-YY.FDB' and five dll files. To start the programme double click on 'TLDReader.exe', you will then be presented with a number of options in the top left corner of the opening widow. The options and indented sub-options are shown below.

Connect → this option allows you to connect to the TLD 'TLD DD-MM-YY.FDB'. It toggles with Disconnect which closes the database connection. When you first connect to the TLD you are asked if you wish to view Public, Private or All data. If you select Private or All a password is required. Currently, this password appears automatically as a default. If you select Public those surveys with Private status will not be available.

Sites → Clicking on a site shows all the surveys (with appropriate status) for that site

Surveys → Clicking on a survey shows all the sample types for that survey

Survey data → Clicking on a sample type shows all the measurements for that sample type.

Save to TSV → saves data displayed to a tab delimited file that can be opened in a spreadsheet.

More → Shows additional functions (use a single click to toggle with 'Less' and hide the Quick Links)

Quick Links: Animal Types → click to show all the animals sampled

Quick Links: Plant Types → click to show all the plants sampled

Quick Links: Soil Types → click to show all the soils sampled

Quick Links: Water Body Types → click to show the water bodies sampled

Quick Links: Measurements → click to show measurement techniques used

Quick Links: Quantities → click to show quantities measured and units

Quick Links: Samples → click to show additional details of samples

Quick Links: Nuclides/Elements → click to show radionuclides and elements sampled

Quick Links: Version Info → click to show version number and references for surveys

Double clicking on any of the above Quick Links shows the surveys in which they can be found. Double clicking on a survey takes you to that survey.

Run → click to run an SQL database query that can be typed by the user in the adjacent box

DB Structure → click to show the Tables and Fields used in the database

Exit → closes the TLD Reader

5 Datasets included in TLD

The TLD currently holds seven distinct datasets for five sites. The datasets include NORM contamination of a Belgian forest, a Norwegian fen and Rontok Lake in Poland, ^{137}Cs contamination of the Fukushima region in Japan and contamination of the Sellafield coastal environment from historical discharges of various radionuclides. The datasets are described in more detail below.

5.1 Belgian NORM Site

The Belgian NORM site (Vanhoudt, 2015) is one of the four radioecological observatories selected for study by the European Radioecology Alliance https://radioecology-exchange.org/content/belgian-norm-site.

SCK•CEN have actively contributed to the TLD database with a detailed dataset of measurements from this site. These cover a measurement pre-campaign and four quarterly measurement campaigns during Fall: November 2017, Winter: February 2018, Spring: May 2018 and Summer: August 2018, resulting in activity concentration measurements in soil (top and lower), roots, bark (outer and inner), sapwood/heartwood, needles and twigs (<1 year old and >1 year old) and moss, all of which were analysed for the determination of ^{238}U, ^{232}Th, ^{226}Ra and ^{210}Pb. This involved the cutting down of trees and extraction of sections at 24, 29 and 31 cm for the wood determinations (Fig, 5.1-1). SCK•CEN also produced dose calculations to biota and a γ-ray dose survey.

Figure 5.1-1: Illustration of the vegetation sampling procedure

Although not currently included in the TLD, additional monitoring data are available from the instrumented forest station which is equipped with sap flow sensors, light sensors, soil moisture probes, piezometers, rain gauges and temperature sensors, integrated in a data logger (Fig. 5.1-2). These sensors detect time-variations in the system critical to forest functioning and radionuclide cycling, such as temperature, precipitation and evapotranspiration cycles across the day/night cycle and the seasonal cycle.

SCK•CEN also introduced into the TLD radon gas measurements as determined by a soil gas probe at 90 cm below ground and an air pump 10 cm above ground on two separate days on 8 and 24 May 2018 to observe the time variation over the period of one day for comparison with measurements of the relative humidity.

Figure 5.1-2: Monitoring systems at the Belgian NORM site instrumented forest station

Lastly, SCK•CEN introduced into the TLD data from the Belgian NORM site provided by Professor Rafael García-Tenorio (University of Sevilla) who worked collaboratively under project COMET, namely, pre-characterisation of the sludge: radiometric measurements study of the behaviour/distribution of radionuclides in the soil. Analyses included high-resolution γ-ray spectrometry and radiochemistry/α-spectrometry. A validated leaching experiment (USEPA, 1992) was performed for U-isotopes, Th-isotopes and ^{210}Po. In addition, aliquots of the soil samples were analysed by ICP-MS and XRF to determine the presence of mixed contaminants in the soil. These data have also been entered in the TLD.

SCK•CEN are presently completing measurements of soil field capacity and the solid-liquid distribution coefficient (K_d), which are important model parameters. Laboratory batch tests are being used based on OECD guideline 106 “Adsorption-desorption using a batch equilibrium method” (USEPA 2000) with spiked solution for ^{238}U and Pb and with natural Ba present in the soil as an analogue for Ra using (1) a 0.01M CaCl2 solution and (2) a citric acid – sodium citrate buffer at pH 5 in order to mimic the root zone. These measurements have also been reported to the TLD.

To summarise, the data held in the TLD are grouped into five main sample categories, namely Air, Ambient, Animal, Plant and Soil. The Air category contains the above ground ^{222}Rn measurements. The Ambient category contains the γ-ray dose survey of the site. The Animal category includes a STAR 2004 ERICA dose assessment for reference animals. The Plant category also includes a STAR 2004 ERICA dose assessment but for reference plants and includes γ-spectrometry measurements in litter, roots, leaves, needles and the bark of pine trees from the characterisation surveys 2016-2018. Finally, the Soil category contains α-spectrometry measurements for ^{234,238}U, ^{210}Po and ^{230,232}Th in top soil and leachate and also γ-spectrometry measurements for upper soil (4-24 cm) and CaF_2 sludge (^{40}K, ^{210}Pb, ^{231}Pa, ^{238}U, ^{226,229}Ra and ^{228,234}Th), as well as ICP-MS data for a large collection of stable elements a total of more than 1000 entries. Category Soil also includes ^{222}Rn measurements using the soil gas probe. A summary of the data is presented in Table 5.1-1.

Table 5.1-1: Summary of data held in TLD for Belgian NORM site

Samples	Location	Date	Measurements	Radionuclides
Surveys: Characterisation survey 2016 - 2017 SCK (**status: Private**), Characterisation survey Mar 2017 USEV – SCK (**status: Private**) (issue date 19/9/2017) References: See References section: Belgian NORM Site				
Ambient	Latitude, longitude (relative)	Actual date and time of sample	Dose rate (nSv h^{-1})	Gross
Soil	None	Date of sample	Activity concentration dry weight (Bq kg^{-1})	Pb210, K40, Pa231, Po210, Ra226, Ra228, Th228, Th230, Th232, Th234, U234, U238 (+ elements ppm)
Plant	None	Date of sample	Activity concentration dry weight in plant structures (Bq kg^{-1})	Pb210, Pa231, Ra226, Th228, U238
Surveys: Official monitoring station (**status: Private**) (issue date 11/3/2019) References: See References section: Belgian NORM Site				
Air (0.1 m)	None	Date of sample	Activity concentration in air above ground (Bq m^{-3})	Rn222
Soil	None	Date of sample	Activity concentration dry weight (Bq kg^{-1}) Activity concentration in soil gas (Bq m^{-3})	Pb210, Ra226, Th232, U238 Rn222
Plant	None	Date of sample	Activity concentration dry weight in plant structures (Bq kg^{-1})	Pb210, Ra226, Th232, U238
STAR 2004 ERICA dose assessment References: See References section: Belgian NORM Site				
Animal	None	Date of sample	Internal dose rate (µGy h^{-1})	Gross
Plant	None	Date of sample	Internal dose rate (µGy h^{-1})	Gross

5.2 Fukushima Forests

IRSN has actively contributed to the TLD database by providing a detailed set of radiocaesium contamination data acquired in Japanese forests contaminated by atmospheric fallout from the Fukushima Daiichi nuclear accident. All data have been carefully selected from the literature, analysed then processed before being uploaded to the TLD. IRSN has compiled thousands of measurements of ^{137}Cs concentrations (Bq kg^{-1}) in soil layers (organic and mineral layers at depths of 5 cm intervals down to 20 cm) and tree vegetation samples (foliage, branches, trunk bark and trunk wood). These data have been collected over the period 2011-2017 at dozens of sites located in Fukushima and neighbouring prefectures. The review also included time series of ^{137}Cs inventories in soil and tree vegetation (Bq m^{-2}) over the same period, as well as time series of tree depuration fluxes (Bq m^{-2} d^{-1}) for which a distinction is made, where possible, between throughfall, stemflow and litterfall contributions. If available in the relevant publications, further information regarding the characteristics of the forest sites such as the mean stand age (y), the stand density (trees ha^{-1}) or the above ground biomass (kg m^{-2}) was also provided.

Selection of field studies

The review focused on research published in international or Japanese literature that provided quantitative data on either radiocaesium contamination levels in soil layers, tree organs or tree depuration fluxes. Another important criterion for selecting a forest site was the possibility to estimate the deposit, based on either the in-situ measurement of radiocaesium inventories in soil and vegetation or the geographical coordinates. Knowledge of the deposit was of primary importance in order to normalize radiological quantities and to compare sites (see hereafter). The studies considered in the review are listed in Table 5.2-1. They have been pooled into 12 groups according to the research institution that conducted the study and the location of the forest sites. The review covers 82 sites that were classified into 2 categories depending on the dominant tree species which populate the forest plot: evergreen coniferous (EGC, 70 sites) and deciduous broadleaf (DBL, 12 sites). EGC stands are by far the most common ones. They mainly consist of Japanese cedar (Cryptomeria japonica), Japanese cypress (Chamaecyparis obtusa) or red pine trees (Pinus densiflora). Although multi-species, the DBL forest sites are dominated by oak trees (Quercus serrata) and sometimes associated with red pine trees.

Table 5.2-1. List of the forest studies selected in the review, indicating: the research institution, the type of forest (EGC: evergreen coniferous forest, DBL: deciduous broadleaf forest), the number of investigated sites, the type of measurements and the publications reviewed.

Research group (ID)	Type of forest (dominant species)	Number of sites	Type of measurements	Reference
University of Tsukuba, Institute of Radioprotection and Nuclear Safety, France	EGC (Cedar) EGC (Cypress) DBL (Oak)	3 1 1	BP, TF, SF, LF(*) Tree: inventories, biomasses, concentrations Soil: inventories & concentrations	Kato et al., 2012, 2014, 2017, 2019; Loffredo et al., 2014, 2015; Coppin et al., 2016; Takahashi, 2015; Hisadome et al., 2013; Teramage et al., 2014; Hurtevent et al., 2019; Takahashi et al., 2018
Forestry and Forest Products Research Institute, Tsukuba	EGC (Cypress) EGC (Cedar) DBL (Oak)	1 9 1	BP, TF	Itoh et al., 2015
Forestry and Forest Products Research Institute, Tsukuba	EGC (Cypress) EGC (Cedar) DBL (Oak)	2 2 1	Tree: inventories, biomasses, concentrations Soil: inventories & concentrations	Komatsu et al., 2016; Kajimoto et al., 2015; Kuroda et al., 2013; Imamura et al., 2017; Ohashi et al., 2017
Forestry and Forest Products Research Institute, Tsukuba	EGC (Cedar)	22	Tree: concentrations	Akama et al., 2013
National Regulatory Authority	EGC (Pine)	14	Tree: concentrations	NRA, 2017
University of Tokyo, Chiba University	EGC (Cedar) DBL (Oak)	1 2	BP, TF, SF, LF	Endo et al., 2015; Murakami et al., 2014

Research group (ID)	Type of forest (dominant species)	Number of sites	Type of measurements	Reference
Kyoto University	EGC (Red pine) DBL (Oak)	1 1	BP, TF, SF, LF	Okada et al., 2015; Nakai et al., 2015; Ohashi et al., 2014
National Institute for Environ-mental Studies, Tsukuba	EGC (Cedar) EGC (Cypress)	2 2	BP, TF, LF Tree: concentrations	Nishikiori et al., 2015, 2019
Institute of Environmental Radioactivity, Fukushima	EGC (Cedar)	2	TF, SF, LF Tree: inventories, biomasses, concentrations Soil: inventories & concentrations	Yoschenko et al., 2016, 2018
Japanese Atomic Energy Agency, Fukushima	EGC (Cedar) DBL (Oak)	1 2	TF, SF, LF	Niizato et al. , 2016
National Institute for Environmental Studies, Tamuragunn	EGC (Cedar) EGC (Cypress) EGC (Red pine) DBL (Oak)	2 1 3 3	Soil: inventories & concentrations	Shoko et al., 2017
Forestry and Forest Products Research Institute, Chuo-ku	EGC(Cypress,Cedar) DBL (Oak)	1 1	Soil: inventories & concentrations	Toriyama et al., 2018; Shinomiya et al., 2014; Hiruta et al. 2016

(*) BP: Bulk precipitation, TF: Throughfall , SF: Stemflow, LF: Litterfall

Pre-treatment of site-specific data.

All ^{137}Cs measurements were first decay-corrected to the sampling dates. Site-specific radiocaesium concentrations in tree organs and litterfall samples were then recalculated for both EGC and DBL tree categories, separately, by log-averaging all data acquired for a specific date whatever the tree species. Although not shown, statistical analysis of data did not show any significant differences between tree species of the same category. In addition to the geometrical mean, standard deviations were also computed that accounted for variability between the values reported at a site as well as the uncertainty associated with each measured value (when reported by the authors). Calculations were made through Monte-Carlo simulations based on the assumption of log-normal distributions for the concentrations. When stemflow was not measured at a site, the total depuration flux (*DF=TF+SF+LF*) was estimated based on the measured values of the throughfall (*TF*) and litterfall (*LF*) fluxes, i.e. stemflow contribution (*SF*) can be neglected.

Comparison between the site-specific studies was not straightforward due to the variety of experimental protocols, disparate sampling periods, differences in the forest stand characteristics and, last but not least, spatial variability of the deposits or interception conditions. Radiocaesium deposits vary greatly among sites, from about 10 kBq m^{-2} to more than 1 000 kBq m^{-2} in the forests located to the north-west of the Fukushima Daiichi nuclear site. Thus, in order to reduce the spatial variability between sites, many radioactive quantities were further normalized by the total deposit (Bq m^{-2}) estimated at each site. In the TLD, these normalized quantities are referred to as concentrations, fluxes or inventories per unit deposition; they are expressed in terms of m^2 kg^{-1}, d^{-1} and unitless, respectively. At sites where the ^{137}Cs inventories in soil and tree vegetation were estimated, *in-situ* measurements were used to derive the desired value of the deposit. For other sites, the deposit could be estimated from the 4th airborne gamma spectrometry survey (Sanada et al, 2014a,b; NRA, 2017) and the geographical coordinates, thanks to geostatistical interpolation. Despite normalization, some residual spatial variability persisted. This variability is likely to have resulted from differences in the stand characteristics, climate characteristics and the atmospheric conditions which prevailed at the time of deposition (i.e. differences in the actual fraction of the deposit which was intercepted by forest vegetation).

Averaging data over forest sites.

It was recognized that no single field study listed in Table 5.2-1 was comprehensive enough to provide a complete picture of radiocaesium dynamics in the forest medium from March 2011 to March 2017. Detailed information on radiocaesium concentrations, inventories and fluxes was not available at a single site for the whole 6-year period. This is the main reason why a mean representative evolution of ^{137}Cs contamination in EGC and DBL Japanese forests was derived based on the assumption that all forest stands of the same type obeyed the same "generic" dynamics (within the range of unexplained residual variability). To achieve this, site-specific temporal data were first resampled in time in order to provide estimations at the same frequency: they were re-estimated by averaging in time the measured values over each resampling period [t, $t+\Delta t$]. The resampling time step Δt was arbitrarily fixed to about 15 days for fluxes and 30 days for concentrations and inventories. The generic values of the depuration fluxes, concentrations and inventories were then computed as the logarithmic means of the (time resampled) site-specific values. For concentration data, a further standard deviation was evaluated to account for: spatial variability between sites, time variability at scales smaller than the resampling period and spatial variability at scales smaller than the forest plot (when stated by the authors). Calculations were made through Monte-Carlo simulations based on the assumption of log-normal distributions. Standard deviations were not estimated for fluxes because too few sites provided information at the same period.

A summary of the data held in the TLD is given in Table 5.2-2.

Table 5.2-2: Summary of data held in TLD for Fukushima forests

Samples	Location	Date	Measurements	Radionuclides
Surveys: Generic Deciduous Broadleaf (DBL) (**status: Public**) (issue date 1/9/2017) References: See Reference section Fukushima Forests				
Plant	Latitude, longitude are representative of total forest region which ranges between 35° and 38° latitude, 138 and 141° longitude	Actual date and time of sample	Activity concentration dry weight per unit deposition (m2 kg^{-1}) (plant parts) Activity transfer rate per unit deposition (d^{-1}) (Throughfall, Litterfall, Stemflow) Mass dry weight transfer rate (g m^{-2} d^{-1}) (Biomassfall) Activity inventory per unit deposition (dimensionless) (whole plant)	Cs137
Soil	As above	As above	Activity inventory per unit deposition (dimensionless)	Cs137
Meteorological data	As above	As above	Rainfall rate (mm d^{-1})	-
Surveys: Generic Evergreen Coniferous (EGC) (Feb 2019) (**status: Public**) (issue date 12/2/2019) References: This is an update of the EGC dataset from 1/9/2017. See Reference section Fukushima Forests				
Plant	Latitude, longitude are representative of total forest region which ranges between 35° and 38° latitude, 138 and 141° longitude	Actual date and time of sample	Activity concentration dry weight per unit deposition (m2 kg^{-1}) (plant parts) Activity transfer rate per unit deposition (d^{-1}) (Throughfall, Litterfall, Stemflow) Activity inventory per unit deposition (dimensionless) (whole plant)	Cs137
Soil	As above	As above	Activity concentration dry weight per unit deposition (m2 kg^{-1}) Activity inventory per unit deposition (dimensionless)	Cs137

5.3 Fukushima Airborne Surveys and Deposition Estimates

The Fukushima Daiichi nuclear power plant (FDNPP) accident resulted in extensive atmospheric releases of radioactive substances that were dispersed and deposited on the continental and oceanic surfaces. In order to monitor radiocaesium deposition onto the ground, airborne gamma-ray surveys were performed periodically following the accident up to a distance of 80 km from the FDNPP. The surveys were carried out by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) (Table 5.3-1 and Figure 5.3-1). Three conversions were applied to the data: (i) altitudes of the measured gamma-rays were corrected to 1 m above ground level, (ii) the count rates were converted to dose rates and (iii) the dose rates were converted into ground surface activity concentrations of ^{134}Cs and ^{137}Cs in (Bq m^{-2}) (Gonze et al., 2014; Sanada et al., 2014). Details of the data processing are available at https://emdb.jaea.go.jp/emdb/en/ (JAEA, 2014).

To interpolate ^{137}Cs deposition levels on a 500 m by 500 m reference grid, within six square test sites of length 20 km (Figure 5.3-1), ordinary block kriging algorithm (Wackernagel, 2003) was applied to five airborne surveys performed from 2011 to 2013. The interpolation procedure was carried out using Isatis commercial software (Masoudi et al., n.d.):

- **Normalization:** distribution of ^{137}Cs, which is usually lognormal, was transformed to normal, using logarithm function.
- **Trend modelling and residual extraction:** the trend of data is modelled by moving average; then extracted from the data to produce the residual.
- **Gaussian normalization:** normalization of the residual was done by the frequency inversion anamorphosis algorithm (Bleines et al., 2004).
- **Variography analyses:** experimental variogram was computed and fitted through a spherical variogram model.
- **Interpolation:** block ordinary kriging system of equations is used to interpolate the value at the reference grid cells.

Then, environmental decay of soil contamination was calculated for the time intervals between the surveys. In each test site, the ^{137}Cs maps were used to calculate the environmental decay between each pair of survey dates. Equation 1 is derived from the universal equation of radioactive decay, replacing $\lambda = \lambda_{rad} + \lambda_{env}$.

$$\lambda_{env} = \frac{1}{t} ln\left(\frac{A_0}{A_t e^{t\lambda_{rad}}}\right) \qquad (1)$$

where λ_{rad} and λ_{env} are radioactive and environmental decay, respectively (for ^{137}Cs, radioactive decay is 6.2909×10^{-5} per day). t is timespan in days. A_0 and A_1 are interpolated ^{137}Cs activity concentrations (Bq m^{-2}) at the beginning and end of the timespan, respectively.

A summary of the data held in the TLD is given in Table 5.3-2.

Table 5.3-1 Airborne surveys over Fukushima region.

Airborne	Start date	End date	Base date	Flight-line spacing
#4	25.10.2011	05.11.2011	05.11.2011	1.8-2 km
#5	22.06.2012	28.06.2012	28.06.2012	1.8 km
#6	30.03.2012	15.11.2012	16.11.2012	1.8 km
#7	27.08.2013	18.09.2013	28.09.2013	0.6-0.9 km
#8	05.11.2013	18.11.2013	19.11.2013	0.6-0.9 km

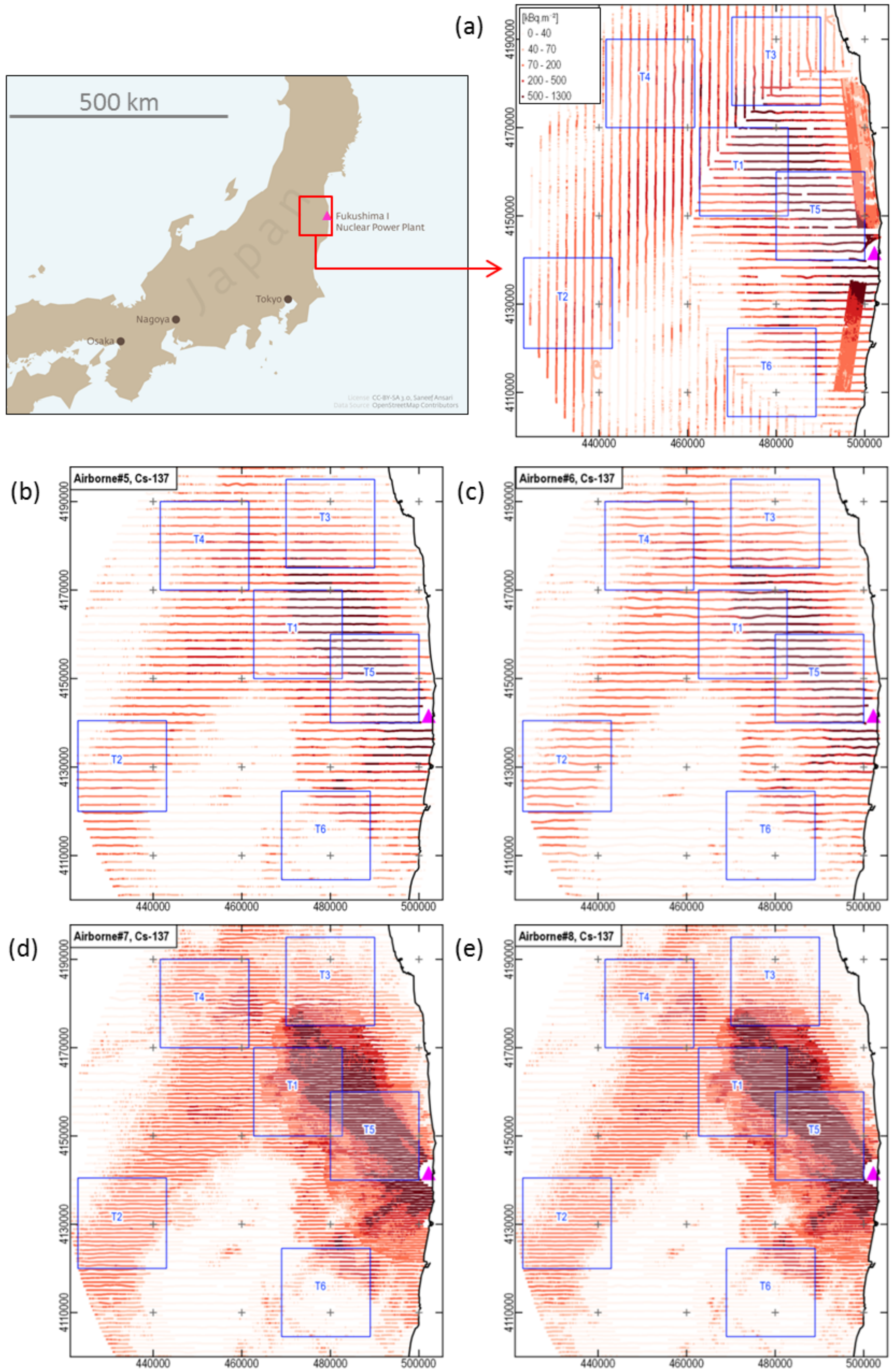

Figure 5.3-1. Airborne surveys #4 (a), #5 (b), #6 (c), #7 (d) and #8 (e) over the Fukushima region. The six test sites (T1 to T6) are illustrated.

Table 5.3-2: Summary of data held in TLD for Fukushima derived deposition levels

Samples	Location	Date	Measurements	Radionuclides
Surveys: Five surveys at six different sites. (**status: Public**) (Issue date 19/2/2019) References: See Reference section Fukushima Airborne Surveys and Deposition Estimates.				
Soil	Latitude, longitude	Actual date of survey	Activity concentrations per unit area, derived from airborne gamma ray survey (Bq m^{-2}) Derived environmental decay rate (d^{-1})	Cs137

5.4 Norwegian Fen Complex

The Fen Complex is located in the Telemark County in south-eastern Norway. It is a geologically well-known intrusive complex of alkaline and carbonatite rocks of magmatic, volcanic origin (Heincke et al., 2008). Among the most abundant rock types of the Fen Complex area are søvite, rauhaugite, rødbergite, damtjernite and fenite. The area has for many decades been subject to public and mining exploration activities due to the presence of large estimated quantities of thorium (Th) ore that according to Berg et al. (2012) could reach 675 000 tonnes. However, although rocks rauhaugite and rødbergite are known to be particularly rich in ^{232}Th, the uncertainty about the exact quantities has been emphasized and further work on estimations is needed (Thorium Committee, 2008). Apart from ^{232}Th, the Fen Complex has been an area of interest, for many years, due to mining of iron (Fe) and niobium (Nb), as well as due to possibilities for extraction of rare earth elements (REE). High levels of naturally occurring radioactive material (NORM) in rocks and soil with heterogeneous distribution and observed 'hot spots' were measured previously in the Fen Complex (IFE, 2006, NGI-NMBU; 2010, Mrdakovic Popic et al. 2011). The area of interest is shown in Figure 5.1-3.

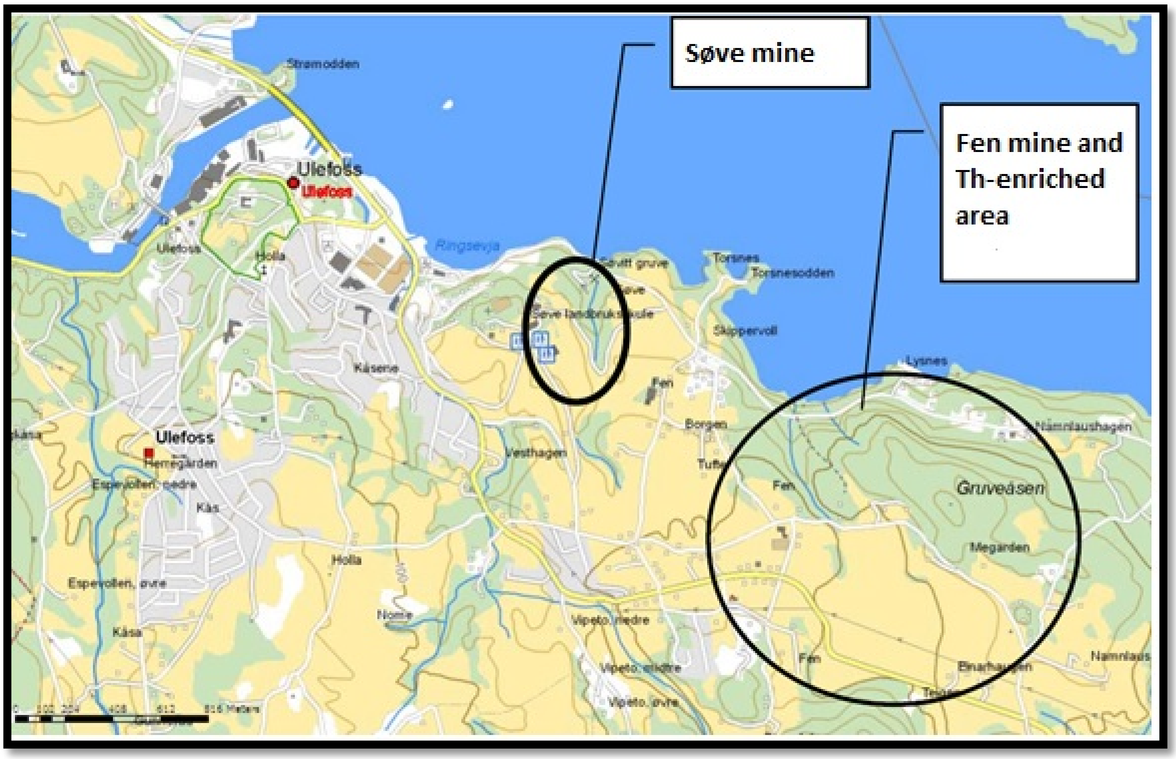

Figure 5.1-3. Map of Fen complex showing locations of the Søve and Fen mining areas and Lake Nordsjø (blue area). Reproduced from NGI-UMB (2010).

For the purpose of the current work, data from the following sites within the Fen Complex were used:

- Part of former Fe mining site (Fen mine) on the shores of Lake Nordsjø;
- Bolladalen, undisturbed NORM rich area; and
- Søve former Nb mine.

The iron mine (Fen mine) in the Fen area is located in the eastern parts of the Complex (N 59°16.625' E 009° 18.226') along the shores of Lake Nordsjø. This area is rich in rødbergite rock and mines have been operating from 1652 to 1926. Reliable data on the mined quantities and produced Fe are not available. Open pits and parts of underground mining tunnels from Fe production period, as well as the waste area on the slope of the Lake Nordsjø, are still visible.

Site Bolladalen is located in the centre of the Fen Complex (N 59°16.424' E 009° 18.945') and in close proximity to the larger former Fe mining area (Gruvehaugen) and an inhabited area. The site is comprised of an undisturbed wooded zone with no visible signs of former mining such as open pits or underground mining tunnels. Nevertheless, due to naturally elevated background levels of ^{232}Th and progeny, high levels of terrestrial gamma radiation and outdoor radon and thoron levels were previously measured.

The former mining site Søve is a decommissioned facility in the western part of the Fen Complex (N 59°16.902' E 009° 17.162') with rock type søvite predominant in the bedrock. A mining facility was in operation from 1953 to 1965; Nb was extracted from mineral pyrochlore on a commercial basis. Waste material from the production of ferro-niobium was dumped as an aluminium-rich slag at a small hill nearby. The slag included about 570 tonnes, which were covered and sealed with marine clays afterwards. In a remediation action conducted after the mine decommission, the entire site at Søve was covered with sand layers. Currently, a mechanical engineering shop is located at this former mining site, while the main hazard areas, including a sludge disposal site, wash house and slag heap (NGI-UMB, 2010) are freely accessible. Recent measurements have shown enhanced gamma radiation dose rates, and elevated ^{232}Th and ^{238}U concentrations, due to the disturbance of protective sand layers and mixing with contaminated soil (IFE, 2006; NGI-UMB, 2010).

The Fen Complex data, from the sites described above and selected for inclusion in the TLD, were collected during fieldwork organized in period 2008-2011 as a part of PhD and MSc projects at Norwegian University of Life Sciences (NMBU) and as part of activities of the Centre for Environmental Radioactivity in Norway (CERAD). Data that have been provided for the TLD, primarily from Mrdakovic Popic et al. (2011; 2012) and Mrdakovic Popic (2014), include terrestrial gamma dose measurements, activity concentrations of ^{232}Th, ^{238}U and certain decay-chain progeny in soil, plant and earthworms and results of basic soil chemistry analyses.

Terrestrial gamma dose rates in the outdoor air were measured in several fieldworks, during all seasons to account for possible seasonal variation. All measurements were made at 1 m height above the ground. A portable gamma detector (Geiger Müller counter) type Automess (radiacmeter 6150 AD 4 LF) with a response range 0.01 – 20.00 µGy per hour was used. Hand measurements were organized at sub-sites delineated by regular grids 10 x 10 m while readings were repeated until a constant signal was obtained. In addition, thermo-luminescent dosimeters (TLDs) type MR 200C with luminescence material CaF_2 doped with Mn, developed by the Jozef Stefan Institute, Slovenia, were used for long-term measurements (3 months) of gamma radiation.

Samples of soil, plant and earthworms were collected during different fieldworks in the period 2008-2011 and in different seasons. Soil for the total element analysis was collected as bulk samples with the usual sample weight from 0.2 to 1.0 kg. Some samples for analysis of the vertical distribution were collected at depths of 0.05, 0.1, 0.2, 0.25 and 0.3 m by incremental excavation of the wall of the soil pit, but this was limited due to high abundance of the stones in the pits of soil. Soil was dried in the laboratory at 40°C, homogenized by sieving though 2 mm sieve and proper sub-samples were selected for analyses. Basic soil physical and chemical parameters (pH, grain size, H_2O (%), OM (%), P_2O_5, $CaCO_3$, CEC, Exch, Ca) were determined. Part of the soil samples were sent to Norwegian Radiation Protection Authority (NRPA) for gamma spectrometry while part of the soil was measured at NMBU, by ICP-MS. Prior to ICP-MS analysis, soil samples were acid-microwave decomposed.

Plants and earthworms were collected at different sampling points within sites. Plants that were found to be in abundance were regarded as representative, and in total, nine different plant species (moss, lichen, fern, birch, pine, spruce, dandelion, grass, strawberry) and four earthworms (endogeic and epigeic) species were collected. The chosen plants covered a relatively wide range of wild forest flora, with vascular and non-vascular plants, flowering plants, deciduous and coniferous trees. Earthworms were collected by digging the soil and hand sorting of organisms that were then transported to the laboratory in plastic boxes together with soil, roots and leaf litter.

After identifying the plant species, aboveground plant parts and roots were divided, cleaned and dried. Acid microwave decomposition was carried out according to standard protocols and radionuclides were measured by ICP-MS. Earthworm species were also identified; they were starved for 48h on moist filter paper to depurate the gut content, frozen in liquid nitrogen, freeze dried and milled into a fine powder. After acid-microwave decomposition the earthworms were measured by ICP-MS.

The data set described above has been supplemented in the TLD by an extensive gamma air kerma rate survey undertaken in 2010 over a high-resolution sampling grid for the Søve mining complex in Fen and including a limited number of additional soil measurements. These data were collated as part of the Norway Grants "PORANO" project and have been reported in Dowdall et al. (2012).

A summary of data held in the TLD is given in table 5.1-4.

Table 5.1-4: Summary of data held in TLD for Norwegian fen site

Samples	Location	Date	Measurements	Radionuclides
Surveys: PORANO Søve (**status: Public**), IFE Søve (**status: Private**) (Issue date 20/10/2017) References: See Reference Section Norwegian Fen Complex [Dowdall et al. (2012)]				
Ambient	Latitude, longitude	Actual date of survey	Ambient Dose Equivalent H*(10) ($\mu Sv\ h^{-1}$)	Gross
Soil	Latitude, longitude	Actual date of survey	Activity concentration fresh weight ($Bq\ kg^{-1}$)	U238, Ra226, Pb210, Th232, Ra228, Th228
Surveys: NMBU PhD surveys public, NMBU/CERAD Surveys (**status: Public**), NMBU MSc survey (**status: Public**) (Issue date 21/6/2018) References: See Reference Section Norwegian Fen Complex [Mrdakovic Popic et al. (2011; 2012), Mrdakovic Popic (2014)]				
Ambient	Latitude, longitude	Actual date of survey	Gamma dose rate ($\mu Gy\ h^{-1}$)	Gross
Soil	Latitude, longitude	Actual date of survey	Activity concentration fresh weight ($Bq\ kg^{-1}$) Activity concentration dry weight ($Bq\ kg^{-1}$)	Th232, U238, Ra226, Ra228, K40
Plant	Latitude, longitude	Actual date of survey	Activity concentration fresh weight ($Bq\ kg^{-1}$) Activity concentration dry weight ($Bq\ kg^{-1}$)	Th232, U238, Cs137, Ra226, Ra228, K40
Animal	Latitude, longitude	Actual date of survey	Activity concentration dry weight ($Bq\ kg^{-1}$)	Th232, U238

5.5 Sellafield particles

Monitoring of beaches around the Sellafield site in the UK has been part of the routine environmental monitoring programme since 1983. In 2003, during a routine survey, a radioactive particle was found which prompted a review of beach monitoring. Following agreement with the environmental regulator, an intensive programme of beach monitoring commenced in 2006 using a vehicle mounted array of radiation detectors.

The finds have been classified in terms of physical size and radioactivity. Any find with an average size of 2 mm or greater is defined as an 'object' whilst finds smaller than 2 mm are defined as 'particles'. A find for which the ^{241}Am activity is greater than the ^{137}Cs activity is called alpha-rich and a find for which the ^{137}Cs activity is greater than the ^{241}Am activity is called beta-rich. Americium-241 and the alpha emitting isotopes of plutonium are the most important constituents of alpha-rich finds. The most important constituents of beta-rich finds are ^{137}Cs and ^{90}Sr.

To the end of 2017, approximately 3000 finds had been detected by the monitoring programme, of which about 2300 are particles detected on beaches between St Bees and Drigg (Figure 5.5-1). Approximately 85% of particles detected are alpha-rich with about 60% of these alpha-rich particles being detected on Sellafield beach itself with most of the remainder being detected on beaches to the north of Sellafield. The vast majority of beta-rich particles detected (80%) have also been detected on Sellafield beach. This is described in detail in the annual monitoring report (Sellafield Ltd, 2018). Any find detected by the monitoring programme is removed from the beach and sent for further analysis if considered necessary based on a protocol established by the regulator (UK Government, 2017).

Whilst the exact age of beta rich particles cannot be identified, they were most likely formed between 1953 - 1985 when beta activity discharges to the sea were more than an order of magnitude higher than contemporary levels. Age estimates for the majority of beta rich larger objects were broadly in line with those for beta rich particles, with age estimates being greater than 30 - 40 years. Most beta rich larger objects were classified as stones and hence were likely to have been formed from natural materials coming into contact with radioactive effluents that were released from the sealines.

It was estimated that the majority of alpha rich finds were produced during reprocessing in the late 1960s and early 1970s and that releases of alpha rich particles stopped by around 1983.

Data held in the TLD for each object found include the date of the find, the location (name of beach and geographical coordinates), type of object (particle or object; alpha-rich, beta-rich, cobalt rich or excess beta), radionuclide content, radioactivity, particle size and detection equipment used. In addition, an estimate of the depth is recorded for some finds. A summary of the data is given in Table 5.5-2.

Figure 5.5-1 Map illustrating the main beaches where monitoring for Sellafield particles is performed (GoogleMaps™)

Table 5.5-2: Summary of data held in TLD for Sellafield particles

Samples	Location	Date	Measurements	Radionuclides
Surveys: Divided into 10 regions – Allonby, Braystones, Drigg, Harrington, Seabed, Seascale, Sellafield, St_Bees, Whitehaven, Workington (**status: Public**) (issue date: 20/11/17) References: See Reference section Sellafield Particles				
Particle < 2 mm Object >= 2 mm	Latitude, longitude	Actual date and time of the find	Activity (Bq)	Co60, Cs137, Pu238, Pu239, Am241

5.6 Sellafield authorised discharges

Authorised discharges of radioactive material from the Sellafield site to the Irish Sea have been ongoing since the 1950s. As part of the authorization process it is a requirement to make regular measurements of activity concentrations in environmental media and report these to the regulator. Selected measurements have been added to the TLD. These include activity concentrations of ^{3}H, ^{99}Tc, ^{137}Cs, $^{239/240}Pu$ and ^{241}Am in sea water, sediments and marine biota in the Irish Sea region adjacent to the Sellafield coast and additional activity concentrations of ^{137}Cs in seawater and sediments near to selected nuclear power plants (Figure 5.6-1). A summary of the data is given in Table 5.6-1. It should be noted that the coordinates of the measurements are only indicative and have been derived by inspection using a graphical information system.

Activity concentrations in this environment are not at levels that require remediation but this dataset has been included to enable the marine dispersion models being used in the TERRITORIES project to be calibrated. This is made possible by the fact that current and historical annual discharges from the sites considered are available to the TERRITORIES project.

Figure 5.6-1 Map showing location of nuclear sites where routine monitoring is performed (GoogleMaps™)

Table 5.6-1: Summary of data held in TLD for Sellafield routine monitoring

Samples	Location	Date	Measurements	Radionuclides
Surveys: Divided into 42 regions near Sellafield (**status: Public**) (issue date: 5/6/2018) References: See Reference section Sellafield Authorised Discharges (BNFL. Discharges and monitoring of the environment in the UK. Annual reports 1997, 1998, 1999, 2000, 2001, 2002.)				
Seawater filtered	Latitude, longitude (estimate)	Annual	Activity concentration (Bq l^{-1})	H3, Tc99, Cs137, Pu239/Pu240, Am241
Surface sediment	Latitude, longitude (estimate)	Annual	Activity concentration dry weight (Bq kg^{-1})	H3, Tc99, Cs137, Pu239/Pu240, Am241
Marine plants	Latitude, longitude (estimate)	Annual	Activity concentration fresh weight (Bq kg^{-1})	H3, Tc99, Cs137, Pu239Pu240, Am241
Marine animals (fish, molluscs, crustaceans)	Latitude, longitude (estimate)	Annual	Activity concentration fresh weight (Bq kg^{-1})	H3, Tc99, Cs137, Pu239/Pu240, Am241
Surveys: Surveys for seawater near sites (Wylfa, Heysham, Sellafield, Torness, Hartlepool and Sizewell) and for sediments near Sellafield (**status: Public**) (issue date: 19/12/2017) References: See Reference section Sellafield Authorised Discharges (Leonard K et al (2017), Hunt J et al (2013))				
Seawater filtered	Latitude, longitude (estimate)	Annual	Activity concentration (Bq l^{-1})	Cs137
Surface sediment	Latitude, longitude (estimate)	Annual	Activity concentration dry weight (Bq kg^{-1})	Cs137

5.7 Upper Silesian Coal Basin: The Rontok Lake

The Upper Silesian Coal Basin (USCB) is one of the four radioecological observatories selected for study by the European Radioecology Alliance (https://radioecology-exchange.org/content/upper-silesian-coal-basin). The USCB is situated in the southern part of Poland and contains several waterbodies, including Rontok Lake. The lake's surface is around 32 ha, the water level is artificially managed and fluctuates between 0.4 and 2 m in depth. From 1977 to 2002, the lake was used as a settling pond by the local coal mining operator. It received mine waters containing high levels of radium and barium that were mixed with other underground waters containing sulfate ions thus allowing the precipitation of Ba and Ra into radiobarite $(Ba,Ra)SO_4$. Until 2018 the lake was used as a storage reservoir. However, during this period, the lake evolved into a "natural ecosystem", raising the question of the sustainability of radium trapping within the deposits at the bottom of the lake (i.e., "Does the sediment act as a source or trap for contaminants regarding the overlying water?").

In Rontok Lake, the quality of sediment and water is not surveyed routinely; several single campaigns were performed at different times by different European partners [Chalupnik et al. (2001); Leopold et al. (2007); Courbet et al. (2016)]. Only data obtained throughout the TERRITORIES project were added to the TLD. In April 2018, a single sampling campaign was performed by IRSN in collaboration with GIG (Central Mining Institute in Katowice, Poland). The surface water was sampled and analysed for Ra-226 activity concentration by emanometry and ICPMS. Three sediment cores of 28−30 cm length were collected in order to characterize the depth profiles:

- at a cm-resolution scale:
  - (1) the activity concentration of gamma-emitting radionuclides in the particulate fraction of sediment by gamma-spectrometry (^{226}Ra, ^{210}Pb, ^{228}Ra and ^{228}Th),
  - (2) the activity concentration of ^{226}Ra in the sediment porewaters by ICPMS,
- at a µm-resolution scale:
  - (3) the oxygen penetration through the surface water-sediment interface using Unisense micro-electrodes.

Only radionuclide data that were above the limit of detection were added to the TLD. The activity concentration of ^{226}Ra in the sediment porewaters did not exceed 0.2 Bq.L^{-1}. A summary of data held in the TLD is given in Table 5.7-1.

Table 5.7-1: Summary of data held in TLD for Rontok Lake

Samples	Location	Date	Measurements	Radionuclides
Surveys: Survey A (**status: Public**) (Issue date 5/2/2019) References: See Reference section Upper Silesian Coal Basin: The Rontok Lake				
Surface water (one measurement only)	None	Actual date of survey	Activity concentration (Bq L^{-1})	Ra226
Sediment	None	Actual date of survey	Activity concentration dry weight (Bq kg^{-1})	Pb210, Ra226, Ra228, Th228

6 Quality Assurance

Two important properties of a database such as the TLD are the fidelity of the data with respect to the original sources and the consistency of terminology used (eg to describe quantities and units) from one set of input data to another.

The fidelity of the TLD has been addressed by automating as much as possible the process by which data are taken from the spreadsheets provided by the data owners and entered into the database. Some manipulation of the data in the spreadsheets provided by the data owners has been necessary but any changes were made in consultation with the data owners. Tests were also carried out to compare output from the TLD with the spreadsheets and no errors were found. It is recommended that this type of comparison test should be conducted in future if new data are added to the TLD.

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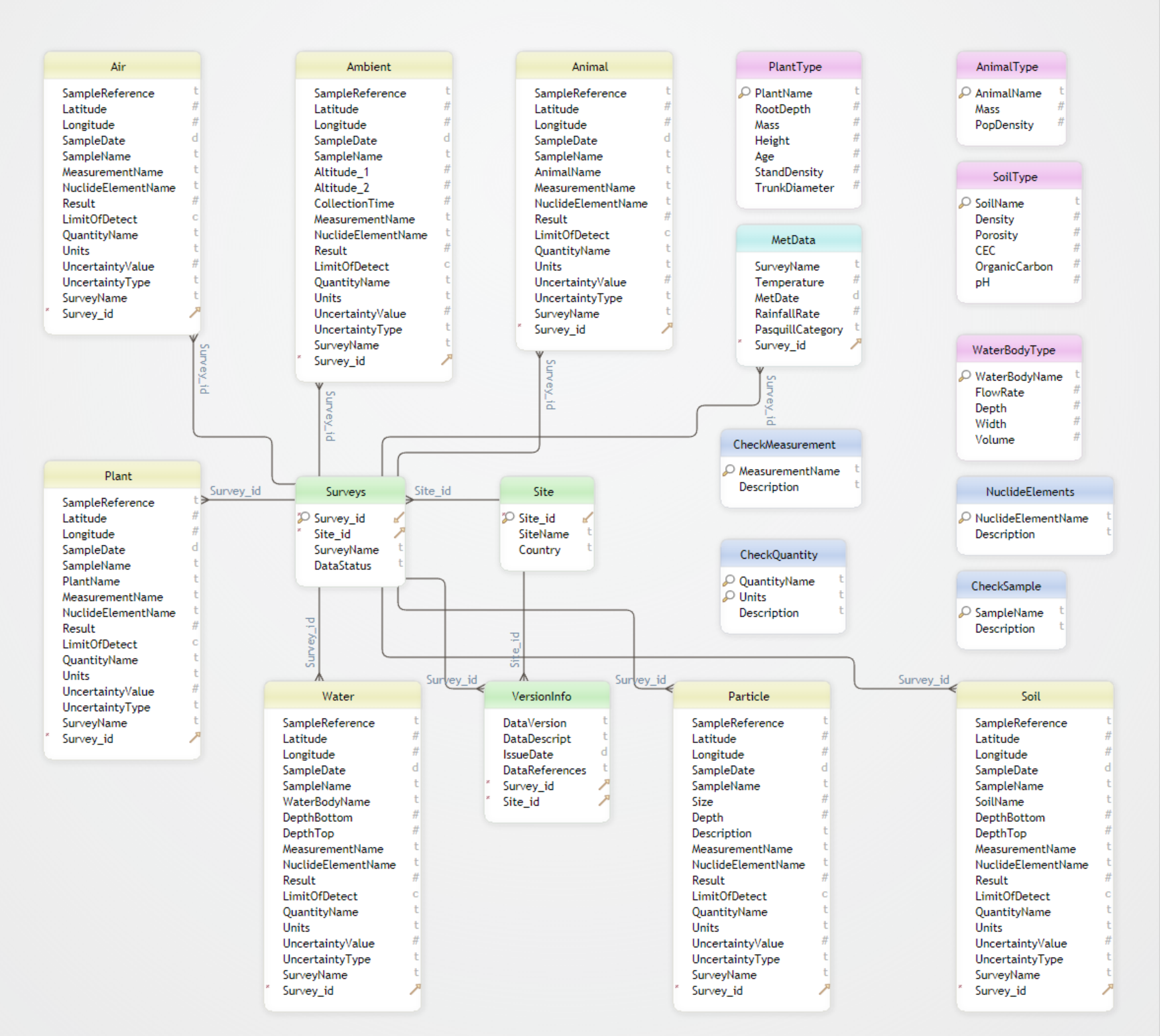
Annex 1 Structure of the TLD (TemplateTerritories_Firebird_v0.N.sql)

Table A1-1: TLD table structure



The SQL script used to create the TLD tables shown in Table A1-1.

```
/****** Object:  Database TemplateTerritories    Script Date: 12/09/2017 12:25:00 ******/

/****** Object:  Table Site    Script Date: 12/09/2017 12:25:01 ******/

CREATE TABLE Site(
        Site_id int NOT NULL,
        SiteName varchar(50),
        Country varchar(50),
        primary key (Site_id)
);

/****** Object:  Table Surveys    Script Date: 12/09/2017 12:25:01 ******/

CREATE TABLE Surveys(
        Survey_id int NOT NULL,
        Site_id int NOT NULL,
        SurveyName varchar(50),
        DataStatus varchar(50),
        primary key (Survey_id),
    foreign key (Site_id) references Site(Site_id)
);

/****** Object:  Table Air    Script Date: 12/09/2017 12:25:01 ******/

CREATE TABLE Air(
        SampleReference varchar(30),
        Latitude float,
        Longitude float,
        SampleDate timestamp,
        SampleName varchar(50),
        MeasurementName varchar(50),
        NuclideElementName varchar(10),
        Result float,
        LimitOfDetect char(1),
        QuantityName varchar(50),
        Units varchar(50),
        UncertaintyValue float,
        UncertaintyType varchar(50),
        SurveyName varchar(50),
        Survey_id int NOT NULL,
        foreign key (Survey_id) references Surveys(Survey_id)
);
```

```
/****** Object:  Table Ambient    Script Date: 12/09/2017 12:25:01 ******/

CREATE TABLE Ambient(
        SampleReference varchar(30),
        Latitude float,
        Longitude float,
        SampleDate timestamp,
        SampleName varchar(50),
        Altitude_1 float,
        Altitude_2 float,
        CollectionTime float,
        MeasurementName varchar(50),
        NuclideElementName varchar(10),
        Result float,
        LimitOfDetect char(1),
        QuantityName varchar(50),
        Units varchar(50),
        UncertaintyValue float,
        UncertaintyType varchar(50),
        SurveyName varchar(50),
        Survey_id int NOT NULL,
        foreign key (Survey_id) references Surveys(Survey_id)
);

/****** Object:  Table Animal    Script Date: 12/09/2017 12:25:01 ******/

CREATE TABLE Animal(
        SampleReference varchar(30),
        Latitude float,
        Longitude float,
        SampleDate timestamp,
        SampleName varchar(50),
        AnimalName varchar(50),
        MeasurementName varchar(50),
        NuclideElementName varchar(10),
        Result float,
        LimitOfDetect char(1),
        QuantityName varchar(50),
        Units varchar(50),
        UncertaintyValue float,
        UncertaintyType varchar(50),
        SurveyName varchar(50),
        Survey_id int NOT NULL,
        foreign key (Survey_id) references Surveys(Survey_id)
);
```

```
/****** Object:  Table AnimalType    Script Date: 12/09/2017 12:25:01 ******/

CREATE TABLE AnimalType(
        AnimalName varchar(50),
        Mass float,
        PopDensity float,
        unique (AnimalName)
);

/****** Object:  Table CheckMeasurement    Script Date: 12/09/2017 12:25:01 ******/

CREATE TABLE CheckMeasurement(
        MeasurementName varchar(50),
        Description varchar(50),
        Unique (MeasurementName)
);

/****** Object:  Table CheckQuantity    Script Date: 12/09/2017 12:25:01 ******/

CREATE TABLE CheckQuantity(
        QuantityName varchar(50),
        Units varchar(50),
        Description varchar(50),
        Unique (QuantityName, Units)
);

/****** Object:  Table CheckSample    Script Date: 12/09/2017 12:25:01 ******/

CREATE TABLE CheckSample(
        SampleName varchar(50),
        Description varchar(50),
        Unique (SampleName)
);

/****** Object:  Table MetData    Script Date: 12/09/2017 12:25:01 ******/

CREATE TABLE MetData(
        SurveyName varchar(50),
        Temperature float,
        MetDate timestamp,
        RainfallRate float,
        PasquillCategory varchar(10),
        Survey_id int NOT NULL,
        foreign key (Survey_id) references Surveys(Survey_id)
);
```

```
/****** Object:  Table NuclideElements    Script Date: 12/09/2017 12:25:01 ******/

CREATE TABLE NuclideElements(
	NuclideElementName varchar(10),
	Description varchar(50),
	Unique(NuclideElementName)
);

/****** Object:  Table Particle    Script Date: 12/09/2017 12:25:01 ******/

CREATE TABLE Particle(
	SampleReference varchar(30),
	Latitude float,
	Longitude float,
	SampleDate timestamp,
	SampleName varchar(50),
	Size float,
	Depth float,
	Description varchar(50),
	MeasurementName varchar(50),
	NuclideElementName varchar(10),
	Result float,
	LimitOfDetect char(1),
	QuantityName varchar(50),
	Units varchar(50),
	UncertaintyValue float,
	UncertaintyType varchar(50),
	SurveyName varchar(50),
	Survey_id int NOT NULL,
	foreign key (Survey_id) references Surveys(Survey_id)
);
```

```
/****** Object:  Table Plant    Script Date: 12/09/2017 12:25:01 ******/

CREATE TABLE Plant(
	SampleReference varchar(30),
	Latitude float,
	Longitude float,
	SampleDate timestamp,
	SampleName varchar(50),
	PlantName varchar(50),
    MeasurementName varchar(50),
	NuclideElementName varchar(10),
	Result float,
	LimitOfDetect char(1),
	QuantityName varchar(50),
	Units varchar(50),
	UncertaintyValue float,
	UncertaintyType varchar(50),
	SurveyName varchar(50),
	Survey_id int NOT NULL,
	foreign key (Survey_id) references Surveys(Survey_id)
);

/****** Object:  Table PlantType    Script Date: 12/09/2017 12:25:01 ******/

CREATE TABLE PlantType(
	PlantName varchar(50),
	RootDepth float,
	Mass float,
	Height float,
	Age float,
	StandDensity float,
	TrunkDiameter float,
	Unique (PlantName)
);
```

```
/****** Object:  Table Soil    Script Date: 12/09/2017 12:25:01 ******/

CREATE TABLE Soil(
	SampleReference varchar(30),
	Latitude float,
	Longitude float,
	SampleDate timestamp,
	SampleName varchar(50),
	SoilName varchar(50),
	DepthBottom float,
	DepthTop float,
	MeasurementName varchar(50),
	NuclideElementName varchar(10),
	Result float,
	LimitOfDetect char(1),
	QuantityName varchar(50),
	Units varchar(50),
	UncertaintyValue float,
	UncertaintyType varchar(50),
	SurveyName varchar(50),
	Survey_id int NOT NULL,
	foreign key (Survey_id) references Surveys(Survey_id)
);

/****** Object:  Table SoilType    Script Date: 12/09/2017 12:25:01 ******/

CREATE TABLE SoilType(
	SoilName varchar(50),
	Density float,
	Porosity float,
	CEC float,
	OrganicCarbon float,
	pH float,
	Unique (SoilName)
);

/****** Object:  Table VersionInfo    Script Date: 12/09/2017 12:25:01 ******/

CREATE TABLE VersionInfo(
	DataVersion varchar(10),
	DataDescript varchar(1000),
	IssueDate timestamp,
	DataReferences varchar(1000),
	Survey_id int NOT NULL,
	Site_id int NOT NULL,
	foreign key (site_id) references Site(site_id),
	foreign key (Survey_id) references Surveys(Survey_id)
);
```

```
/****** Object:  Table Water    Script Date: 12/09/2017 12:25:01 ******/

CREATE TABLE Water(
	SampleReference varchar(30),
	Latitude float,
	Longitude float,
	SampleDate timestamp,
	SampleName varchar(50),
	WaterBodyName varchar(50),
	DepthBottom float,
	DepthTop float,
	MeasurementName varchar(50),
	NuclideElementName varchar(10),
	Result float,
	LimitOfDetect char(1),
	QuantityName varchar(50),
	Units varchar(50),
	UncertaintyValue float,
	UncertaintyType varchar(50),
	SurveyName varchar(50),
	Survey_id int NOT NULL,
	foreign key (Survey_id) references Surveys(Survey_id)
);

/****** Object:  Table WaterBodyType    Script Date: 12/09/2017 12:25:01 ******/

CREATE TABLE WaterBodyType(
	WaterBodyName varchar(50),
	FlowRate float,
	Depth float,
	Width float,
	Volume float,
	Unique (WaterBodyName)
);
```