ABmerit – nuclear science and software

SOFTWARE ENGINEERING, AUTHOR OF COMPUTER CODE ESTE
TECHNICAL SUPPORT FOR NUCLEAR POWER PLANTS AND CRISIS CENTERS
RADIATION SAFETY AND DOSIMETRY, ARCHITECT OF EMERGENCY RESPONSE SYSTEMS
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ESTE Annual Impacts for BNPP

version 0.00

System for calculation of radiological impacts of airborne and liquid discharges from normal operation of nuclear facilities

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1. INTRODUCTION

ESTE AI (Annual Impacts) is system (software) for calculation of radiation doses caused by effluents in routine releases of the plant of interest (NPP or decommissioned site) to the atmosphere and to the hydrosphere.

Doses to the members of critical (representative) groups of inhabitants in the vicinity of NPP are calculated and as a result, critical group (representative) is determined.

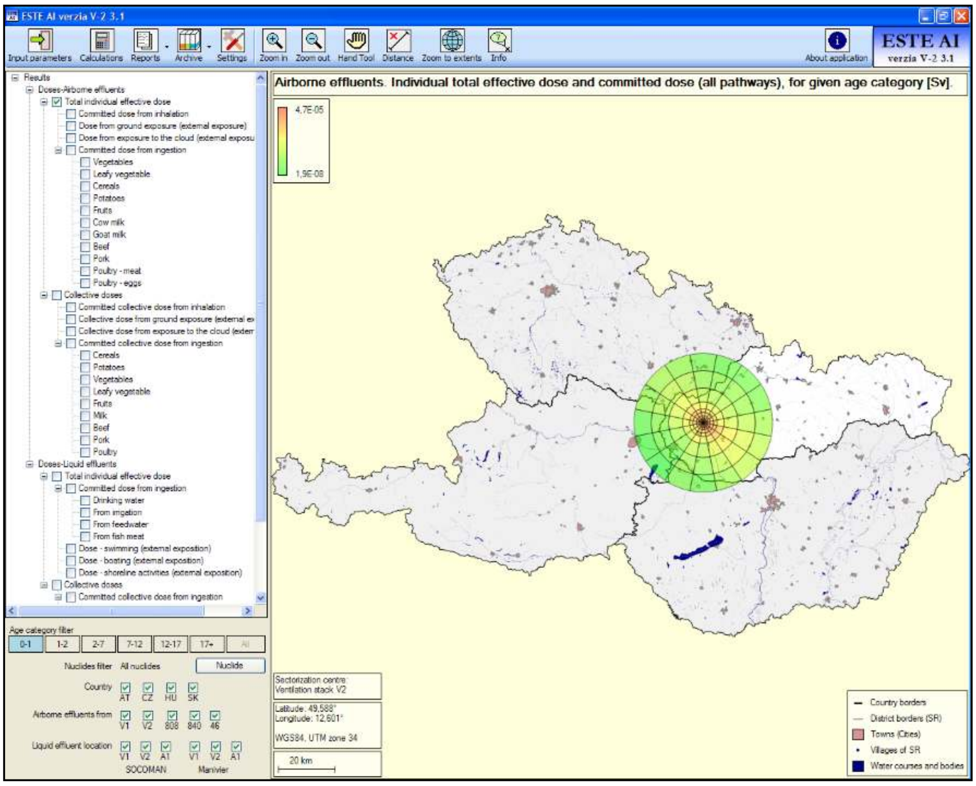
Collective doses to the inhabitants living in the vicinity of the NPP are calculated. ESTE AI calculates doses to the whole population of the impacted countries, e.g. in case of NPP Bohunice (Slovakia) doses to the population of Slovakia, Czech Republic, Austria and Hungary.

The program enables to calculate and to document beyond-border radiological impacts of effluents caused by routine operation or by decommissioning process.

ESTE AI implementations:

- NPP Bohunice (VVER-440, 2 reactors)
- Slovak decommissioning facility JAVYS (former plants Bohunice V-1, A1 + waste processing facilities + spent fuel storage facility).
- Temelin NPP and Dukovany NPP (implemented at the Czech Nuclear Regulatory Body, Prague).
- (MODARIA - Chinon NPP, France) - special version provided for the 3rd TM on Modelling and Data for Radiological Impact Assessments (Modaria/IAEA), WG5.

Main user interface of the system:



The system is completely based on geographical information system (GIS) - all inputs, internal databases and outputs are stored and calculated on the GIS base – information is spatial.

GIS approach enables us to manage and update very effectively information about agricultural production and about number of inhabitants sorted by age in villages in 100 km zone. This should be performed annually.

Release points of effluents are placed to real points (to specific stack with specific coordinates and specific height).

Applied atmospheric dispersion model (Puff Trajectory Model - PTM) enables us also to model "calm conditions" (with very low or negligible wind rate).

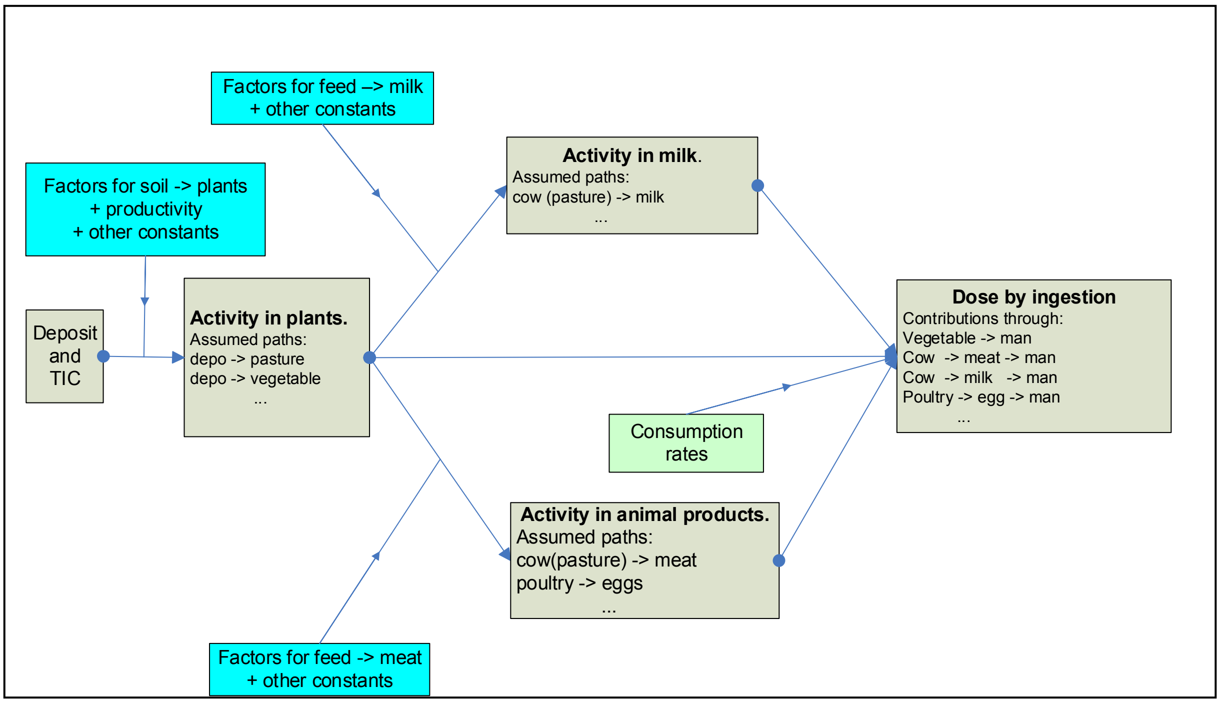
Impacts beyond 100 km zone are calculated - caused by "global nuclides" and caused by "export of ingestion".

Local and global impacts of C-14 are calculated.

Effluents and impacts are modelled at time interval of 1 year (at least 1 month).

The system can calculate radiological impacts for 127 most common radionuclides and their combinations.

Calculation scheme, airborne releases:



1.1 Exposition pathways assumed in ESTE Annual Impacts

- External exposure from cloud/dose
- External ground deposition/dose
- Inhalation of activity in air/dose (for particular age categories)
- Ingestion (for particular age categories)
- Leafy vegetables – man (direct ingestion)
- Other agricultural products – man (direct ingestion)
(Cereals, potatoes, fruits, grapevine, hop, etc., in case of data availability – an individual pathway for each „other crop“)
- Cow grazing on fresh pasture – milk – man
- Cow fed in the stable (hay) – milk – man
- Goat grazing on fresh pasture – milk – man
- Goat fed in the stable (hay) – milk – man
- Cow grazing on fresh pasture – meat – man
- Cow fed in the stable (hay) – meat – man
- Cereals - Poultry fed in the stable by cereals – meat – man
- Cereals – Poultry fed in the stable by cereals – eggs – man
- Swimming
- Boating (fisherman)
- Shoreline activities (fisherman)

+ expected in case of Bushehr:

- Sea water – fish meat – man
- Sea water – aquatic animals – man

1.2 Inputs to calculation

- meteorological situation (wind speed and direction, precipitation rate, category of stability) – locally measured every hour.
- atmospheric releases (monthly or annual averages) from the point of interest - ventilation stacks, cooling towers, machinery rooms, service water cooling towers.
- liquid releases from the point of interest (to river, lake, sea) – monthly or annual average.
- in case of Bushehr: parameters of the sea.
- calculation time interval - year, quarter of year, month or custom time interval.

1.3 In-build parameters - databases

System ESTE AI uses a large set of in-build parameters (databases):

- database of constants and factors for each calculated radionuclide,
- statistical database of foodstuff production of interested regions,
- statistical database of foodstuff consumption of interested regions,
- database of numbers of inhabitants in 100km zone around site of interest - for each city, town and village and for each calculated age category.

Databases of foodstuff production/consumption and databases of inhabitants should be periodically updated.

2. DISPERSION MODEL: PUFF TRAJECTORY MODEL (PTM)

The model is a method for calculation of dispersion in the atmosphere. Atmospheric diffusion in horizontal direction is described by Gaussian dispersion and atmospheric dispersion in vertical direction is described and solved by diffusion equation.

Lower part of the atmosphere (between the terrain and mixing boundary layer) is divided into "N" layers (boxes), e.g. N = 10.

The exchange of radioactive material between vertical layers is described by diffusion equation and horizontal dispersion is described by Gaussian equation. In the ESTE model we assume that the wind rate and wind direction is in every box (layer) of the atmosphere represented by weighting mean of the real wind rate and wind direction. Therefore the i-th trajectory of the puff has the same coordinates (LAT and LONG) in each layer (in each box).

3. MODEL FOR LIQUID EFFLUENTS - DISPERSION IN SEA WATER

The algorithm uses a PTM-like model. Using the current vector field the center of each puff is moved, and at the same time the puffs evolve using the given dispersion constants. Each shift of the puff represents its defined movement in time. After each shift we evaluate the corresponding value of concentration for all boxes.

One input to dispersion calculation is the sea current, specifying the flow of water in the Persian Gulf. The user can either insert single value defining the current near the site which is extended to the whole computational region by program using simple interpolation methods, or load file with data specifying the current vector field for the whole region (if available). In both cases the user specifies monthly values of the flow in the gulf.

The dispersion is described by formulas:

$$\varepsilon\_x = 4.66 \times 10^{-6} \times (d / U)^{1.34}$$
$$\varepsilon\_y = 3.44 \times 10^{-7} \times (d / U)^{1.34}$$

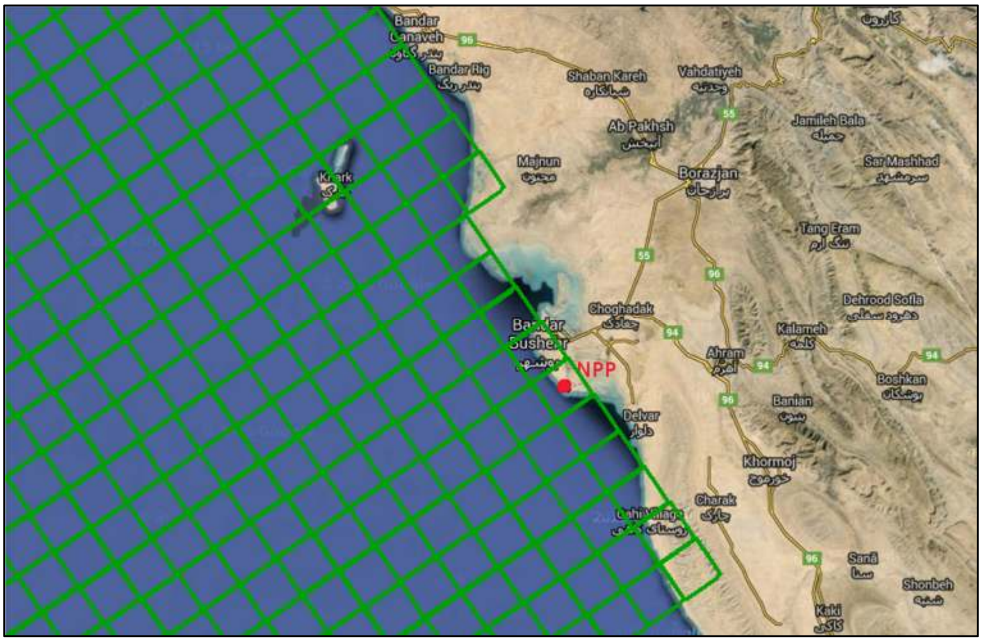
where $t = d / U$ is the total time of the puff movement, ε_x and ε_y are the longitudinal and lateral dispersion coefficient. The relations are based:

Okubo, A. 1971. “Oceanic Diffusion Diagrams.” Deep Sea Research 18: 789–802.

The model considers further:
a) The puffs move along trajectories given by the vector field of the sea current. The longitudinal and lateral direction is preserved unchanged.
b) The dispersion is given by solution of the advection-diffusion equation
c) We assume well-mixed situation in vertical direction all the time.
d) The reflection term from the coast is included.

Afterwards, the activity concentration in each box is determined as time-averaged (over one month) value for all months.

Figure: Example of boxes for the Persian Gulf. Each box in the figure has 10 km x 10 km size.

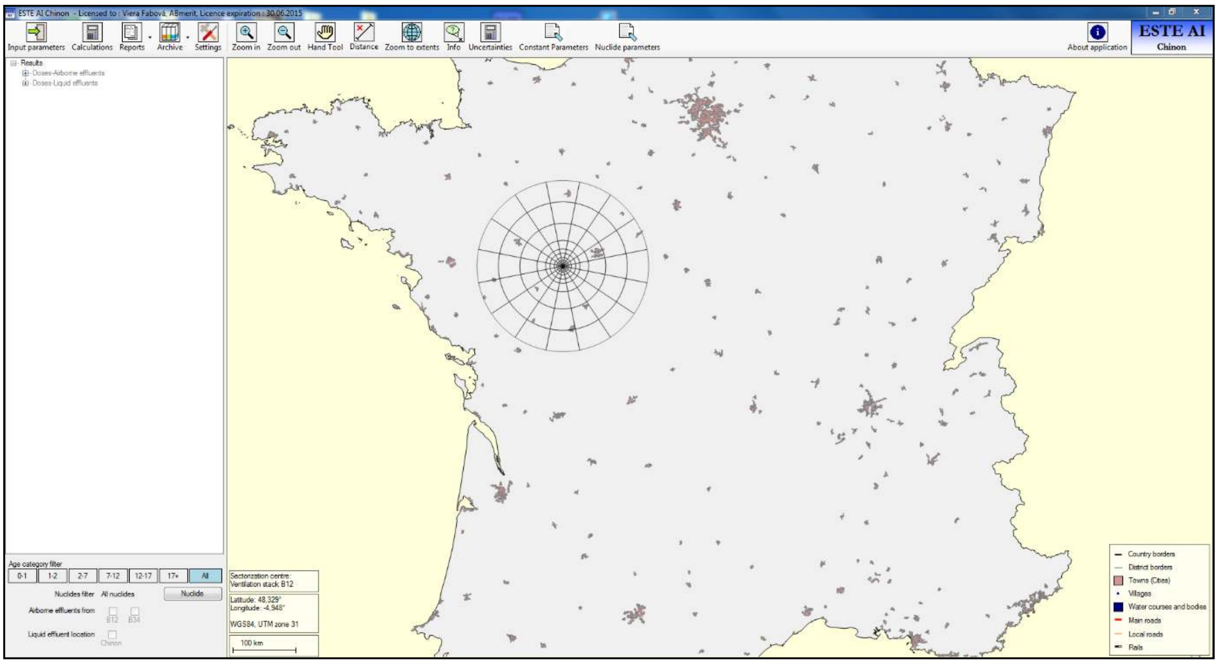


4. USER'S GUIDE/EXAMPLES OF GRAPHICAL OUTPUTS

4.1 How to start the program?

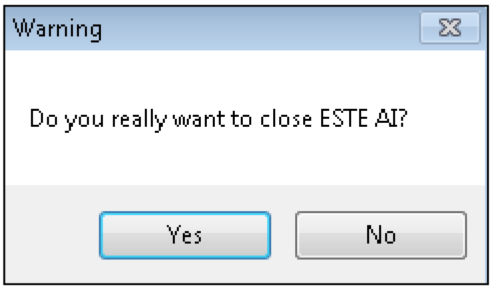
To start the program, the user should double-click the ESTE AI icon on the desktop:
Note: in case of BNPP here will be specific GUI (figure) for BNPP.

Then the main screen appears:



The main screen usually (e.g. after program restart) displays sectors overlay and a map of the country containing the sectors. Also country border, districts borders, settlements, roads and waters are displayed. *Note: in case of BNPP here will be specific map for BNPP*.

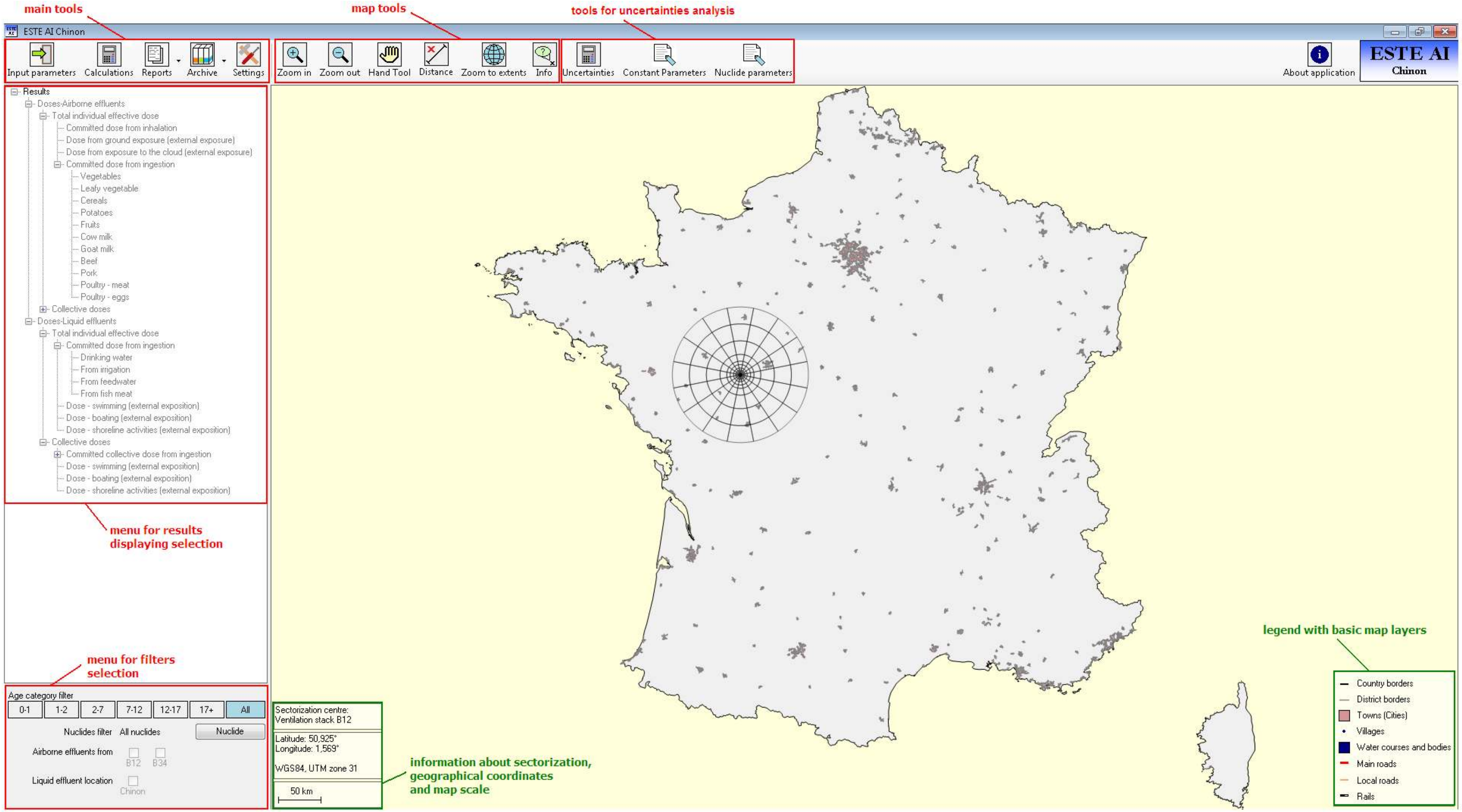
4.2 How to turn off ESTE AI?



The system ESTE AI can be turned off by clicking the button in the right upper corner (x). Before the system is turned off, the user has to confirm his choice:

4.3 Description of main control icons (functions) of ESTE AI

Tools and information on the main screen:

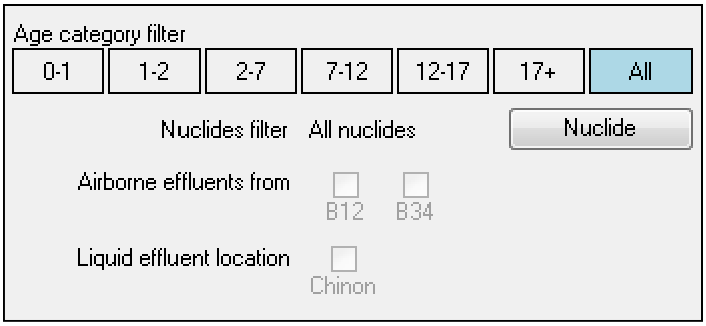


Note: in case of BNPP here will be specific map for the BNPP and specific user interface for BNPP (without tools for uncertainties analyzes).

The main menu on the main screen:

Tools:	Input parameters Calculations Reports Archive Settings
Map tools:	Zoom in Zoom out Hand tool Zoom to extents Info Distance

On the left side of the main screen, the menu for calculation results is placed:

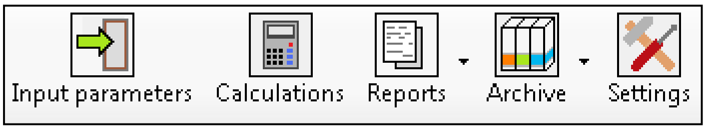


Note: in case of BNPP here will be the GUI specific for the BNPP.

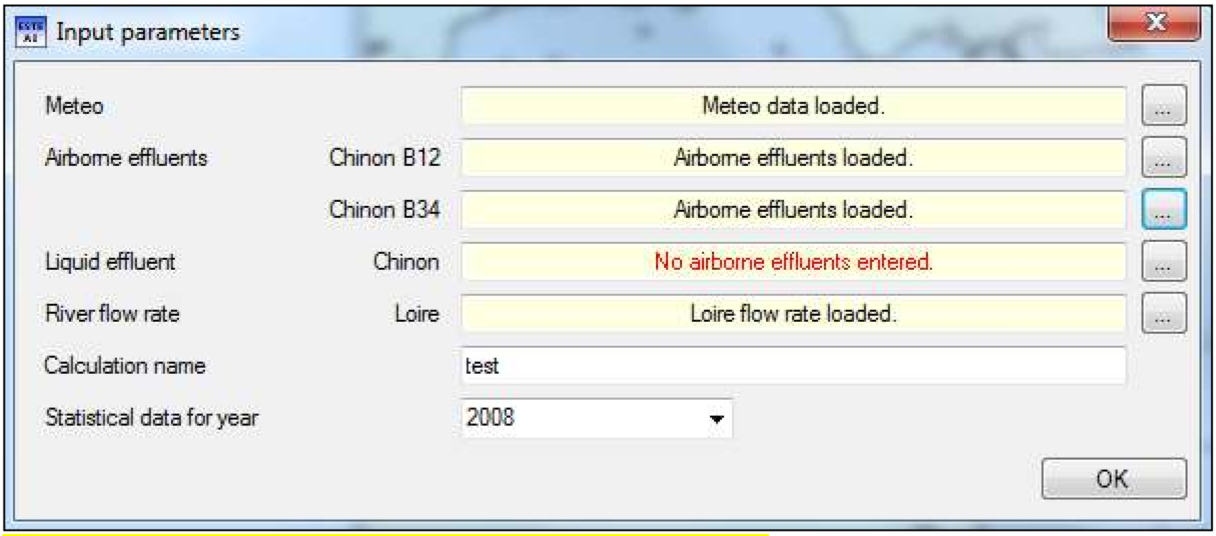
It enables to set the following filters:
- age category
- nuclides
- airborne effluents from the ventillation stack:
- liquid effluents location – (sea in case of BNPP).

4.4 System tools

<u>Main tools</u>:



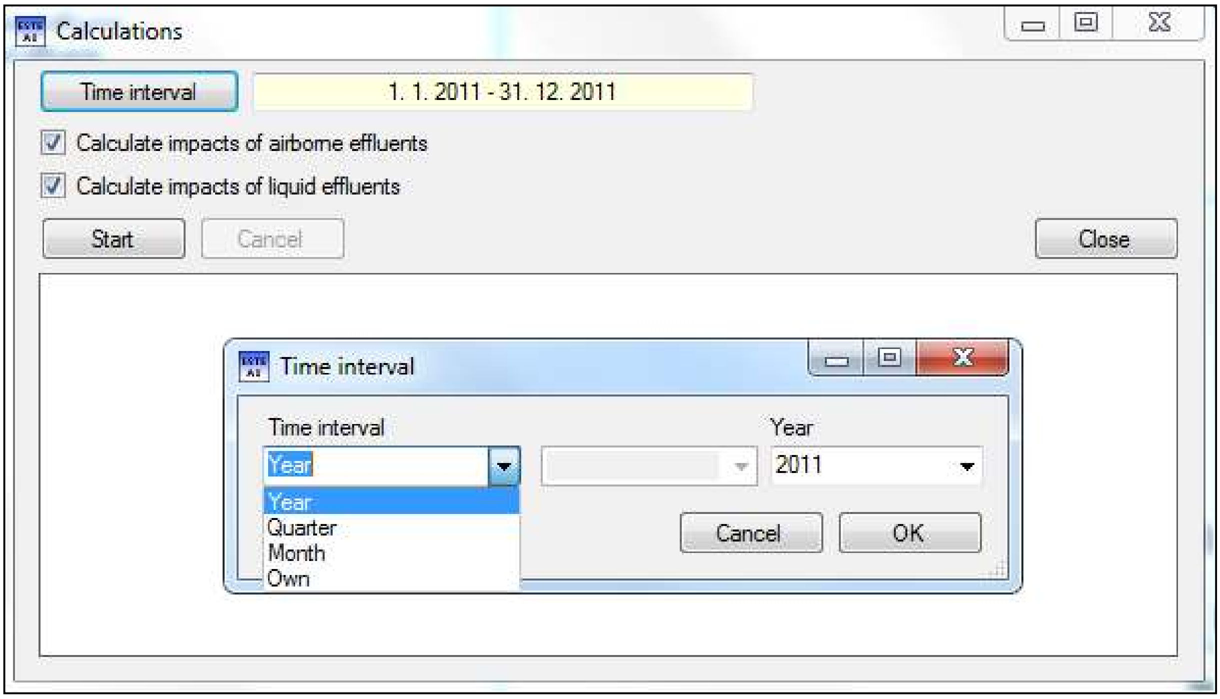
Input parameters – the tool serves to enter the input parameters for calculation (meteo, liquid and airborne effluents). The system ESTE AI reports to the user successful loading of input data (e.g. message „Liquid effluents loaded“). The user can also enter his own name of calculation. This name will be used for export of particular results, archive files, etc.



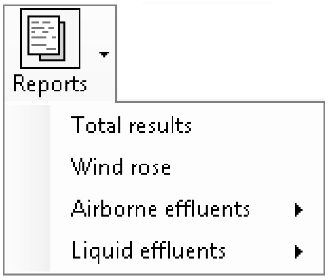
Note: in case of BNPP here will be the GUI specific for the BNPP.

The drop-down menu „Statistical data for year“ enables the user of ESTE to select appropriate year of statistical data (consumptions, production) which will be used for analyses.

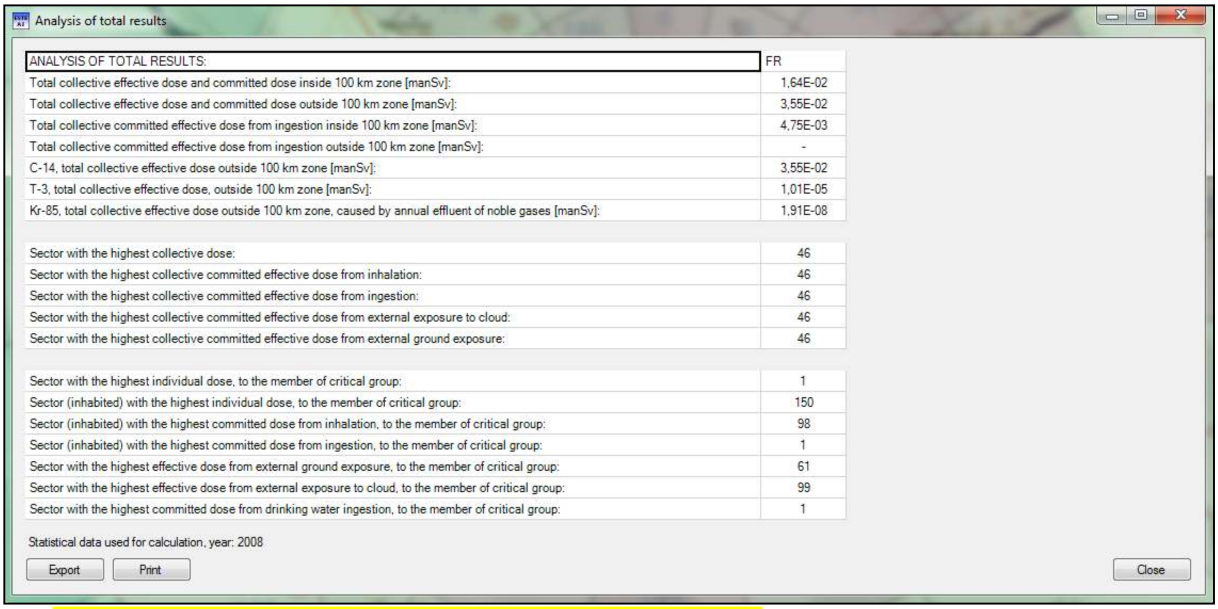
Calculations – this menu enables to start calculations of liquid and/or airborne effluents impacts for (generally) the selected period of time.



Reports – the drop-down menu „Reports“ enables the user to display:



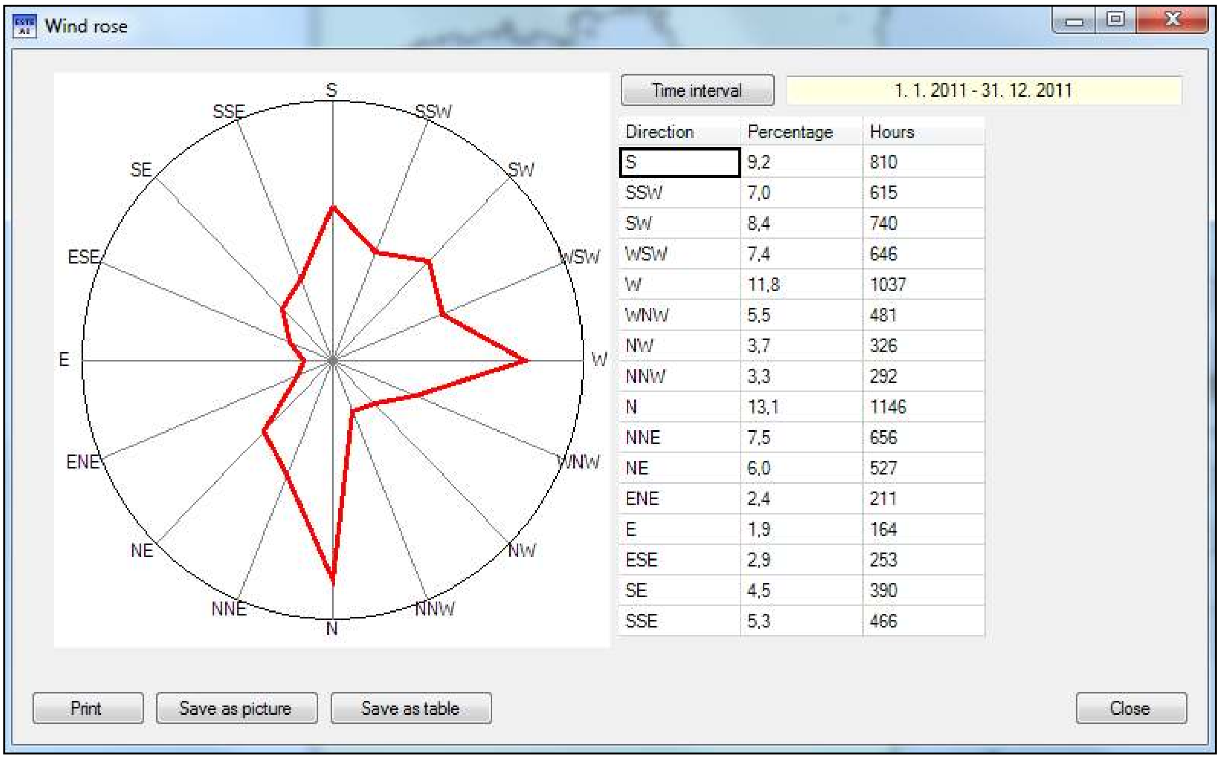
1. Analyses of total results:



ANALYSIS OF TOTAL RESULTS:	FR
Total collective effective dose and committed dose inside 100 km zone [manSv]:	1,64E-02
Total collective effective dose and committed dose outside 100 km zone [manSv]:	3,55E-02
Total collective committed effective dose from ingestion inside 100 km zone [manSv]:	4,75E-03
Total collective committed effective dose from ingestion outside 100 km zone [manSv]:	-
C-14, total collective effective dose outside 100 km zone [manSv]:	3,55E-02
T-3, total collective effective dose, outside 100 km zone [manSv]:	1,01E-05
Kr-85, total collective effective dose outside 100 km zone, caused by annual effluent of noble gases [manSv]:	1,91E-08
Sector with the highest collective dose:	46
Sector with the highest collective committed effective dose from inhalation:	46
Sector with the highest collective committed effective dose from ingestion:	46
Sector with the highest collective committed effective dose from external exposure to cloud:	46
Sector with the highest collective committed effective dose from external ground exposure:	46
Sector with the highest individual dose, to the member of critical group:	1
Sector (inhabited) with the highest individual dose, to the member of critical group:	150
Sector (inhabited) with the highest committed dose from inhalation, to the member of critical group:	98
Sector (inhabited) with the highest committed dose from ingestion, to the member of critical group:	1
Sector with the highest effective dose from external ground exposure, to the member of critical group:	61
Sector with the highest effective dose from external exposure to cloud, to the member of critical group:	99
Sector with the highest committed dose from drinking water ingestion, to the member of critical group:	1

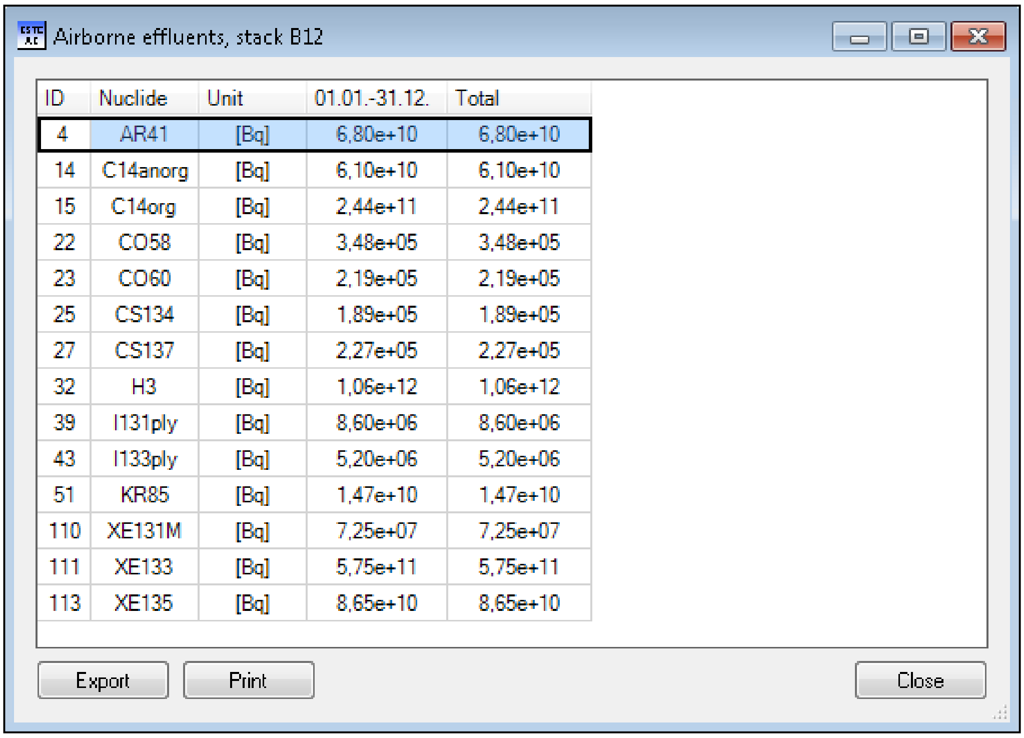
Note: in case of BNPP this GUI will be specific for the BNPP.

2. The wind rose (if the meteo data are loaded):



Direction	Percentage	Hours
S	9,2	810
SSW	7,0	615
SW	8,4	740
WSW	7,4	646
W	11,8	1037
WNW	5,5	481
NW	3,7	326
NNW	3,3	292
N	13,1	1146
NNE	7,5	656
NE	6,0	527
ENE	2,4	211
E	1,9	164
ESE	2,9	253
SE	4,5	390
SSE	5,3	466

3. Airborne (or liquid) discharges applied for analyses:



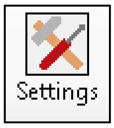
ID	Nuclide	Unit	01.01.-31.12.	Total
4	AR41	[Bq]	6,80e+10	6,80e+10
14	C14anorg	[Bq]	6,10e+10	6,10e+10
15	C14org	[Bq]	2,44e+11	2,44e+11
22	CO58	[Bq]	3,48e+05	3,48e+05
23	CO60	[Bq]	2,19e+05	2,19e+05
25	CS134	[Bq]	1,89e+05	1,89e+05
27	CS137	[Bq]	2,27e+05	2,27e+05
32	H3	[Bq]	1,06e+12	1,06e+12
39	I131ply	[Bq]	8,60e+06	8,60e+06
43	I133ply	[Bq]	5,20e+06	5,20e+06
51	KR85	[Bq]	1,47e+10	1,47e+10
110	XE131M	[Bq]	7,25e+07	7,25e+07
111	XE133	[Bq]	5,75e+11	5,75e+11
113	XE135	[Bq]	8,65e+10	8,65e+10

Note: in case of BNPP this GUI will be specific for the BNPP.

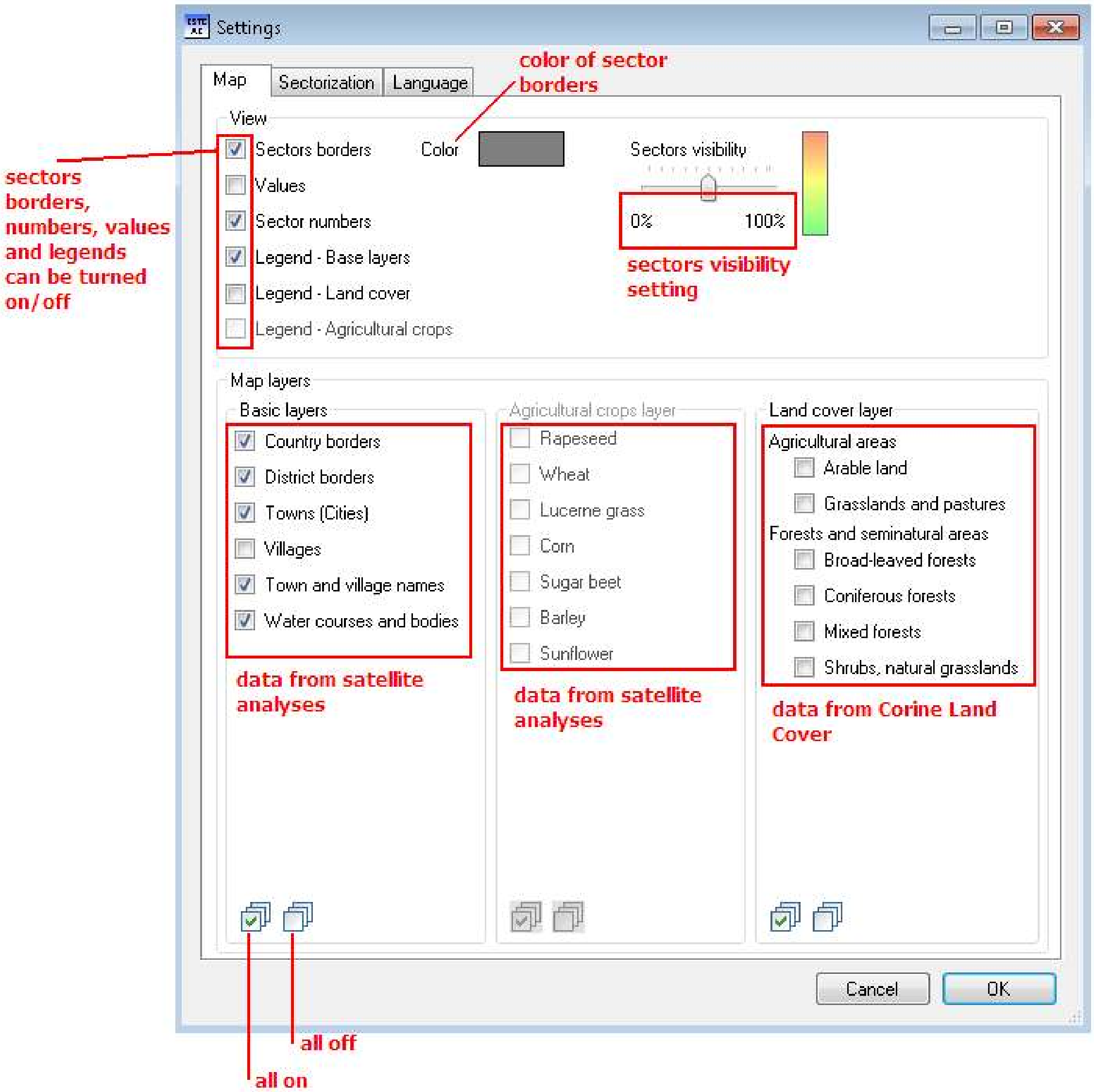
Archive – the drop-down menu „Archive“ enables to:

1. „Load archive“ – to load already calculated results (files *.eai – ESTE AI) – by this choice, the whole project of already calculated impacts can be re-loaded.

2. „Save archive“ – to save currently calculated results. The results are saved as a file in *.eai format. Then the user can re-load the file and work with it at any time in future.

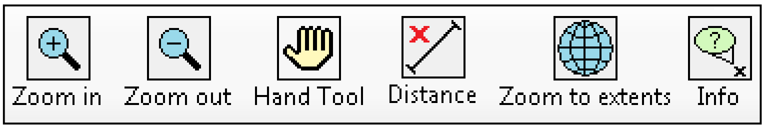
Settings – this menu enables to change attributes of maps and clustering  settings.

Map: in the following window, the user can turn on/off the map layers and the corresponding legend. Parameters for displayed attributes of sectors on the maps can be managed here.
The choice „Color“ enables to change the color of sector borders.
The level of visibility of colored sectors with impacts can be set by the tool „Sectors visibility“.

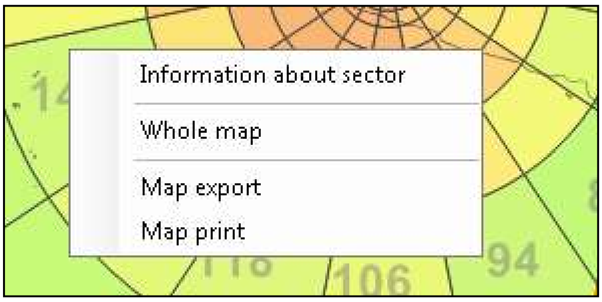


Note: in case of BNPP this GUI will be specific for the BNPP (maps available, etc.).

Map tools:

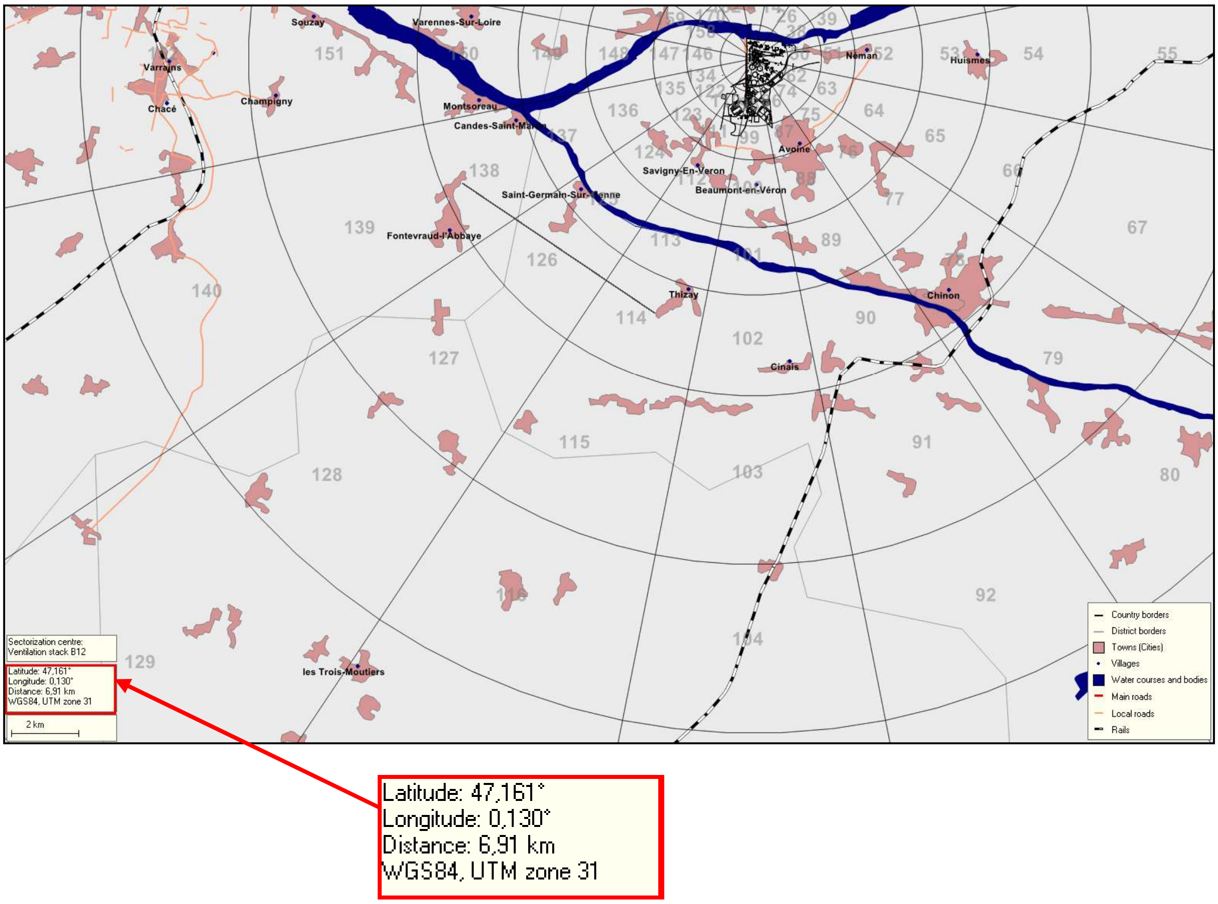


The main control panel includes map tools such as „Zoom in“, „Zoom out“, „Hand tool“, „Distance“ (to measure the distance on the map) and „Zoom to extents“ (it displays the default map of the country). Choosing „Info“ accompanied by clicking at a point on the map enables the user to display complex information about values calculated for the chosen sector. The same information can be displayed after right-click on the chosen sector (the choice “Information about sector”).



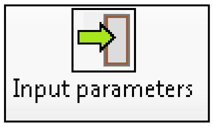
Distance

Choice of „Distance“ accompanied by left-click and movement of pushed mouse button to the point of interest enables to measure distance between 2 points on the map. The system measures real distances in kilometers, the information is displayed in the left bottom corner of the map window. Distance measurement can be also done after clicking on the map and choosing „Distance“ in the pop-up menu.

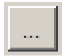


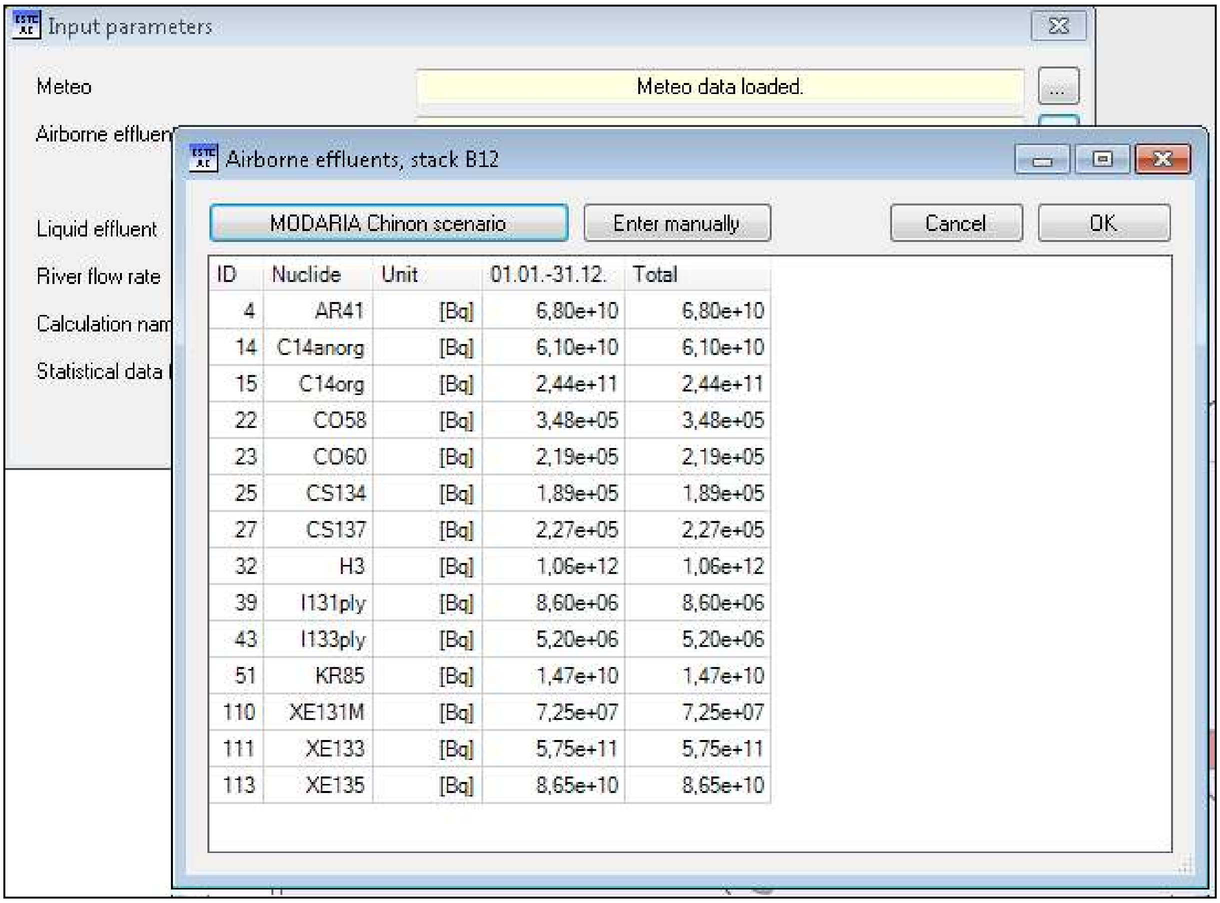
Note: in case of BNPP here will be the specific map for the BNPP.

4.5 How to enter input parameters of airborne/liquid effluents?



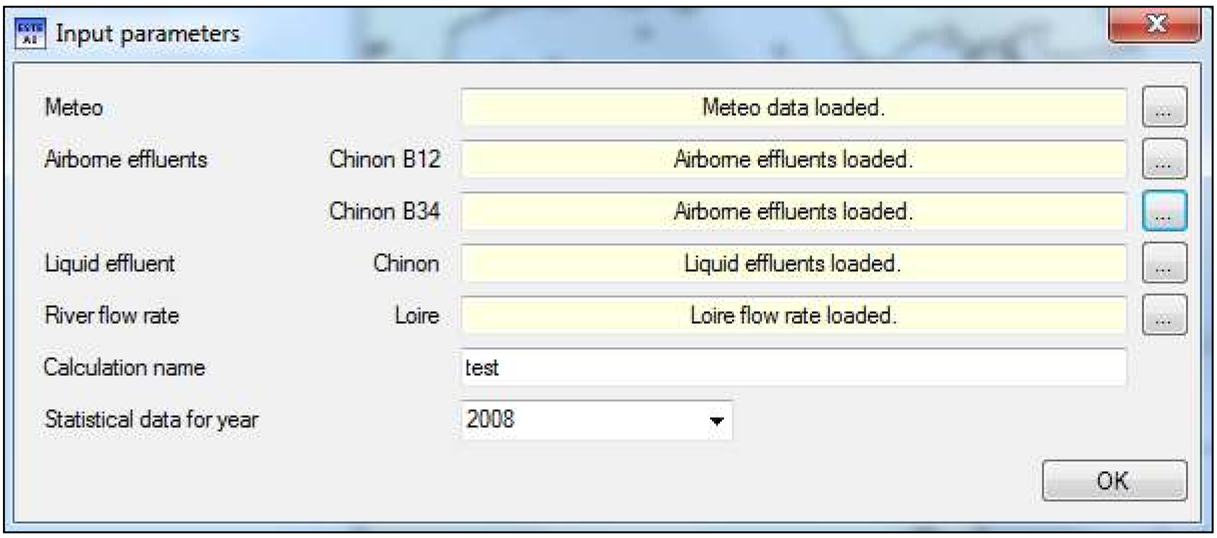
To enter the appropriate data, click the tool „Input parameters“ in the main menu.

The buttons at the end of rows serve to open the way to data input. 



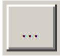
Note: in case of BNPP here will be specific GUI for the BNPP.

The window „Input parameters“ enables to control which data are loaded:



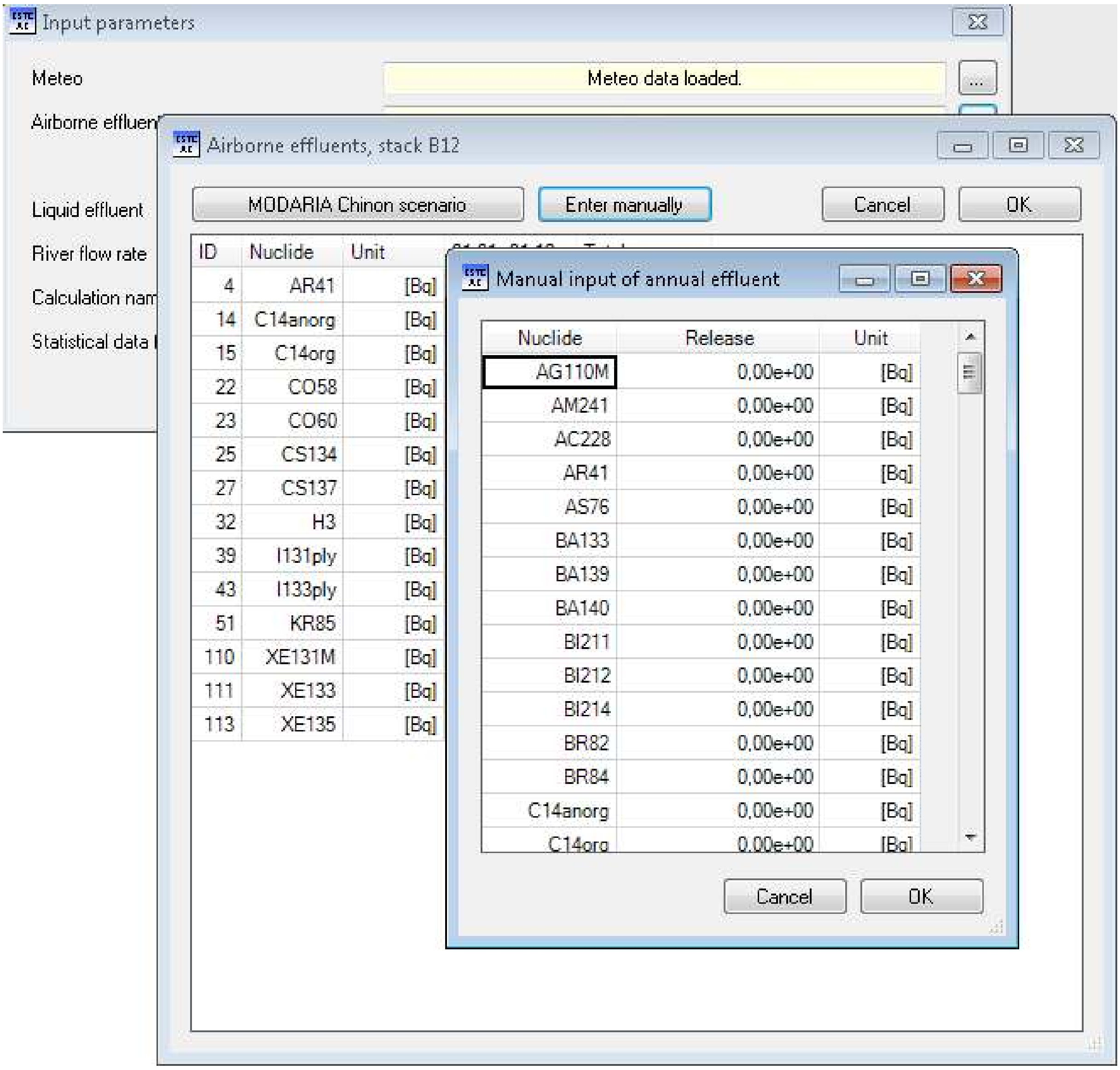
Note: in case of BNPP here will be specific GUI for the BNPP (including the parameters of the sea).

4.6 How to enter the airborne/liquid discharges manually?

Manual input of annual airborne/liquid discharges can be performed by the choice „Input parameters“ in the main menu. The button at the end of the row  displays for example a window: „Airborne effluents, stack B12“.

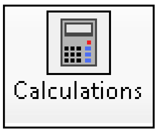
The button „Enter manually“ presents a window for manual input of annual effluents. The user can enter values and confirm them.

Liquid annual discharges can be entered similarly.



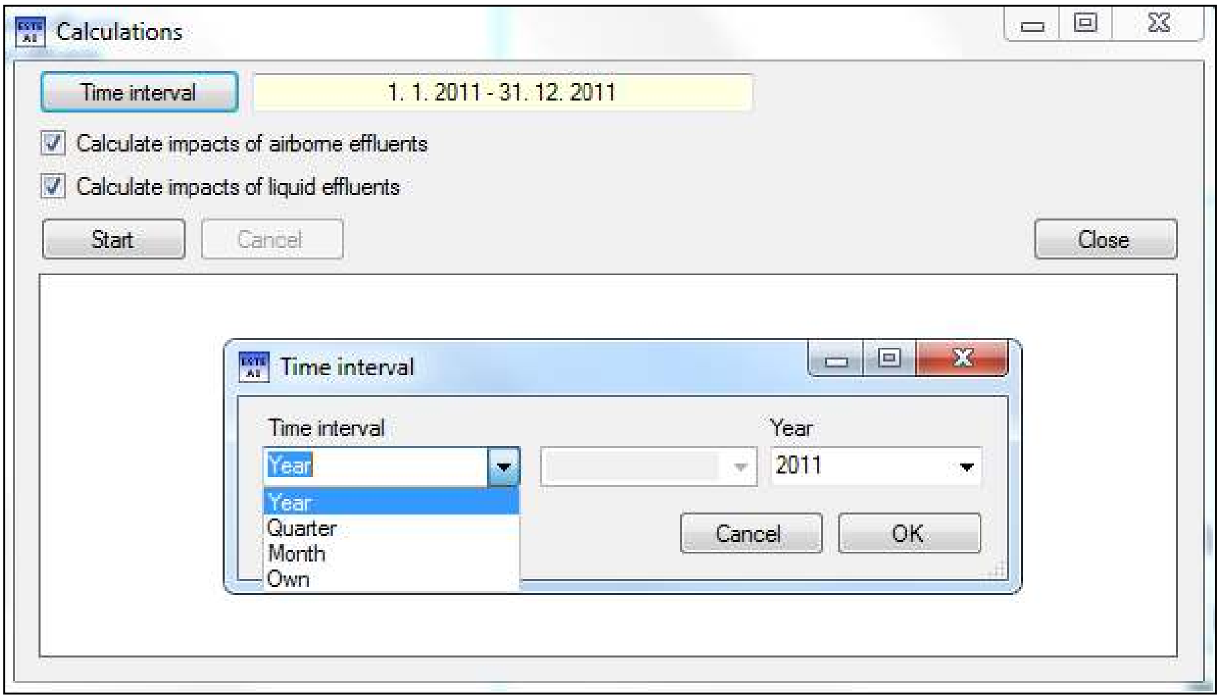
Note: in case of BNPP here will be specific GUI for the BNPP.

4.7 How to start impacts calculation?



The tool „Calculations" from the main menu activates a window, which enables us to select time interval for the calculation of radiological impacts of airborne and/or liquid discharges.

The button „Time interval" opens a window with drop-down menus, where the user can specify the year, quarter, month, or to define his own time interval. The „Start" button initiates the calculation.



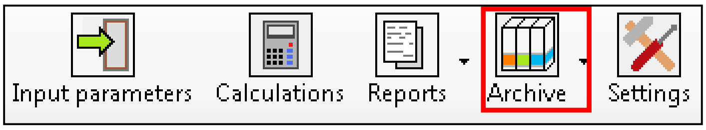
4.8 Recommended method for impacts calculation

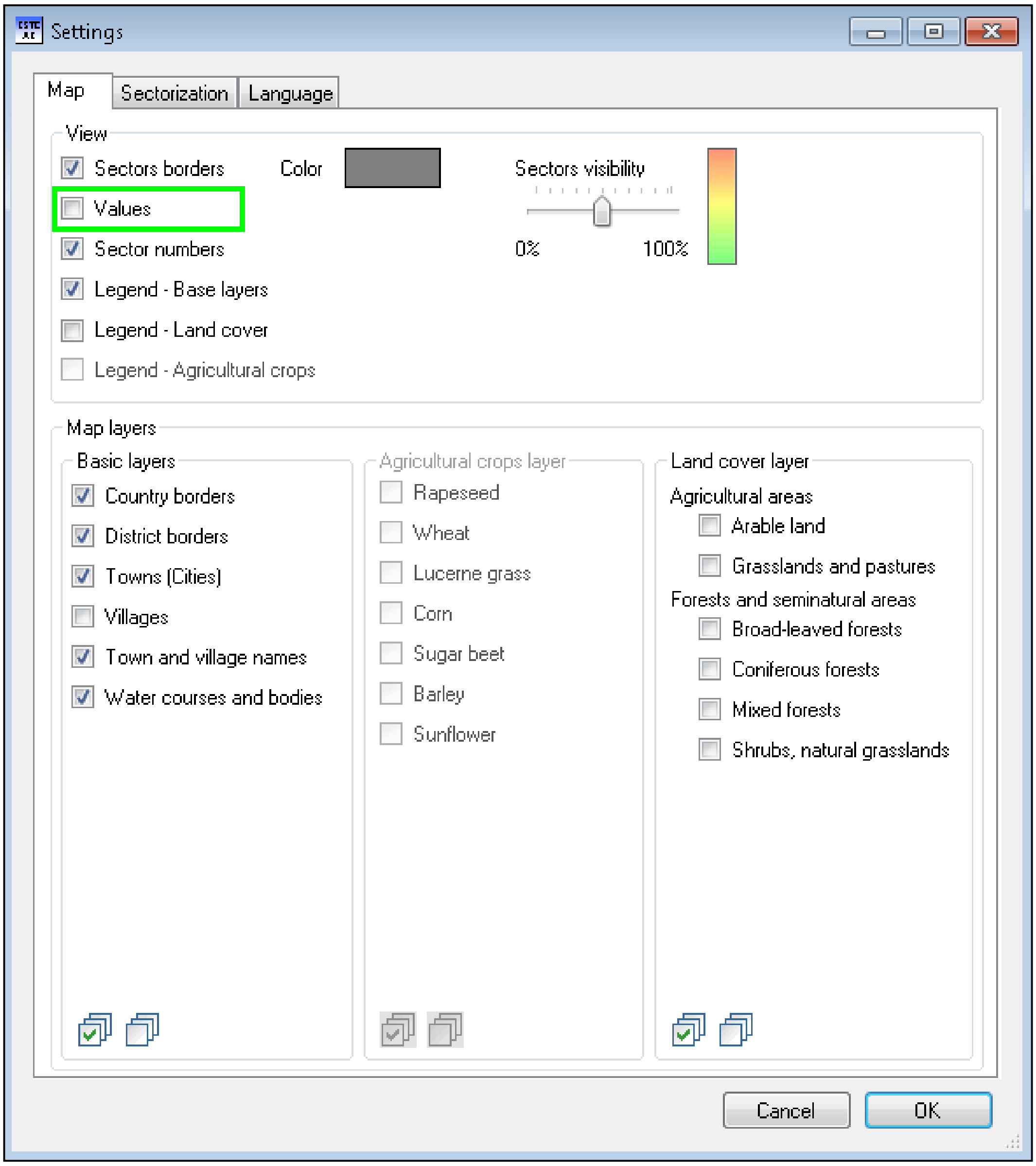
Recommended way of calculation is as follows:

1) Input all the parameters (meteo, discharges, other parameters).
2) Run the calculation and then analyze the results.
3) Archive your results in order to use them later.

4.9 How to display on the map calculated values (numbers) of radiological parameters?

Click on „Settings“ (located in the upper part of the screen, among the main tools) and use the tab „Map“.





Note: in case of BNPP here will be specific GUI for the BNPP.

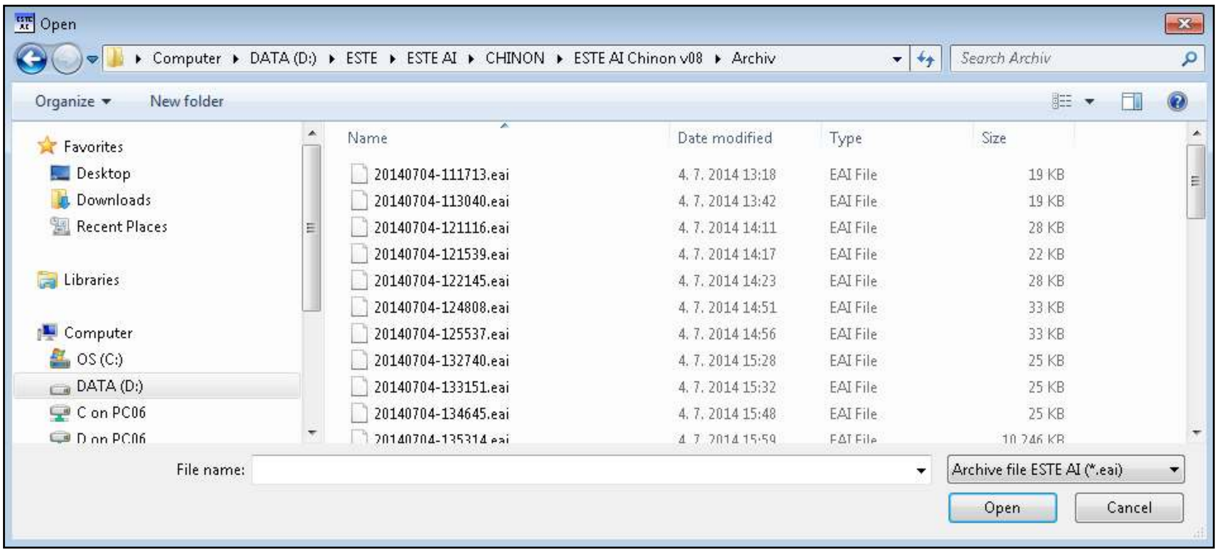
The choice „Values“ enables the user to turn on/off the view of calculated values of radiological parameters on the map of impacts.

4.10 How to archive calculated impacts?

The choice „Archive“ in the main menu serves for results saving („Save archive“) and loading („Load archive“).

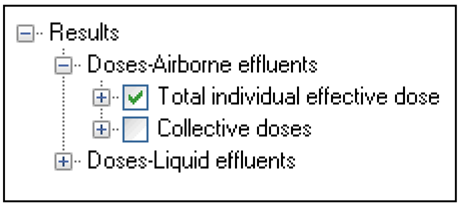
„Save archive“ saves currently calculated results. The results are saved as a file in *.eai format. Then the user can load the file and work with it.

„Load archive“ loads already calculated results (files *.eai – ESTE AI) – due to this choice, the archive file with already calculated impacts is loaded.

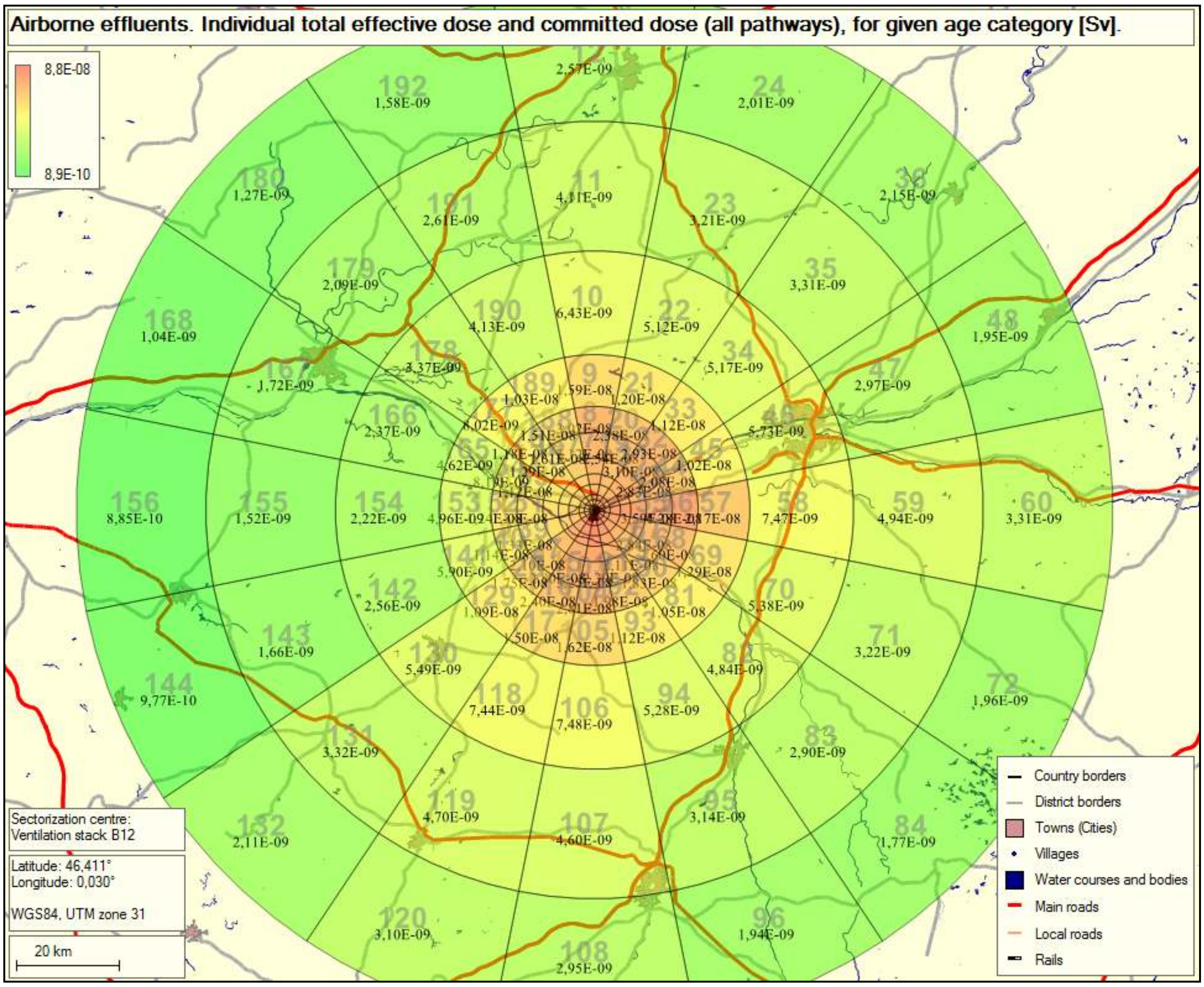


4.11 How to display the map of impacts?

The menu on the left side of the main screen of ESTE AI includes many categories to be rolled out: or rolled up:



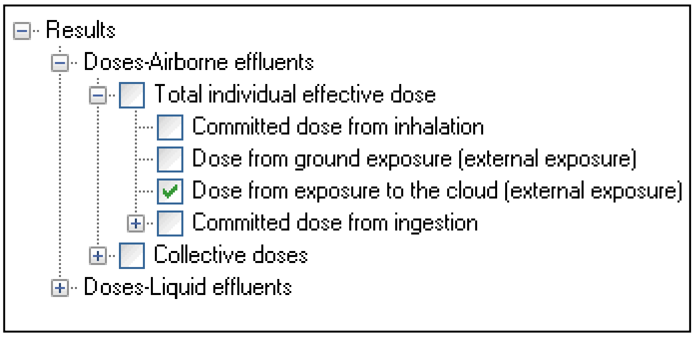
The user can select which map of impacts should be displayed. The selection is done by checking the appropriate box in the menu (in this case „Total individual effective dose").

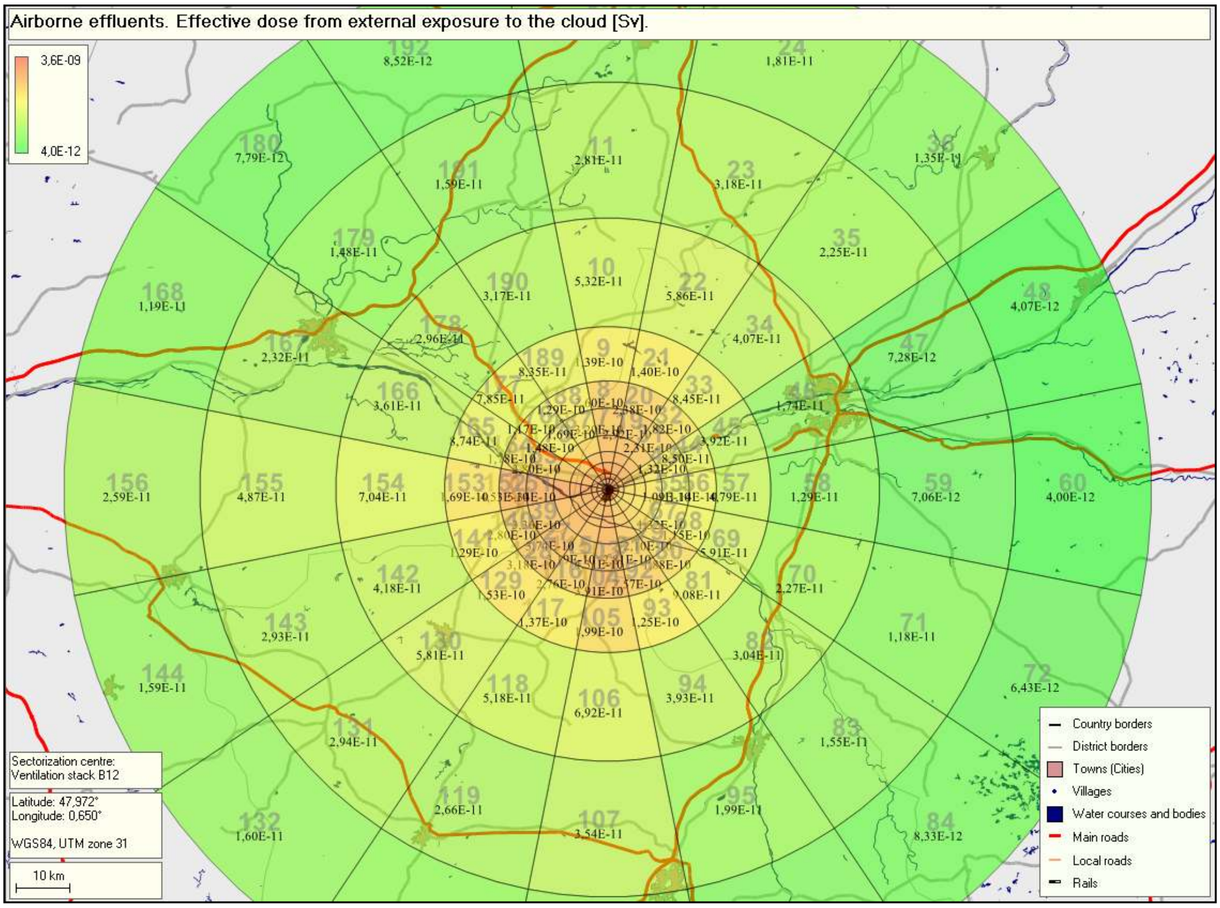


Note: in case of BNPP here will be specific map and GUI for the BNPP.

4.12 External exposure from cloud

The choice „Dose from exposure to the cloud (external exposure)“ displays a map of effective dose from external exposure to the cloud.

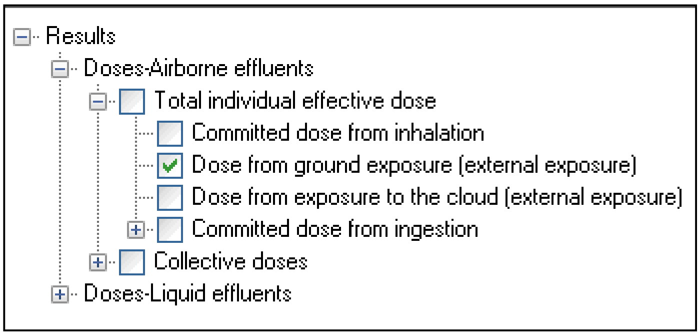


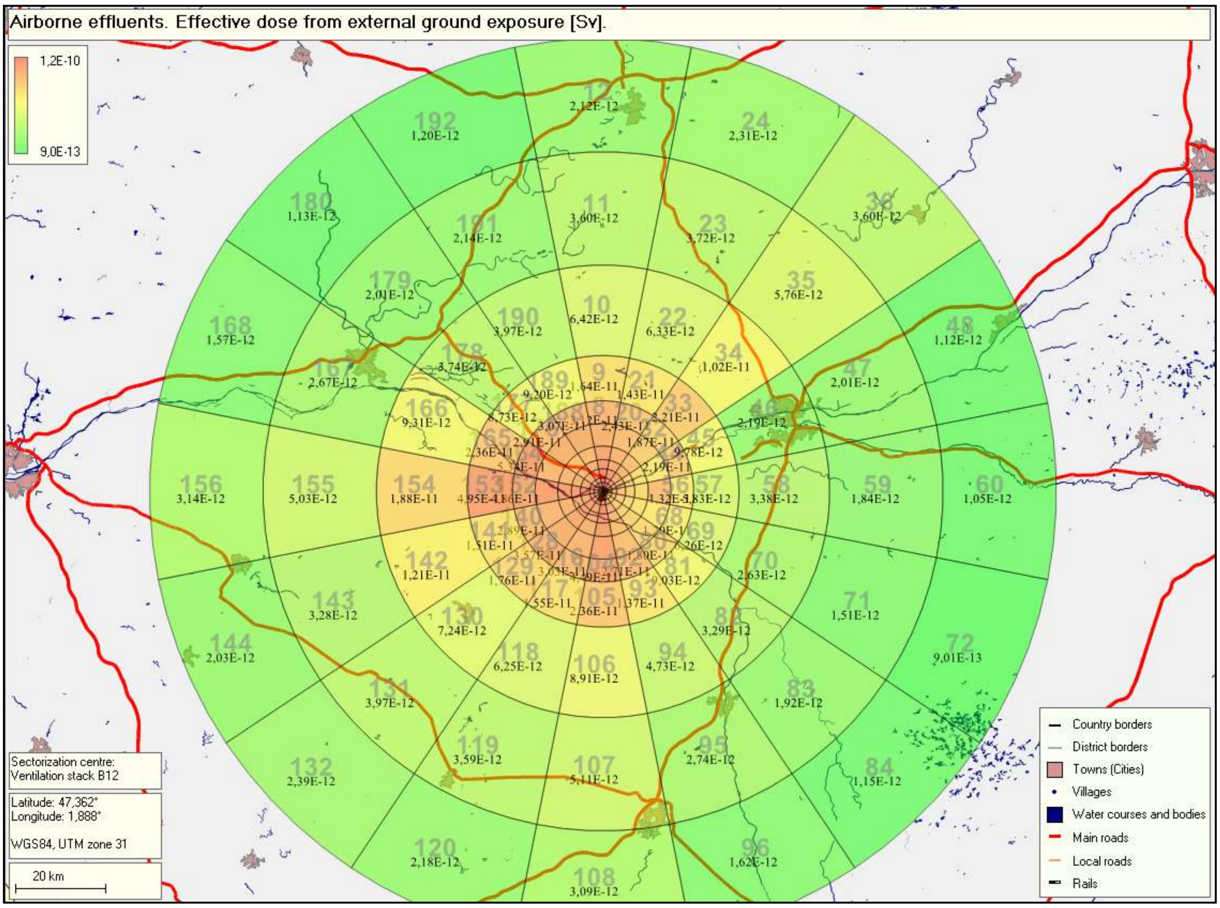


Note: in case of BNPP here will be specific map and GUI for the BNPP.

4.13 External exposure from ground

The choice „Dose from ground exposure (external exposure)“ displays a map of effective dose from external ground exposure.

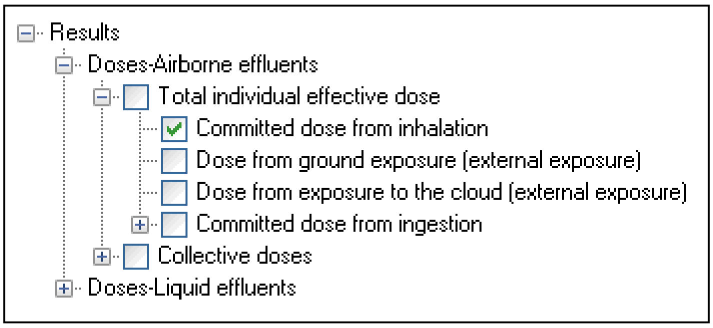


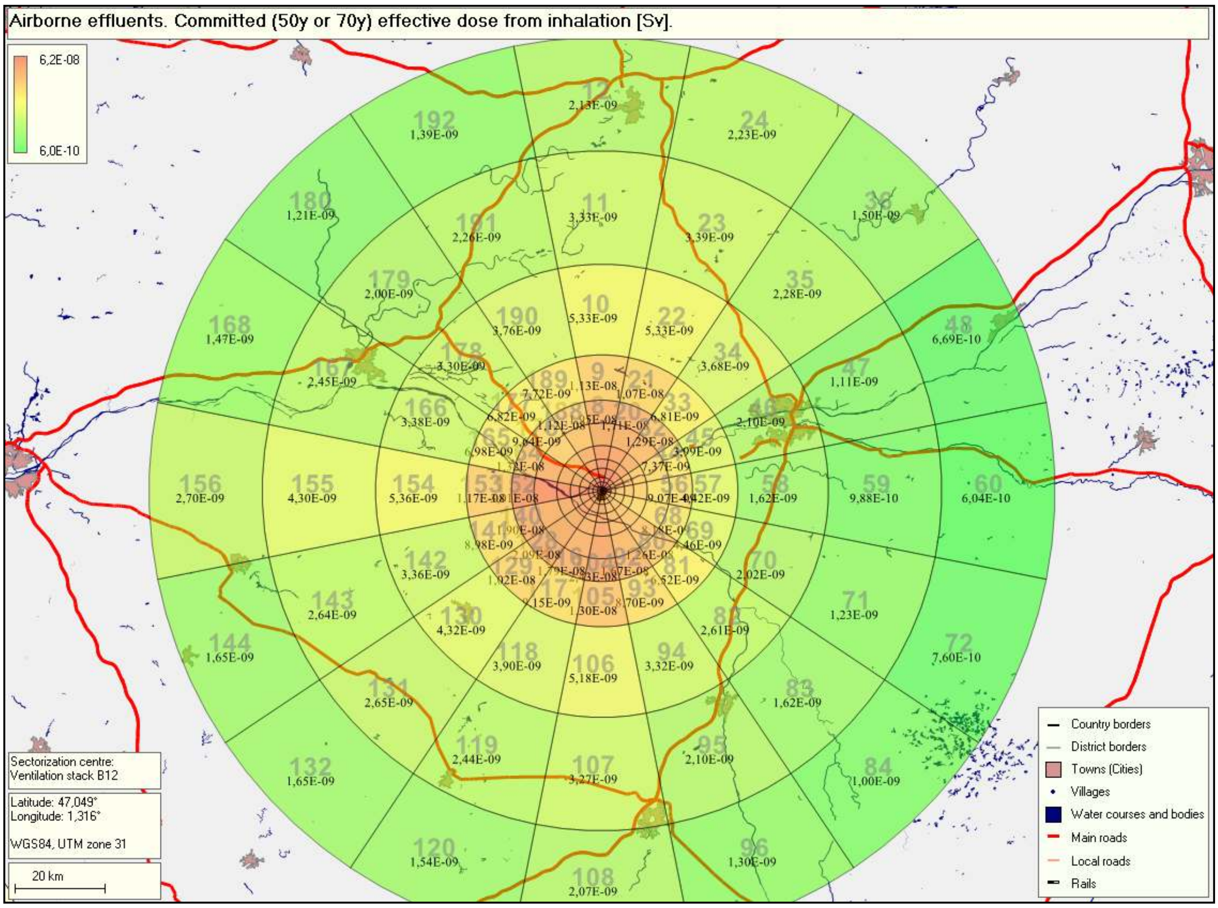


Note: in case of BNPP here will be specific map and GUI for the BNPP.

4.14 Inhalation

The choice „Committed dose from inhalation“ presents a map of committed effective dose from inhalation.

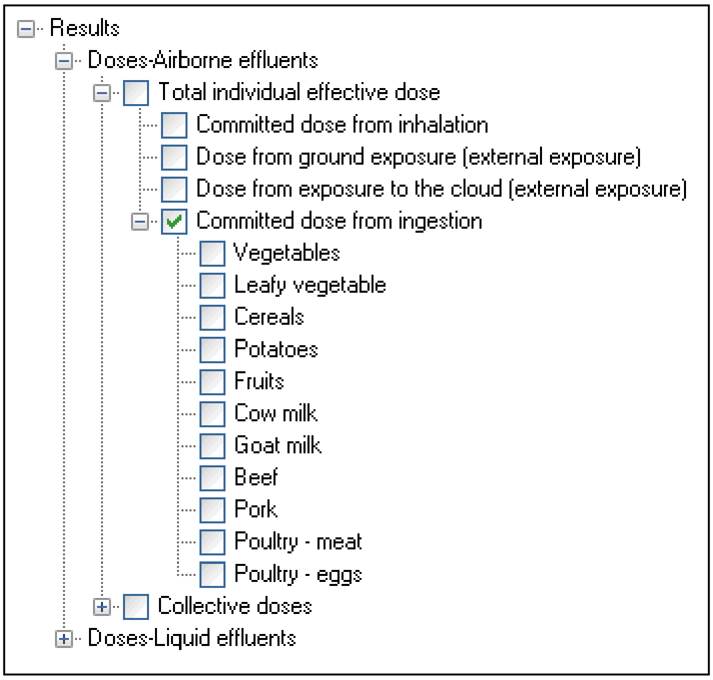


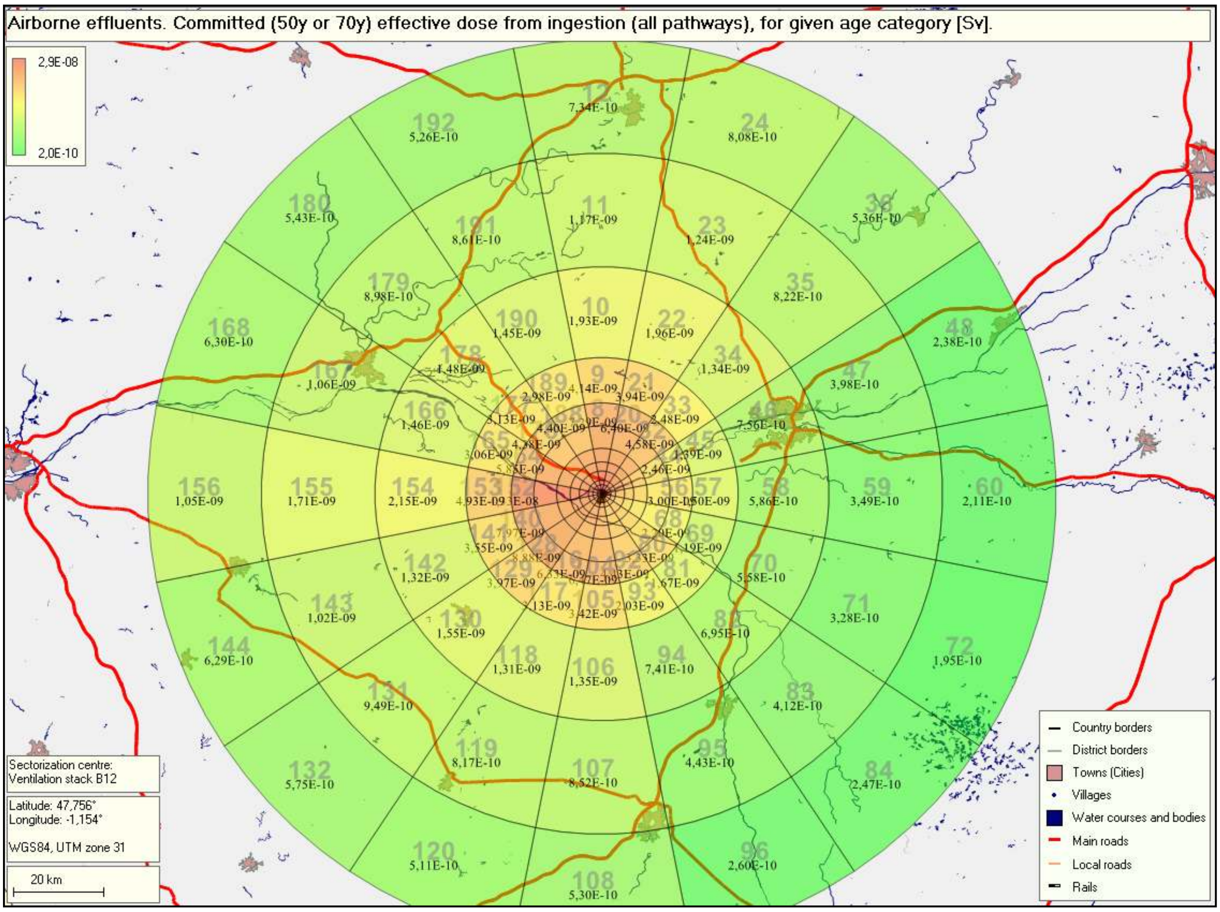


Note: in case of BNPP here will be specific map and GUI for the BNPP.

4.15 Ingestion/atmosphere

The choice „Committed dose from ingestion“ presents a map of committed effective dose from ingestion (all pathways), for the selected age category.

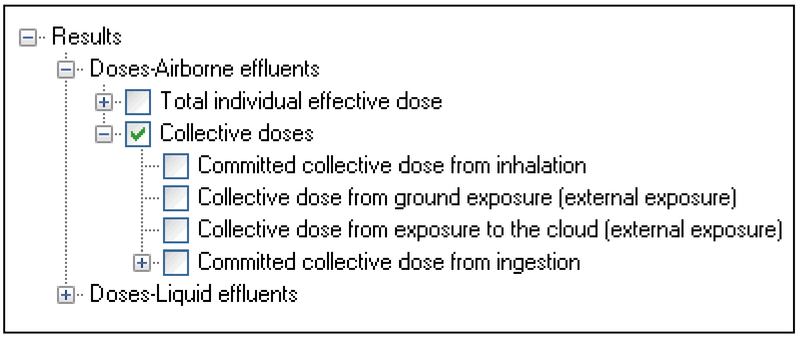


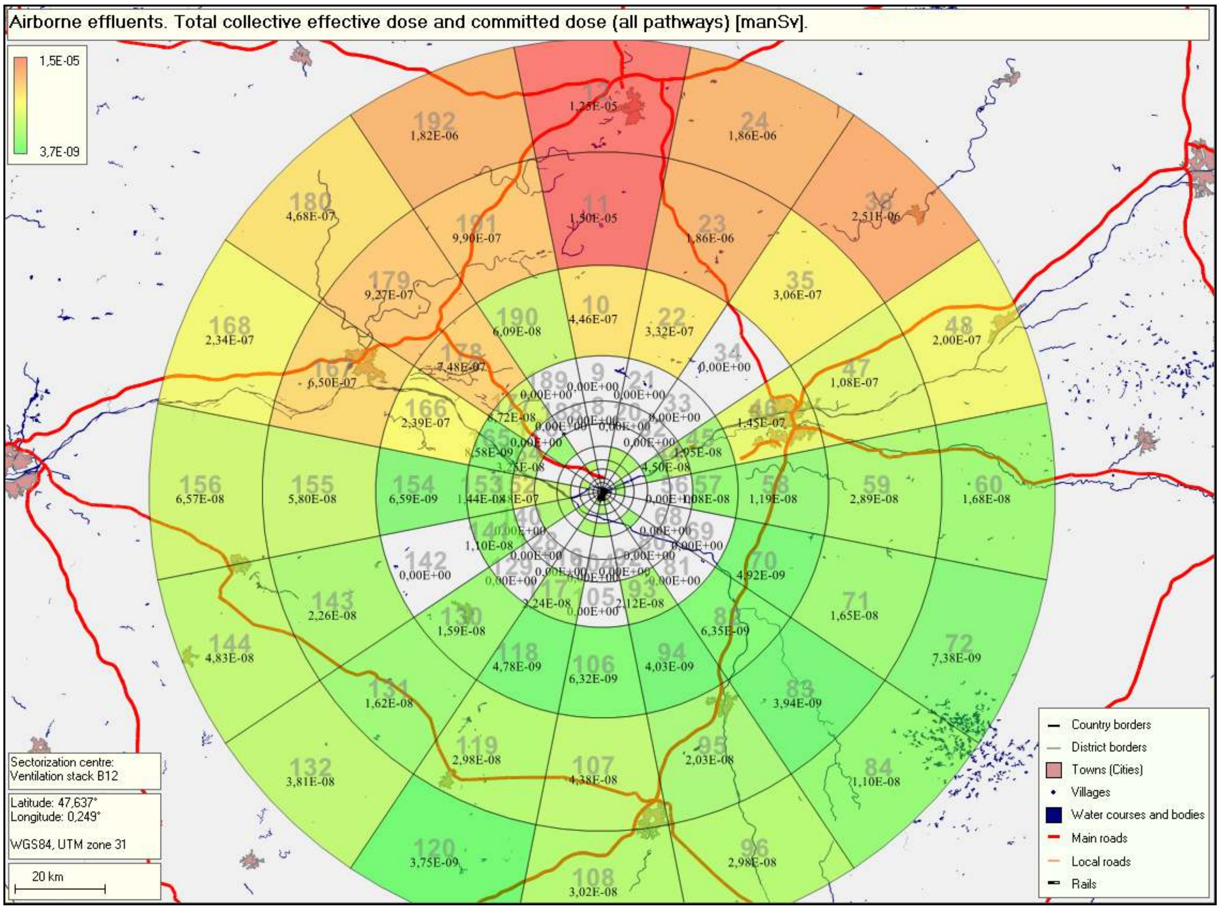


Note: in case of BNPP here will be specific map and GUI for the BNPP.

4.16 Collective doses /atmosphere

The choice „Collective doses“ presents a map of total collective effective dose and committed dose (all pathways).



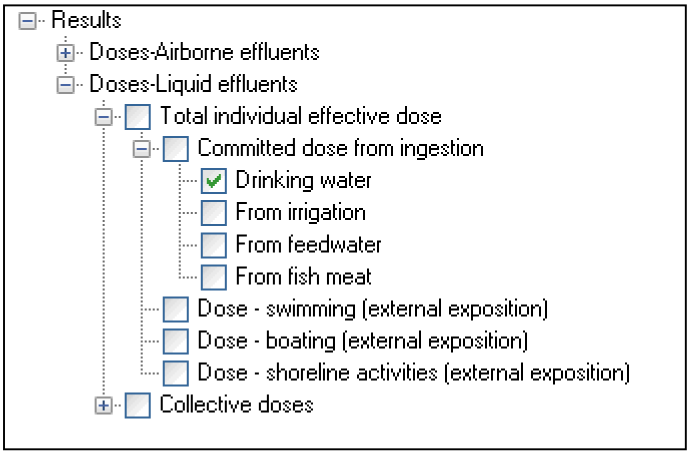


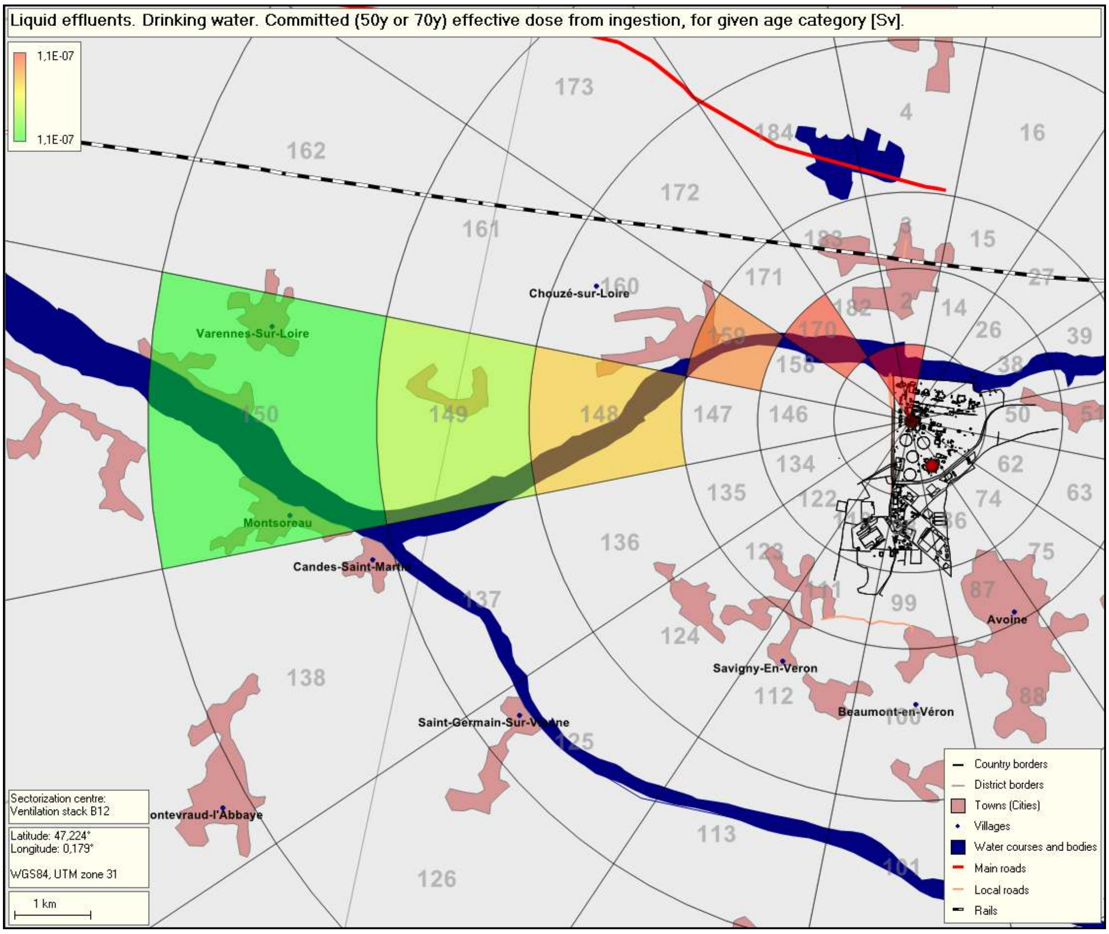
Note: in case of BNPP here will be specific map and GUI for the BNPP.

4.17 Drinking water

Note: in case of BNPP this pathway will be probably not assumed (is not relevant for the BNPP conditions).

The choice „Drinking water“ presents a map of committed effective dose from ingestion (drinking water), for the selected age category.

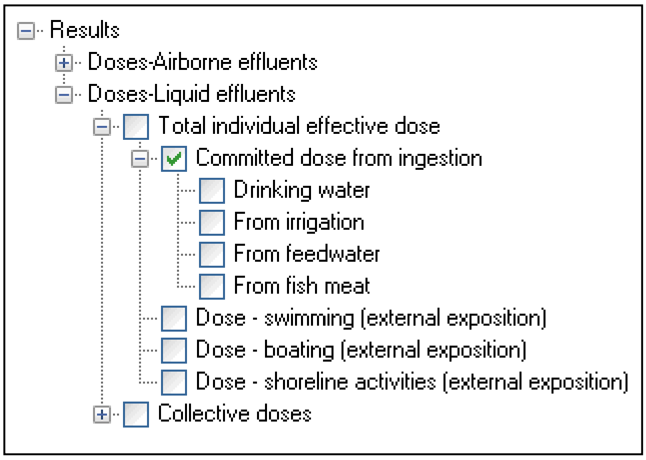


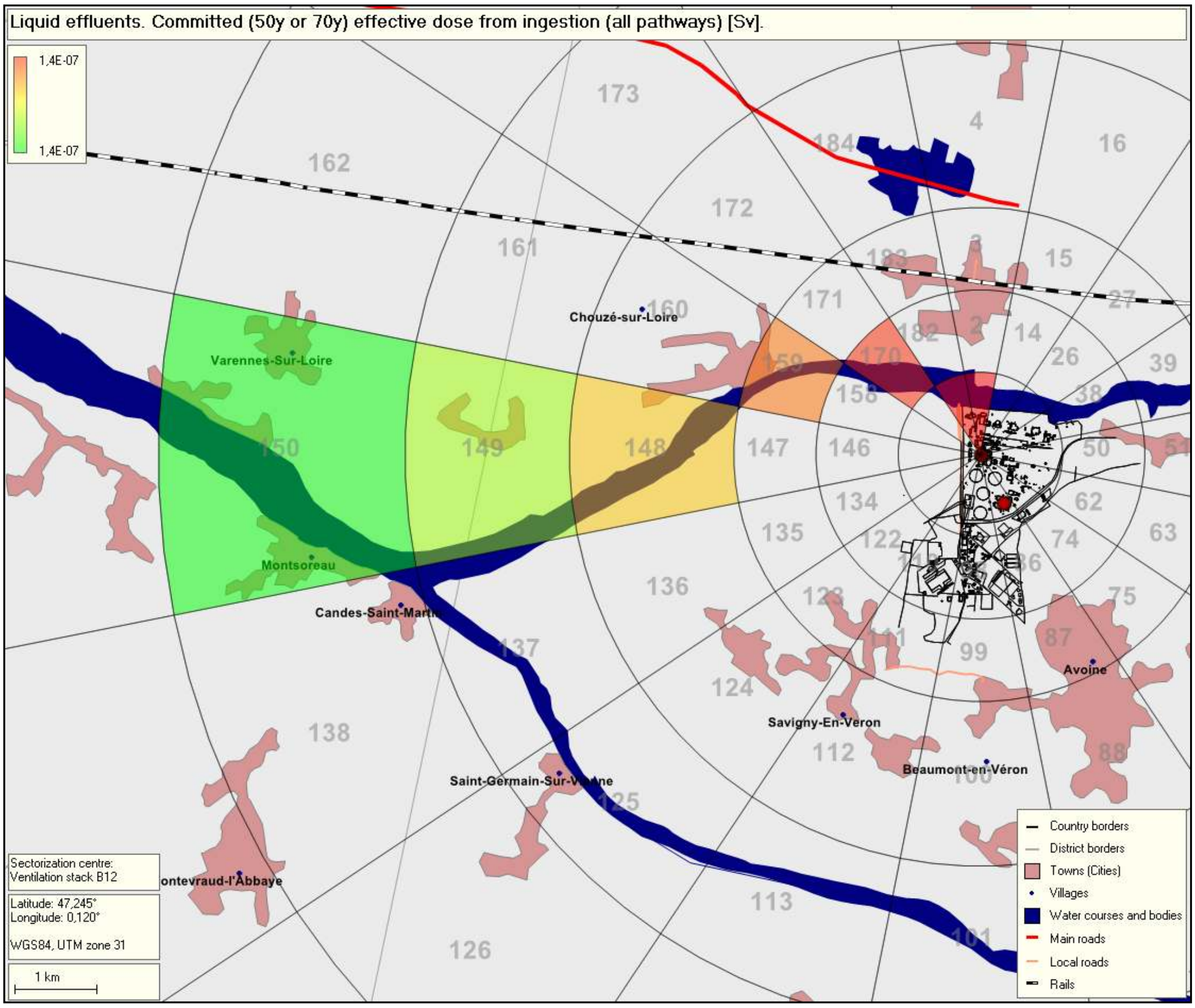


4.18 Ingestion/hydrosphere

Note: in case of BNPP this pathway will be fully accommodated to the BNPP conditions.

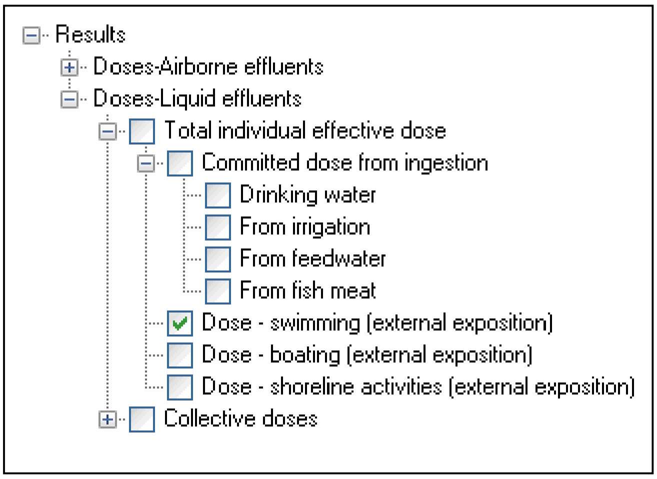
The choice „Committed dose from ingestion“ presents a map of committed effective dose from ingestion (all assumed ingestion pathways), for the selected age category.

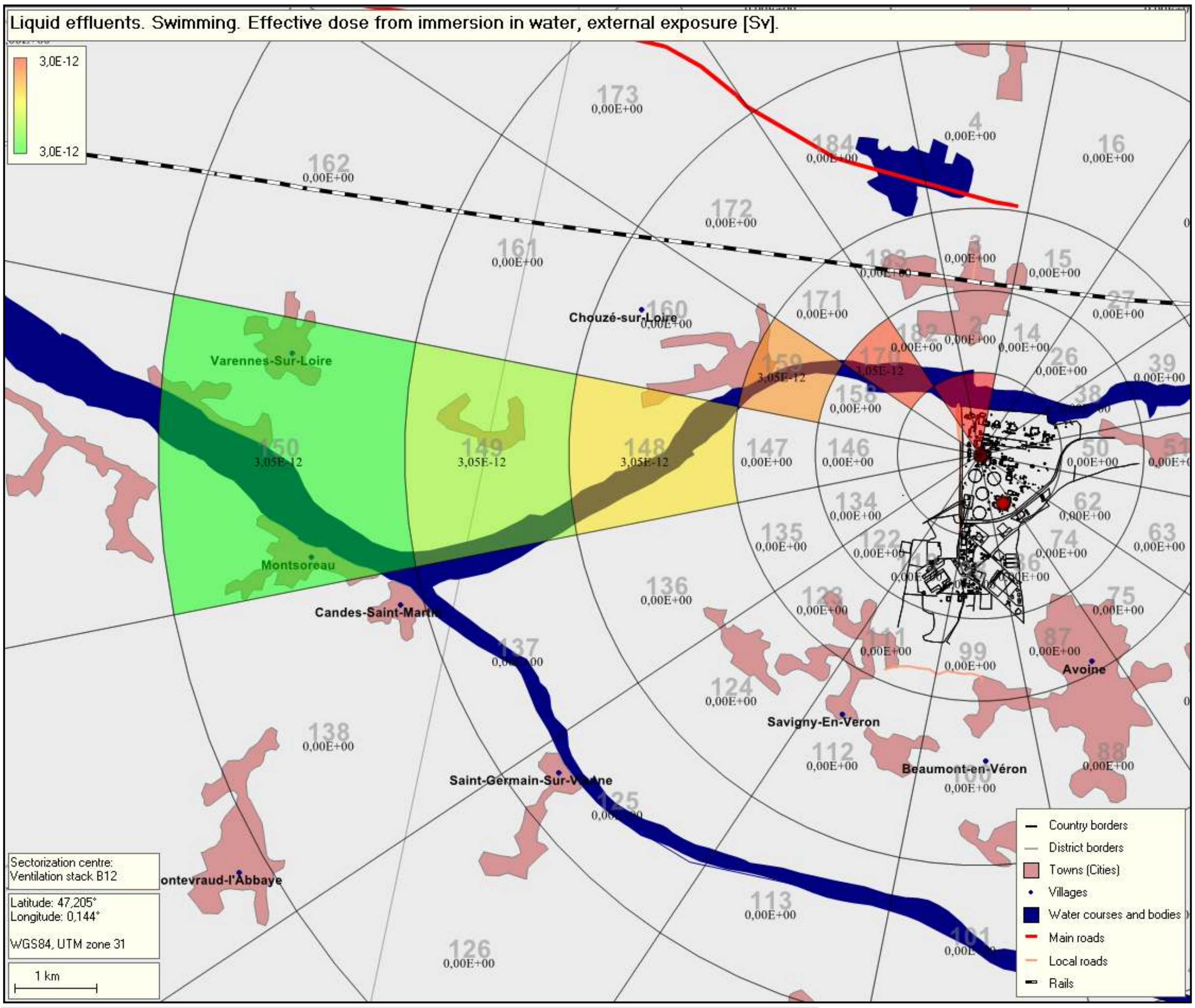




4.19 Shoreline activities, swimming, boating

The choices „Dose – swimming/boating/shoreline activities (external exposition)“ present maps of committed effective dose from immersion in water/from half immersion in water/from external exposure to shoreline, for the selected age category.

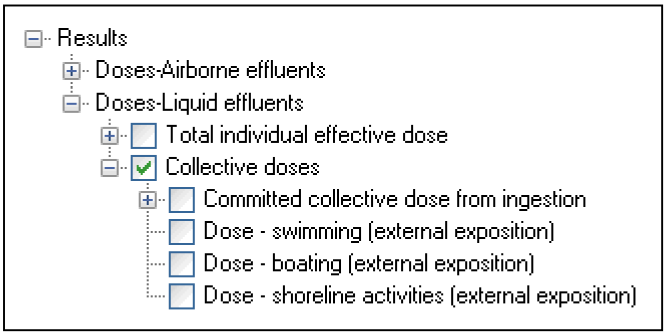


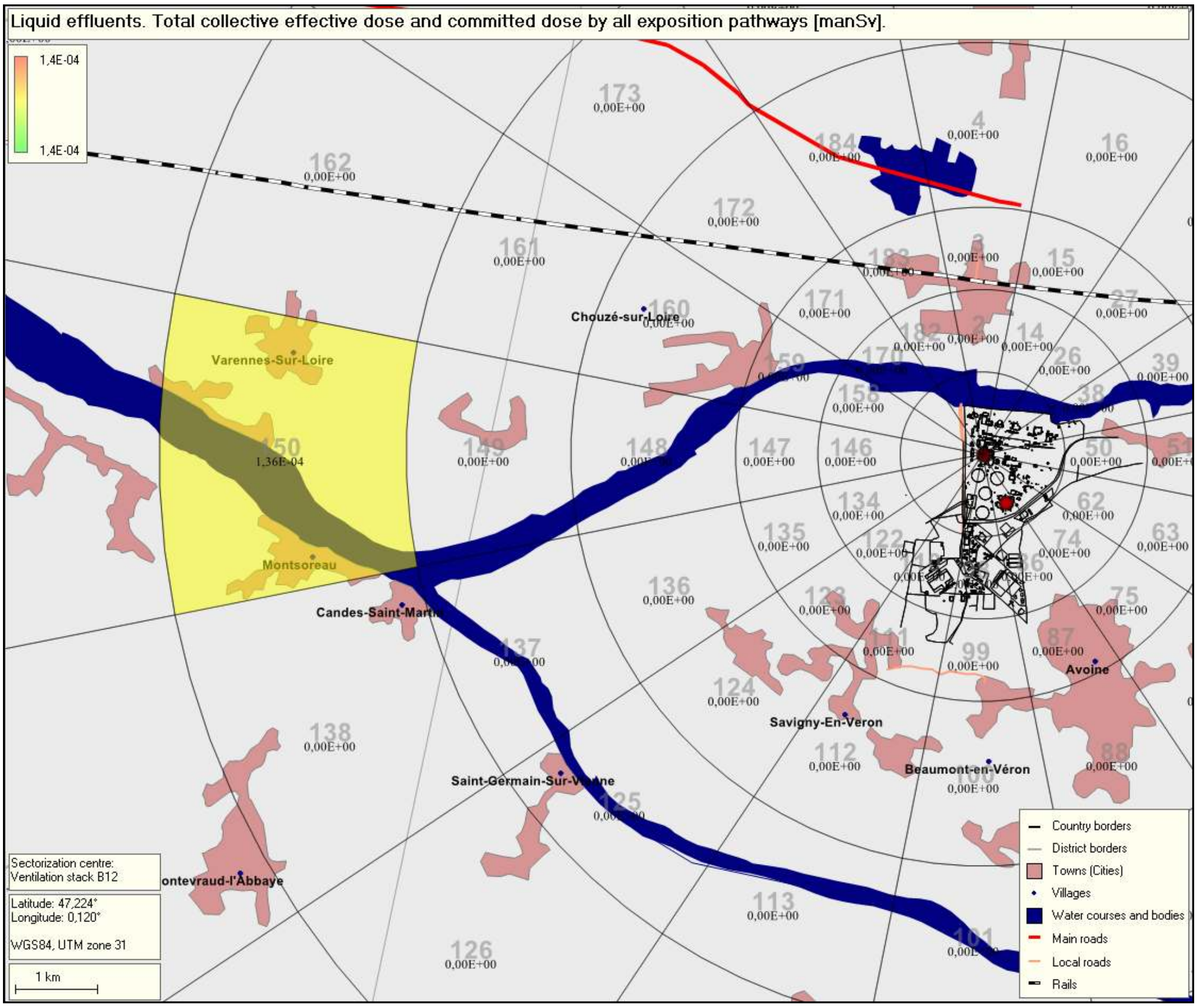


Note: in case of BNPP here will be specific map and GUI for the BNPP.

4.20 Collective doses/hydrosphere

The choice „Collective doses“ (for liquid effluents) presents a map of total collective effective dose and committed dose by all exposition pathways.

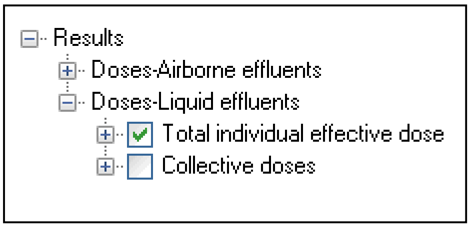


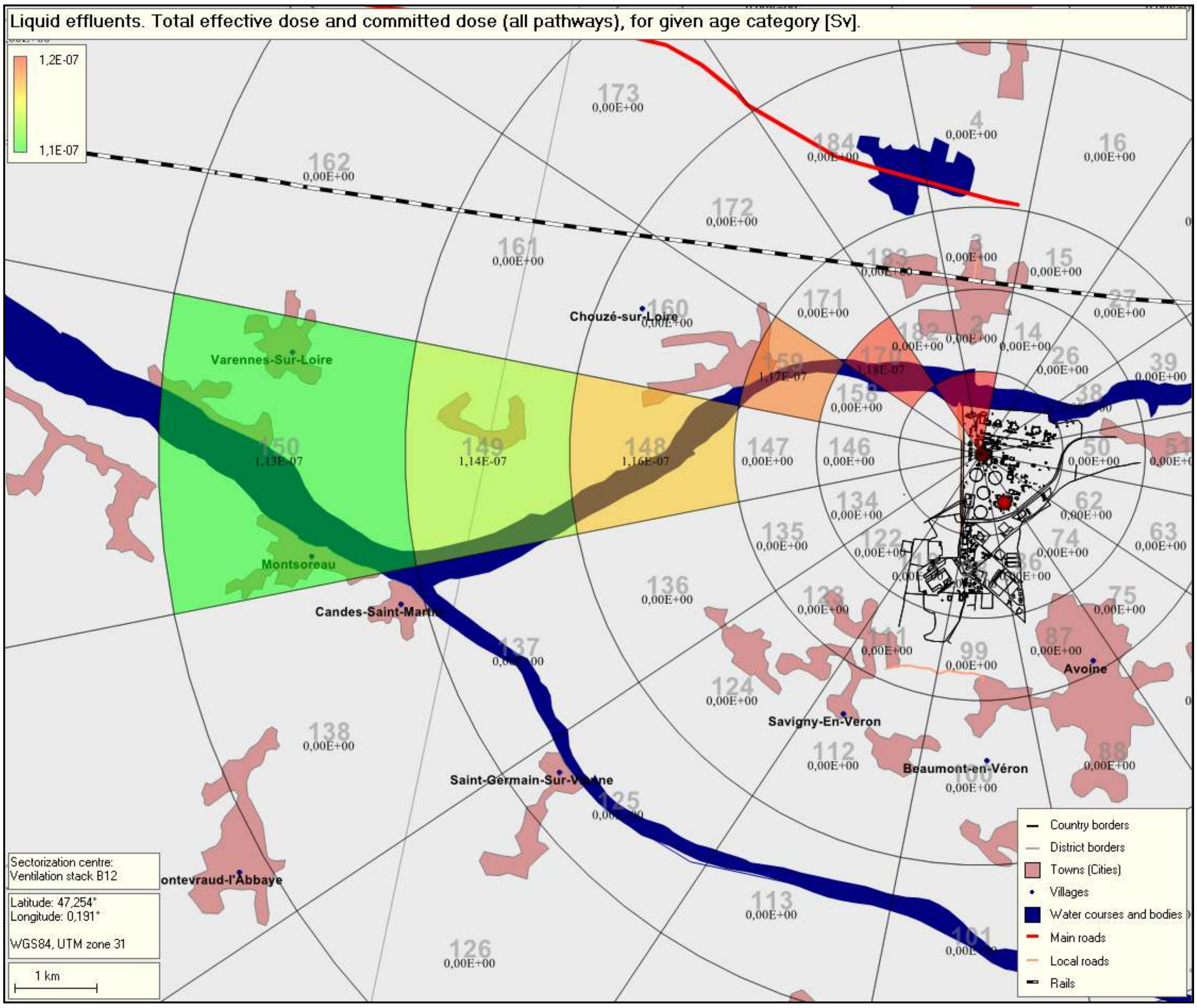


Note: in case of BNPP here will be the GUI (map) specific for BNPP.

4.21 How to display results of total impacts calculated?

The choice „Total individual effective dose“ (for liquid effluents) presents a map of total effective dose and committed dose by all pathways, for the selected age category.

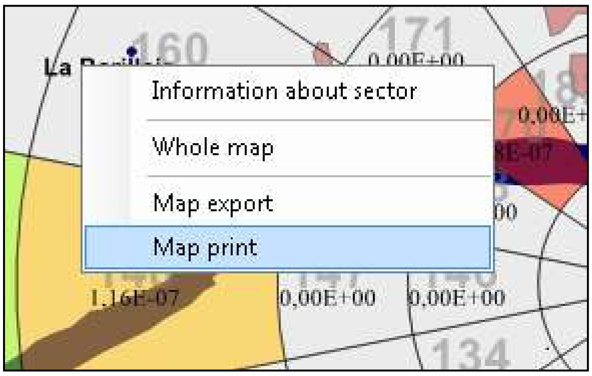




Note: in case of BNPP here will be specific map and GUI for the BNPP.

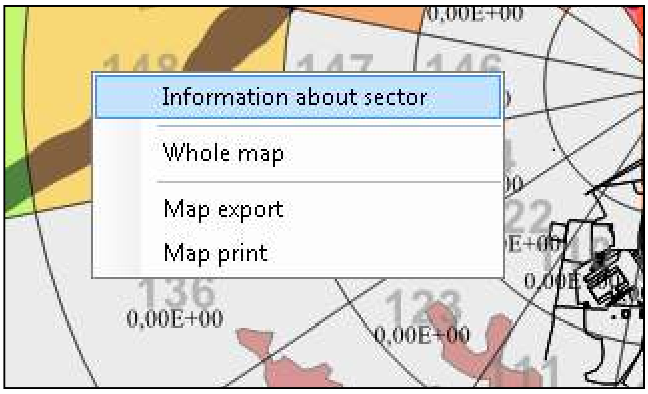
4.22 How to print the current map?

The user can print the currently displayed map by right-clicking on the map and selecting the choice „Map print“.



4.23 How to display analyses of calculated impacts in the chosen sector?

Another possibility to view the analyses is to right-click mouse button on the sector of interest and then select the choice „Information about sector“. The analyses for the sector are displayed in a new window.



4.24 Example (report): a table of calculated impacts analyses in the chosen sector

Information about selected sector

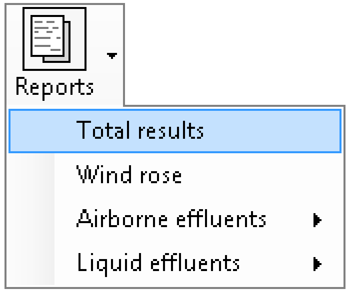
Sector number 150

Analysis over all nuclides | Analysis by nuclides - atmosphere | Analysis by nuclides - hydrosphere

	Age [years]					
	0 - 1	1 - 2	2 - 7	7 - 12	12 - 17	over 17
ATMOSPHERE:	Graph	Graph	Graph	Graph	Graph	Graph
Committed (50yr or 70yr) effective dose from inhalation, the sum over all nuclides [Sv]:	1,10E-08	1,95E-08	2,51E-08	2,49E-08	2,81E-08	2,71E-08
Committed (50yr or 70yr) effective dose from ingestion, the sum over all nuclides [Sv]:	3,98E-09	2,79E-08	1,73E-08	1,39E-08	9,94E-09	1,01E-08
Effective dose from external ground exposure, the sum over all nuclides [Sv]:	1,87E-11	1,87E-11	1,87E-11	1,87E-11	1,87E-11	1,87E-11
Effective dose from external exposure to the cloud, the sum over all nuclides [Sv]:	1,58E-10	1,58E-10	1,58E-10	1,58E-10	1,58E-10	1,58E-10
ATMOSPHERE: Total effective dose by all exposition pathways [Sv]:	1,52E-08	4,75E-08	4,26E-08	3,90E-08	3,82E-08	3,74E-08
	Graph	Graph	Graph	Graph	Graph	Graph
Committed (50yr or 70yr) collective effective dose from inhalation [manSv]:	3,14E-07	1,13E-06	3,75E-06	3,69E-06	4,16E-06	5,05E-05
Committed (50yr or 70yr) collective effective dose from ingestion [manSv]:	1,13E-07	1,62E-06	2,57E-06	2,06E-06	1,47E-06	1,89E-05
Collective effective dose from external ground exposure [manSv]:	2,67E-10	5,44E-10	1,40E-09	1,39E-09	1,39E-09	1,75E-08
Collective effective dose from external exposure to the cloud [manSv]:	4,50E-09	9,19E-09	2,36E-08	2,35E-08	2,34E-08	2,95E-07
Total collective effective dose from all exposition pathways (for given age category) [manSv]:	4,32E-07	2,76E-06	6,34E-06	5,78E-06	5,66E-06	6,96E-05
Total collective effective dose from all exposition pathways (the sum over all categories) [manSv]:						9,06E-05
HYDROSPHERE:						
Committed (50yr or 70yr) effective dose from ingestion, the sum over all nuclides [Sv]:	1,37E-07	2,00E-07	1,72E-07	1,29E-07	9,99E-08	1,13E-07
Drinking water. Committed (50yr or 70yr) effective dose from ingestion, the sum over all nuclides [Sv]:	1,14E-07	8,61E-08	1,00E-07	7,43E-08	5,80E-08	7,06E-08
Irrigation, animal ingestion of drinking water and fish meat. Committed (50yr or 70yr) effective dose from ingestion, the sum over all nuclides [Sv]:	2,34E-08	1,14E-07	7,23E-08	5,51E-08	4,19E-08	4,20E-08
Effective dose from external exposure from immersion in water, swimming [Sv]:	0,00E+00	0,00E+00	3,05E-12	3,05E-12	3,05E-12	3,05E-12
Effective dose from external exposure from half immersion in water, boating [Sv]:	0,00E+00	0,00E+00	2,60E-12	2,60E-12	2,60E-12	2,60E-12
Effective dose from external exposure to shoreline [Sv]:	0,00E+00	0,00E+00	1,56E-10	1,56E-10	1,56E-10	1,56E-10
HYDROSPHERE: Total effective dose from all exposition pathways (for given age category) [Sv]:	1,37E-07	2,00E-07	1,73E-07	1,30E-07	1,00E-07	1,13E-07

Export | Print | Close

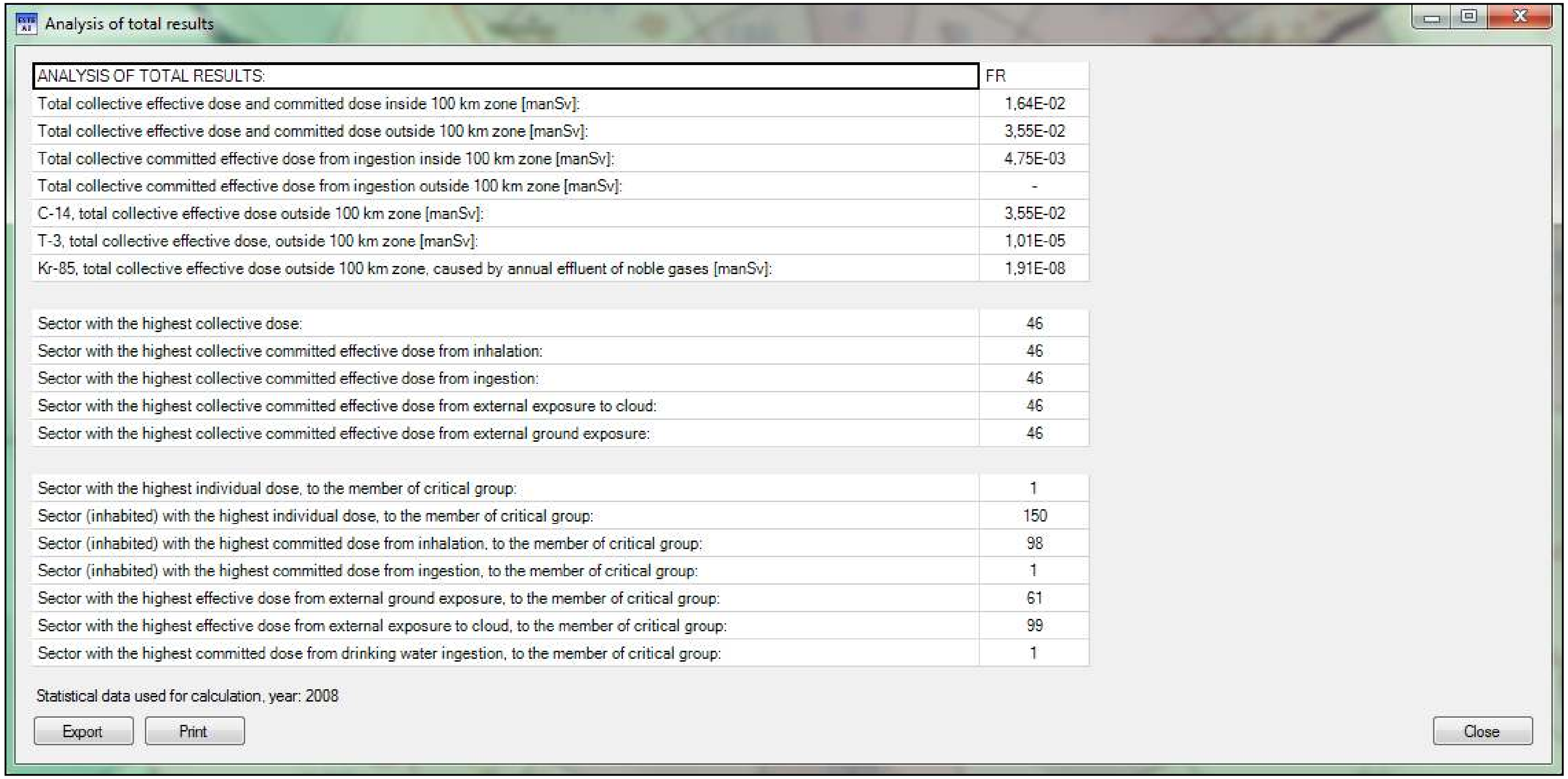
Note: in case of BNPP this report will be fully accommodated to the conditions and pathways relevant to the BNPP.



4.25 How to view a table (report) of total impacts analysis?

The tool „Reports“ enables to view a table with analyses of total results.

4.26 Example: a table of total calculated impacts analyses



Analysis of total results

ANALYSIS OF TOTAL RESULTS:	FR
Total collective effective dose and committed dose inside 100 km zone [manSv]:	1,64E-02
Total collective effective dose and committed dose outside 100 km zone [manSv]:	3,55E-02
Total collective committed effective dose from ingestion inside 100 km zone [manSv]:	4,75E-03
Total collective committed effective dose from ingestion outside 100 km zone [manSv]:	-
C-14, total collective effective dose outside 100 km zone [manSv]:	3,55E-02
T-3, total collective effective dose, outside 100 km zone [manSv]:	1,01E-05
Kr-85, total collective effective dose outside 100 km zone, caused by annual effluent of noble gases [manSv]:	1,91E-08
Sector with the highest collective dose:	46
Sector with the highest collective committed effective dose from inhalation:	46
Sector with the highest collective committed effective dose from ingestion:	46
Sector with the highest collective committed effective dose from external exposure to cloud:	46
Sector with the highest collective committed effective dose from external ground exposure:	46
Sector with the highest individual dose, to the member of critical group:	1
Sector (inhabited) with the highest individual dose, to the member of critical group:	150
Sector (inhabited) with the highest committed dose from inhalation, to the member of critical group:	98
Sector (inhabited) with the highest committed dose from ingestion, to the member of critical group:	1
Sector with the highest effective dose from external ground exposure, to the member of critical group:	61
Sector with the highest effective dose from external exposure to cloud, to the member of critical group:	99
Sector with the highest committed dose from drinking water ingestion, to the member of critical group:	1

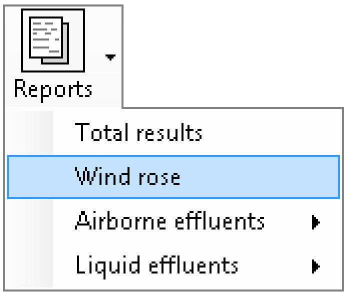
Statistical data used for calculation, year: 2008

Export Print Close

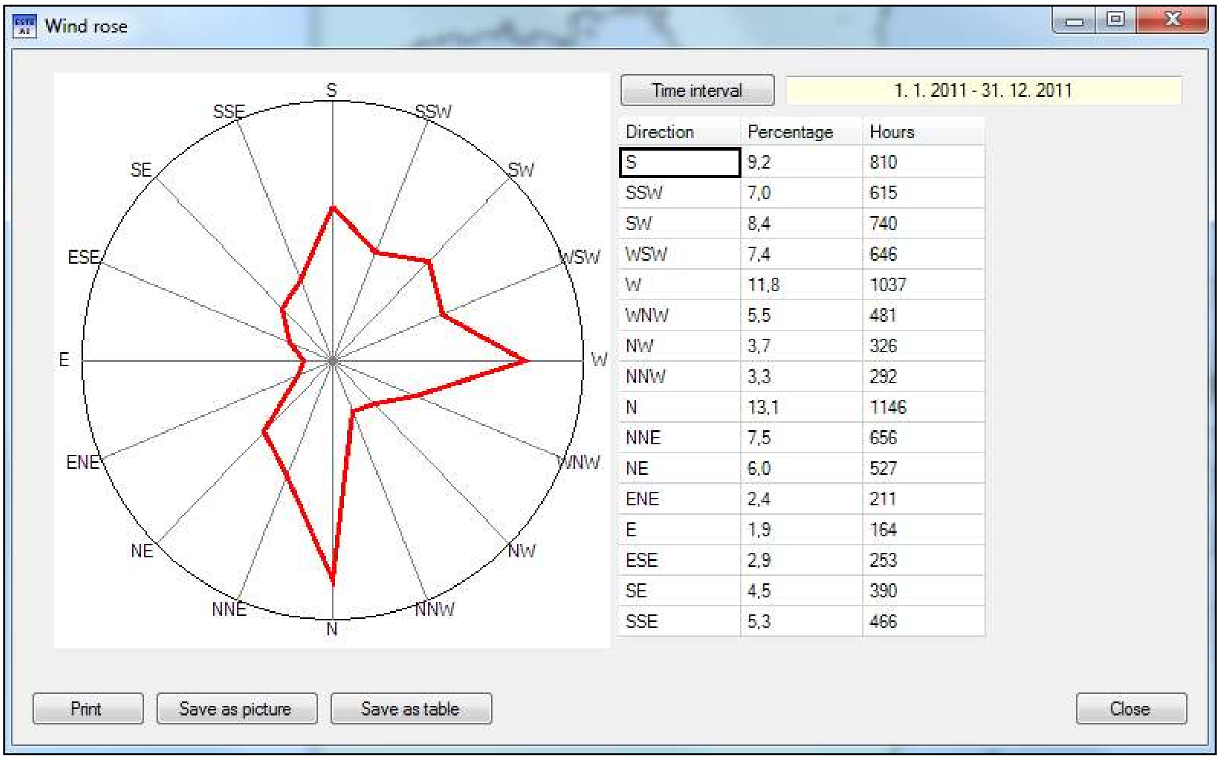
Note: in case of BNPP this report will be fully accommodated to the conditions and pathways relevant to the BNPP.

4.27 How to display the analysis of METEO data?

The table of METEO data analysis is accessible after selecting the choice „Reports“ – „Wind rose“.



The wind rose (similarly as other ESTE AI outputs) can be printed, saved as a picture or saved as a table.



Note: in case of BNPP this output will be accommodated to the conditions of the BNPP.

5. CONSTANTS

Note: in case of BNPP the constants and transfer factors will be updated and accommodated to specific subtropical and arid conditions, on the base of data tabulated and summarized in the IAEA-TECDOC-1616 and other IAEA data sources.

Tab. 1: Decay constant (λ) [s^{-1}]

Nuclide	**λ**
AG110M	3.21E-08
AM241	5.09E-11
AC228	3.14E-05
AR41	1.05E-04
AS76	7.29E-06
BA133	2.05E-09
BA139	1.40E-04
BA140	6.32E-07
BI211	5.42E-03
BI212	1.91E-04
BI214	5.80E-04
BR82	5.46E-06
BR84	3.63E-04
C14inorg	3.84E-12
C14org	3.84E-12
CD109	1.73E-08
CE139	5.81E-08
CE141	2.47E-07
CE144	2.82E-08
CL38	3.11E-04
CO57	2.96E-08
CO58	1.13E-07
CO60	4.17E-09
CR51	2.90E-07
CS134	1.06E-08
CS136	6.12E-07
CS137	7.33E-10
CS138	3.59E-04
CU64	1.52E-05
EU152	1.65E-09
EU154	2.50E-09
FE55	8.14E-09
FE59	1.80E-07
H3	1.79E-09
H3org	1.79E-09
HF181	1.89E-04
HG203	1.72E-07
I124	1.92E-06

Nuclide	**λ**
I133aer	9.26E-06
I133elem	9.26E-06
I134aer	2.20E-04
I134elem	2.20E-04
I135aer	2.91E-05
I135elem	2.91E-05
I130	1.55E-05
K40	1.72E-17
K42	1.55E-05
KR85	2.05E-09
KR85M	4.30E-05
KR87	1.51E-04
KR88	6.78E-05
KR89	3.66E-03
LA140	4.78E-06
MN54	2.57E-08
MN56	7.46E-05
MO90	3.40E-05
MO99	2.92E-06
NA22	8.45E-09
NA24	1.28E-05
NB94	1.08E-12
NB95	2.29E-07
NB95M	2.22E-06
NB96	8.26E-06
NB97	1.60E-04
NI65	7.64E-05
PA231	6.72E-13
PA234	2.87E-05
PA234M	9.87E-03
PB211	3.21E-04
PB212	1.82E-05
PB214	4.31E-04
PU238	2.50E-10
PU239	9.11E-13
RA226	1.37E-11
RB83	9.31E-08
RB88	6.48E-04

Nuclide	**λ**
RU106	2.18E-08
SB122	2.97E-06
SB124	1.33E-07
SB125	7.93E-09
SB126	6.47E-07
SC46	9.57E-08
SE75	6.69E-08
SN113	6.98E-08
SR85	1.24E-07
SR89	1.59E-07
SR90	7.33E-10
SR91	2.03E-05
SR92	7.10E-05
SR93	1.58E-03
TC96	1.87E-06
TC99M	3.20E-05
TE129M	2.39E-07
TE131M	6.42E-06
TE132	2.46E-06
TH227	4.29E-07
TH231	7.57E-06
TH232	1.57E-18
U235	3.12E-17
W187	8.06E-06
XE125	1.15E-05
XE131M	6.78E-07
XE133	1.53E-06
XE133M	3.66E-06
XE135	2.11E-05
XE135M	7.52E-04
XE138	8.18E-04
Y88	7.50E-08
Y91M	2.33E-04
Y92	5.44E-05
Y93	1.91E-05
Y94	6.21E-04
ZN65	3.28E-08
ZN69M	1.40E-05

Nuclide	λ
I126	6.17E-07
I131aer	1.00E-06
I131elem	1.00E-06
I132aer	8.37E-05
I132elem	8.37E-05

Nuclide	λ
RB89	7.61E-04
RH105	5.46E-06
RH106M	8.75E-05
RN219	1.75E-01
RU103	2.04E-07

Nuclide	λ
ZR89	2.45E-06
ZR95	1.25E-07
ZR97	1.14E-05

Tab. 2: Factors of dry deposition for different types of surfaces, m/s, 1 – agricultural, 2 – forest, 3 – urban, 4 – water areas

Nuclide	**Factors for dry deposition**			
	1	2	3	4
AC228	2.00E-03	7.50E-03	5.00E-04	7.00E-04
AG110M	2.00E-03	7.50E-03	5.00E-04	7.00E-04
AM241	2.00E-03	7.50E-03	5.00E-04	7.00E-04
AR41	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AS76	2.00E-03	7.50E-03	5.00E-04	7.00E-04
BA133	2.00E-03	7.50E-03	5.00E-04	7.00E-04
BA139	2.00E-03	7.50E-03	5.00E-04	7.00E-04
BA140	2.00E-03	7.50E-03	5.00E-04	7.00E-04
BI211	2.00E-03	7.50E-03	5.00E-04	7.00E-04
BI212	2.00E-03	7.50E-03	5.00E-04	7.00E-04
BI214	2.00E-03	7.50E-03	5.00E-04	7.00E-04
BR82	2.00E-03	7.50E-03	5.00E-04	7.00E-04
BR84	2.00E-03	7.50E-03	5.00E-04	7.00E-04
C14inorg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C14org	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CD109	2.00E-03	7.50E-03	5.00E-04	7.00E-04
CE139	2.00E-03	7.50E-03	5.00E-04	7.00E-04
CE141	2.00E-03	7.50E-03	5.00E-04	7.00E-04
CE144	2.00E-03	7.50E-03	5.00E-04	7.00E-04
CL38	2.00E-03	7.50E-03	5.00E-04	7.00E-04
CO57	2.00E-03	7.50E-03	5.00E-04	7.00E-04
CO58	2.00E-03	7.50E-03	5.00E-04	7.00E-04
CO60	2.00E-03	7.50E-03	5.00E-04	7.00E-04
CR51	2.00E-03	7.50E-03	5.00E-04	7.00E-04
CS134	2.00E-03	7.50E-03	5.00E-04	7.00E-04
CS136	2.00E-03	7.50E-03	5.00E-04	7.00E-04
CS137	2.00E-03	7.50E-03	5.00E-04	7.00E-04
CS138	2.00E-03	7.50E-03	5.00E-04	7.00E-04
CU64	2.00E-03	7.50E-03	5.00E-04	7.00E-04
EU152	2.00E-03	7.50E-03	5.00E-04	7.00E-04
EU154	2.00E-03	7.50E-03	5.00E-04	7.00E-04
FE55	2.00E-03	7.50E-03	5.00E-04	7.00E-04
FE59	2.00E-03	7.50E-03	5.00E-04	7.00E-04
H3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
H3org	0.00E+00	0.00E+00	0.00E+00	0.00E+00
HF181	2.00E-03	7.50E-03	5.00E-04	7.00E-04
HG203	2.00E-03	7.50E-03	5.00E-04	7.00E-04
I124	2.00E-03	7.50E-03	5.00E-04	7.00E-04
I126	2.00E-03	7.50E-03	5.00E-04	7.00E-04
I130	2.00E-03	7.50E-03	5.00E-04	7.00E-04
I131aer	2.00E-03	7.50E-03	5.00E-04	7.00E-04
I131elem	2.00E-02	7.30E-02	5.00E-03	1.00E-03
I132aer	2.00E-03	7.50E-03	5.00E-04	7.00E-04
I132elem	2.00E-02	7.30E-02	5.00E-03	1.00E-03
I133aer	2.00E-03	7.50E-03	5.00E-04	7.00E-04

Nuclide	Factors for dry deposition			
	1	2	3	4
I133elem	2.00E-02	7.30E-02	5.00E-03	1.00E-03
I134aer	2.00E-03	7.50E-03	5.00E-04	7.00E-04
I134elem	2.00E-02	7.30E-02	5.00E-03	1.00E-03
I135aer	2.00E-03	7.50E-03	5.00E-04	7.00E-04
I135elem	2.00E-02	7.30E-02	5.00E-03	1.00E-03
K40	2.00E-03	7.50E-03	5.00E-04	7.00E-04
K42	2.00E-03	7.50E-03	5.00E-04	7.00E-04
KR85	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR85M	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR87	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR88	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR89	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LA140	2.00E-03	7.50E-03	5.00E-04	7.00E-04
MN54	2.00E-03	7.50E-03	5.00E-04	7.00E-04
MN56	2.00E-03	7.50E-03	5.00E-04	7.00E-04
MO90	2.00E-03	7.50E-03	5.00E-04	7.00E-04
MO99	2.00E-03	7.50E-03	5.00E-04	7.00E-04
NA22	2.00E-03	7.50E-03	5.00E-04	7.00E-04
NA24	2.00E-03	7.50E-03	5.00E-04	7.00E-04
NB94	2.00E-03	7.50E-03	5.00E-04	7.00E-04
NB95	2.00E-03	7.50E-03	5.00E-04	7.00E-04
NB95M	2.00E-03	7.50E-03	5.00E-04	7.00E-04
NB96	2.00E-03	7.50E-03	5.00E-04	7.00E-04
NB97	2.00E-03	7.50E-03	5.00E-04	7.00E-04
NI65	2.00E-03	7.50E-03	5.00E-04	7.00E-04
PA231	2.00E-03	7.50E-03	5.00E-04	7.00E-04
PA234	2.00E-03	7.50E-03	5.00E-04	7.00E-04
PA234M	2.00E-03	7.50E-03	5.00E-04	7.00E-04
PB211	2.00E-03	7.50E-03	5.00E-04	7.00E-04
PB212	2.00E-03	7.50E-03	5.00E-04	7.00E-04
PB214	2.00E-03	7.50E-03	5.00E-04	7.00E-04
PU238	2.00E-03	7.50E-03	5.00E-04	7.00E-04
PU239	2.00E-03	7.50E-03	5.00E-04	7.00E-04
RA226	2.00E-03	7.50E-03	5.00E-04	7.00E-04
RB83	2.00E-03	7.50E-03	5.00E-04	7.00E-04
RB88	2.00E-03	7.50E-03	5.00E-04	7.00E-04
RB89	2.00E-03	7.50E-03	5.00E-04	7.00E-04
RH105	2.00E-03	7.50E-03	5.00E-04	7.00E-04
RH106M	2.00E-03	7.50E-03	5.00E-04	7.00E-04
RN219	2.00E-03	7.50E-03	5.00E-04	7.00E-04
RU103	2.00E-03	7.50E-03	5.00E-04	7.00E-04
RU106	2.00E-03	7.50E-03	5.00E-04	7.00E-04
SB122	2.00E-03	7.50E-03	5.00E-04	7.00E-04
SB124	2.00E-03	7.50E-03	5.00E-04	7.00E-04
SB125	2.00E-03	7.50E-03	5.00E-04	7.00E-04
SB126	2.00E-03	7.50E-03	5.00E-04	7.00E-04
SC46	2.00E-03	7.50E-03	5.00E-04	7.00E-04
SE75	2.00E-03	7.50E-03	5.00E-04	7.00E-04

Nuclide	Factors for dry deposition			
	1	2	3	4
SN113	2.00E-03	7.50E-03	5.00E-04	7.00E-04
SR85	2.00E-03	7.50E-03	5.00E-04	7.00E-04
SR89	2.00E-03	7.50E-03	5.00E-04	7.00E-04
SR90	2.00E-03	7.50E-03	5.00E-04	7.00E-04
SR91	2.00E-03	7.50E-03	5.00E-04	7.00E-04
SR92	2.00E-03	7.50E-03	5.00E-04	7.00E-04
SR93	2.00E-03	7.50E-03	5.00E-04	7.00E-04
TC96	2.00E-03	7.50E-03	5.00E-04	7.00E-04
TC99M	2.00E-03	7.50E-03	5.00E-04	7.00E-04
TE129M	2.00E-03	7.50E-03	5.00E-04	7.00E-04
TE131M	2.00E-03	7.50E-03	5.00E-04	7.00E-04
TE132	2.00E-03	7.50E-03	5.00E-04	7.00E-04
TH227	2.00E-03	7.50E-03	5.00E-04	7.00E-04
TH231	2.00E-03	7.50E-03	5.00E-04	7.00E-04
TH232	2.00E-03	7.50E-03	5.00E-04	7.00E-04
U235	2.00E-03	7.50E-03	5.00E-04	7.00E-04
W187	2.00E-03	7.50E-03	5.00E-04	7.00E-04
XE125	2.00E-03	7.50E-03	5.00E-04	7.00E-04
XE131M	2.00E-03	7.50E-03	5.00E-04	7.00E-04
XE133	2.00E-03	7.50E-03	5.00E-04	7.00E-04
XE133M	2.00E-03	7.50E-03	5.00E-04	7.00E-04
XE135	2.00E-03	7.50E-03	5.00E-04	7.00E-04
XE135M	2.00E-03	7.50E-03	5.00E-04	7.00E-04
XE138	2.00E-03	7.50E-03	5.00E-04	7.00E-04
Y88	2.00E-03	7.50E-03	5.00E-04	7.00E-04
Y91M	2.00E-03	7.50E-03	5.00E-04	7.00E-04
Y92	2.00E-03	7.50E-03	5.00E-04	7.00E-04
Y93	2.00E-03	7.50E-03	5.00E-04	7.00E-04
Y94	2.00E-03	7.50E-03	5.00E-04	7.00E-04
ZN65	2.00E-03	7.50E-03	5.00E-04	7.00E-04
ZN69M	2.00E-03	7.50E-03	5.00E-04	7.00E-04
ZR89	2.00E-03	7.50E-03	5.00E-04	7.00E-04
ZR95	2.00E-03	7.50E-03	5.00E-04	7.00E-04
ZR97	2.00E-03	7.50E-03	5.00E-04	7.00E-04

Note: in case of BNPP the constants and transfer factors will be updated and accommodated to specific subtropical and arid conditions, on the base of data tabulated and summarized in the IAEA-TECDOC-1616 and other IAEA data sources.

Tab. 3: Factors for washout (wet deposition)

Nuclide	Washout factor
AC228	2.60E-05
AG110M	2.60E-05
AM241	2.60E-05
AR41	0.00E+00
AS76	2.60E-05
BA133	2.60E-05
BA139	2.60E-05
BA140	2.60E-05
BI211	2.60E-05
BI212	2.60E-05
BI214	2.60E-05
BR82	2.60E-05
BR84	2.60E-05
C14inorg	0.00E+00
C14org	0.00E+00
CD109	2.60E-05
CE139	2.60E-05
CE141	2.60E-05
CE144	2.60E-05
CL38	2.60E-05
CO57	2.60E-05
CO58	2.60E-05
CO60	2.60E-05
CR51	2.60E-05
CS134	2.60E-05
CS136	2.60E-05
CS137	2.60E-05
CS138	2.60E-05
CU64	2.60E-05
EU152	2.60E-05
EU154	2.60E-05
FE55	2.60E-05
FE59	2.60E-05
H3	0.00E+00

Nuclide	Washout factor
H3org	0.00E+00
HF181	2.60E-05
HG203	2.60E-05
I124	2.60E-05
I126	2.60E-05
I130	2.60E-05
I131aer	2.60E-05
I131elem	1.30E-04
I132aer	2.60E-05
I132elem	1.30E-04
I133aer	2.60E-05
I133elem	1.30E-04
I134aer	2.60E-05
I134elem	1.30E-04
I135aer	2.60E-05
I135elem	1.30E-04
K40	2.60E-05
K42	2.60E-05
KR85	0.00E+00
KR85M	0.00E+00
KR87	0.00E+00
KR88	0.00E+00
KR89	0.00E+00
LA140	2.60E-05
MN54	2.60E-05
MN56	2.60E-05
MO90	2.60E-05
MO99	2.60E-05
NA22	2.60E-05
NA24	2.60E-05
NB94	2.60E-05

Nuclide	Washout factor
NB95	2.60E-05
NB95M	2.60E-05
NB96	2.60E-05
NB97	2.60E-05
NI65	2.60E-05
PA231	2.60E-05
PA234	2.60E-05
PA234M	2.60E-05
PB211	2.60E-05
PB212	2.60E-05
PB214	2.60E-05
PU238	2.60E-05
PU239	2.60E-05
RA226	2.60E-05
RB83	2.60E-05
RB88	2.60E-05
RB89	2.60E-05
RH105	2.60E-05
RH106M	2.60E-05
RN219	2.60E-05
RU103	2.60E-05
RU106	2.60E-05
SB122	2.60E-05
SB124	2.60E-05
SB125	2.60E-05
SB126	2.60E-05
SC46	2.60E-05
SE75	2.60E-05
SN113	2.60E-05
SR85	2.60E-05
SR89	2.60E-05

Nuclide	Washout factor
SR90	2.60E-05
SR91	2.60E-05
SR92	2.60E-05
SR93	2.60E-05
TC96	2.60E-05
TC99M	2.60E-05
TE129M	2.60E-05
TE131M	2.60E-05
TE132	2.60E-05
TH227	2.60E-05
TH231	2.60E-05
TH232	2.60E-05
U235	2.60E-05
W187	2.60E-05
XE125	0.00E+00
XE131M	0.00E+00
XE133	0.00E+00
XE133M	0.00E+00
XE135	0.00E+00
XE135M	0.00E+00
XE138	0.00E+00
Y88	2.60E-05
Y91M	2.60E-05
Y92	2.60E-05
Y93	2.60E-05
Y94	2.60E-05
ZN65	2.60E-05
ZN69M	2.60E-05
ZR89	2.60E-05
ZR95	2.60E-05
ZR97	2.60E-05

Tab. 4: Inhalation, conversion factors for 50-yr. or 70-yr. committed effective dose

Nuclide	**Conversion factor for committed effective dose, inhalation (Sv/Bq), INH (i, age)**					
	< 1 year	1 - 2	2 - 7	7 - 12	12 – 17	> 17 years
AC228	4.60E-08	4.10E-08	2.60E-08	1.80E-08	1.50E-08	1.20E-08
AG110M	1.80E-04	1.80E-04	1.20E-04	1.00E-04	9.20E-05	9.60E-05
AM241	1.80E-07	1.60E-07	9.70E-08	5.70E-08	2.90E-08	2.50E-08
AR41	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AS76	5.10E-09	4.60E-09	2.20E-09	1.40E-09	8.80E-10	7.40E-10
BA133	3.20E-08	2.90E-08	2.00E-08	1.30E-08	1.10E-08	1.00E-08
BA139	5.70E-10	3.60E-10	1.60E-10	1.10E-10	7.00E-11	5.90E-11
BA140	2.90E-08	2.20E-08	1.20E-08	8.60E-09	7.10E-09	5.80E-09
BI211	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BI212	1.60E-07	1.10E-07	6.00E-08	4.40E-08	3.80E-08	3.10E-08
BI214	8.70E-08	6.10E-08	3.10E-08	2.20E-08	1.70E-08	1.40E-08
BR82	3.80E-09	3.00E-09	1.70E-09	1.10E-09	7.90E-10	6.30E-10
BR84	3.70E-10	2.40E-10	1.10E-10	6.90E-11	4.40E-11	3.70E-11
C14inorg	1.90E-08	1.70E-08	1.10E-08	7.40E-09	6.40E-09	5.80E-09
C14org	1.90E-08	1.70E-08	1.10E-08	7.40E-09	6.40E-09	5.80E-09
CD109	4.50E-08	3.70E-08	2.10E-08	1.40E-08	9.30E-09	8.10E-09
CE139	1.10E-08	8.50E-09	4.50E-09	2.80E-09	1.80E-08	1.50E-09
CE141	1.60E-08	1.20E-08	7.10E-09	5.30E-09	4.80E-09	3.80E-09
CE144	3.60E-07	2.70E-07	1.40E-07	7.80E-08	4.80E-08	4.00E-08
CL38	4.70E-10	3.00E-10	1.40E-10	8.50E-11	5.40E-11	4.50E-11
CO57	4.40E-09	3.70E-09	2.30E-09	1.50E-09	1.20E-09	1.00E-09
CO58	9.00E-09	7.50E-09	4.50E-09	3.10E-09	2.60E-09	2.10E-09
CO60	9.20E-08	8.60E-08	5.90E-08	4.00E-08	3.40E-08	3.10E-08
CR51	2.60E-10	2.10E-10	1.00E-10	6.60E-11	4.50E-11	3.70E-11
CS134	7.00E-08	6.30E-08	4.10E-08	2.80E-08	2.30E-08	2.00E-08
CS136	1.50E-08	1.10E-08	5.70E-09	4.10E-09	3.50E-09	2.80E-09
CS137	1.10E-07	1.00E-07	7.00E-08	4.80E-08	4.20E-08	3.90E-08
CS138	4.20E-10	2.80E-10	1.30E-10	8.20E-11	5.10E-11	4.30E-11
CU64	5.80E-10	5.70E-10	2.90E-10	2.00E-10	1.30E-10	1.20E-10
EU152	1.10E-07	1.00E-07	7.00E-08	4.90E-08	4.30E-08	4.20E-08
EU154	1.60E-07	1.50E-07	9.70E-08	6.50E-08	5.60E-08	5.30E-08
FE55	4.20E-09	3.20E-09	2.20E-09	1.40E-09	9.40E-10	7.70E-10
FE59	2.10E-08	1.30E-08	7.10E-09	4.20E-09	2.60E-09	2.20E-09
H3	1.20E-09	1.00E-09	6.30E-10	3.80E-10	2.80E-10	2.60E-10
H3org	1.20E-09	1.00E-09	6.30E-10	3.80E-10	2.80E-10	2.60E-10
HF181	2.20E-08	1.70E-08	9.90E-09	7.10E-09	6.30E-09	5.00E-09
HG203	5.70E-09	3.70E-09	1.70E-09	1.10E-09	6.60E-10	5.60E-10
I124	4.70E-08	4.50E-08	2.20E-08	1.10E-08	6.70E-09	4.40E-09
I126	8.10E-08	8.30E-08	4.50E-08	2.40E-08	1.50E-08	9.80E-09
I130	7.20E-08	7.20E-08	3.70E-08	1.90E-08	1.10E-08	7.40E-09
I131aer	7.20E-08	7.20E-08	3.70E-08	1.90E-08	1.10E-08	7.40E-09
I131elem	1.10E-09	9.60E-10	4.50E-10	2.20E-10	1.30E-10	9.40E-11
I132aer	1.10E-09	9.60E-10	4.50E-10	2.20E-10	1.30E-10	9.40E-11
I132elem	6.60E-09	4.40E-09	2.10E-09	1.20E-09	7.40E-10	5.50E-10
I133aer	6.60E-09	4.40E-09	2.10E-09	1.20E-09	7.40E-10	5.50E-10
I133elem	4.80E-10	3.40E-10	1.70E-10	1.10E-10	6.80E-11	5.50E-11
I134aer	4.80E-10	3.40E-10	1.70E-10	1.10E-10	6.80E-11	5.50E-11

Nuclide	Conversion factor for committed effective dose, inhalation (Sv/Bq), INH (i, age)					
	< 1 year	1 - 2	2 - 7	7 - 12	12 – 17	> 17 years
I134elem	4.10E-09	3.70E-09	1.70E-09	7.90E-10	4.80E-10	3.20E-10
I135aer	4.10E-09	3.70E-09	1.70E-09	7.90E-10	4.80E-10	3.20E-10
I135elem	8.20E-09	7.40E-09	3.50E-09	1.60E-09	1.00E-09	6.70E-10
K40	2.40E-08	1.70E-08	7.50E-09	4.50E-09	2.50E-09	2.10E-09
K42	1.60E-09	1.00E-09	4.40E-10	2.60E-10	1.50E-10	1.20E-10
KR85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR85M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR87	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR88	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR89	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LA140	8.80E-09	6.30E-09	3.10E-09	2.00E-09	1.30E-09	1.10E-09
MN54	5.20E-09	4.10E-09	2.20E-09	1.50E-09	9.90E-10	8.50E-10
MN56	6.90E-10	4.90E-10	2.30E-10	1.40E-10	7.80E-11	6.40E-11
MO90	2.80E-09	2.10E-09	1.10E-09	6.90E-10	4.50E-10	3.60E-10
MO99	6.90E-09	4.80E-09	2.40E-09	1.70E-09	1.20E-09	9.90E-10
NA22	9.70E-09	7.30E-09	3.80E-09	2.40E-09	1.50E-09	1.30E-09
NA24	2.30E-09	1.80E-09	9.30E-10	5.70E-10	3.40E-10	2.70E-10
NB94	1.20E-07	1.20E-07	8.30E-08	5.80E-08	5.20E-08	4.90E-08
NB95	7.70E-09	5.90E-09	3.60E-09	2.50E-09	2.20E-09	1.80E-09
NB95M	4.60E-09	3.40E-09	1.90E-09	1.30E-09	1.10E-09	8.80E-10
NB96	4.90E-09	3.70E-09	1.90E-09	1.20E-09	8.30E-10	6.60E-10
NB97	3.80E-10	2.60E-10	1.20E-10	8.10E-11	5.50E-11	4.50E-11
NI65	8.10E-10	5.50E-10	2.60E-10	1.70E-10	1.10E-10	9.00E-11
PA231	2.20E-04	2.30E-04	1.90E-04	1.50E-04	1.50E-04	1.40E-04
PA234	2.90E-09	2.10E-09	1.10E-09	7.10E-10	5.00E-10	4.00E-10
PA234M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PB211	6.60E-08	4.80E-08	2.70E-08	2.00E-08	1.50E-08	1.20E-08
PB212	6.70E-07	5.00E-07	3.30E-07	2.50E-07	2.40E-07	1.90E-07
PB214	6.90E-08	5.00E-08	2.80E-08	2.10E-08	1.50E-08	1.50E-08
PU238	2.00E-04	1.90E-04	1.40E-04	1.10E-04	1.00E-04	1.10E-04
PU239	2.10E-04	2.00E-04	1.50E-04	1.20E-04	1.10E-04	1.20E-04
RA226	3.40E-05	2.90E-05	1.90E-05	1.20E-05	1.00E-05	9.50E-06
RB83	4.90E-09	3.80E-09	2.00E-09	1.30E-09	7.90E-10	6.90E-10
RB88	1.90E-10	1.20E-10	5.20E-11	3.20E-11	1.90E-11	1.60E-11
RB89	1.40E-10	9.30E-11	4.30E-11	2.70E-11	1.60E-11	1.40E-11
RH105	2.40E-09	1.70E-09	8.00E-10	5.60E-10	4.50E-10	3.50E-10
RH106M	8.50E-10	6.50E-10	3.30E-10	2.10E-10	1.40E-10	1.10E-10
RN219	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RU103	1.30E-08	1.00E-08	6.00E-09	4.20E-09	3.70E-09	3.00E-09
RU106	2.60E-07	2.30E-07	1.40E-07	9.10E-08	7.10E-08	6.60E-08
SB122	8.80E-09	6.10E-09	3.00E-09	2.00E-09	1.40E-09	1.10E-09
SB124	3.90E-08	3.10E-08	1.80E-08	1.30E-08	1.00E-08	8.60E-09
SB125	4.20E-08	3.80E-08	2.40E-08	1.60E-08	1.40E-08	1.20E-08
SB126	1.90E-08	1.50E-08	8.20E-09	5.00E-09	4.00E-09	3.20E-09
SC46	2.80E-08	2.30E-08	1.40E-08	9.80E-09	8.40E-09	6.80E-09
SE75	5.60E-09	4.70E-09	2.90E-09	2.00E-09	1.60E-09	1.30E-09
SN113	1.30E-08	1.00E-08	5.80E-09	4.00E-09	3.20E-09	2.70E-09
SR85	4.40E-09	3.70E-09	2.20E-09	1.30E-09	1.00E-09	8.10E-10
SR89	3.90E-08	3.00E-08	1.70E-08	1.20E-08	9.30E-09	7.90E-09

Nuclide	Conversion factor for committed effective dose, inhalation (Sv/Bq), INH (i, age)					
	< 1 year	1 - 2	2 - 7	7 - 12	12 – 17	> 17 years
SR90	2.40E-07	4.00E-07	2.70E-07	1.80E-07	1.60E-07	1.60E-07
SR91	3.50E-09	2.50E-09	1.20E-09	7.70E-10	4.90E-10	4.10E-10
SR92	2.20E-09	1.50E-09	7.00E-10	4.50E-10	2.70E-10	2.30E-10
SR93	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TC96	4.80E-09	3.90E-09	2.10E-09	1.40E-09	8.90E-10	7.00E-10
TC99M	1.30E-10	1.00E-10	5.20E-11	3.50E-11	2.50E-11	2.00E-11
TE129M	3.80E-08	2.90E-08	1.70E-08	1.20E-08	9.60E-09	7.90E-09
TE131M	8.70E-09	7.60E-09	3.90E-09	2.00E-09	1.20E-09	8.60E-10
TE132	2.20E-08	1.80E-08	8.50E-09	4.20E-09	2.60E-09	1.80E-09
TH227	3.90E-05	3.00E-05	1.90E-05	1.40E-05	1.30E-05	1.00E-05
TH231	2.40E-09	1.70E-09	7.60E-10	5.20E-10	4.10E-10	3.30E-10
TH232	2.30E-04	2.20E-04	1.60E-04	1.30E-04	1.20E-04	1.10E-04
U235	3.00E-05	2.60E-05	1.70E-05	1.10E-05	9.20E-06	8.50E-06
W187	2.00E-09	1.50E-09	7.00E-10	4.30E-10	2.30E-10	1.90E-10
XE125	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE131M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE133	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE133M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE135	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE135M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE138	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Y88	2.00E-08	1.70E-08	9.80E-09	6.60E-09	5.40E-09	4.40E-09
Y91M	7.40E-11	5.90E-11	3.10E-11	2.00E-11	1.40E-11	1.10E-11
Y92	1.90E-09	1.20E-09	5.50E-10	3.50E-10	2.10E-10	1.80E-10
Y93	4.60E-09	3.00E-09	1.40E-09	8.50E-10	5.00E-10	4.20E-10
Y94	2.90E-10	1.90E-10	8.40E-11	5.20E-11	3.30E-11	2.80E-11
ZN65	1.50E-08	1.00E-08	5.70E-09	3.80E-09	2.50E-09	2.20E-09
ZN69M	2.20E-09	1.70E-09	8.20E-10	5.40E-10	3.30E-10	2.70E-10
ZR89	3.90E-09	2.90E-09	1.50E-09	1.00E-09	6.80E-10	5.50E-10
ZR95	2.40E-08	1.90E-08	1.20E-08	8.30E-09	7.30E-09	5.90E-09
ZR97	8.20E-09	5.60E-09	2.90E-09	1.90E-09	1.20E-09	8.90E-10

Tab. 5: Ingestion, conversion factors for 50-yr. or 70-yr. committed effective dose

Nuclide	**Conversion factor for committed effective dose, ingestion (Sv/Bq), ING (i, age)**					
	< 1 year	1 – 2	2 - 7	7 - 12	12 -17	> 17 years
AG110M	2.40E-08	1.40E-08	7.80E-09	5.20E-09	3.40E-09	2.80E-09
AM241	3.70E-06	3.70E-07	2.70E-07	2.20E-07	2.00E-07	2.00E-07
AR41	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C14	1.40E-09	1.60E-09	9.90E-10	8.00E-10	5.70E-10	5.80E-10
CE141	8.10E-09	5.10E-09	2.60E-09	1.50E-09	8.80E-10	7.10E-10
CE144	6.60E-08	3.90E-08	1.90E-08	1.10E-08	6.50E-09	5.20E-09
CO57	2.90E-09	1.60E-09	8.90E-10	5.80E-10	3.70E-10	2.10E-10
CO58	7.30E-09	4.40E-09	2.60E-09	1.70E-09	1.10E-09	7.40E-10
CO60	5.40E-08	2.70E-08	1.70E-08	1.10E-08	7.90E-09	3.40E-09
CR51	3.50E-10	2.30E-10	1.20E-10	7.80E-11	4.80E-11	3.80E-11
CS134	2.60E-08	1.60E-08	1.30E-08	1.40E-08	1.90E-08	1.90E-08
CS137	2.10E-08	1.20E-08	9.60E-09	1.00E-08	1.30E-08	1.30E-08
FE59	3.90E-08	1.30E-08	7.50E-09	4.70E-09	3.10E-09	1.80E-09
H3	6.40E-11	4.80E-11	3.10E-11	2.30E-11	1.80E-11	1.80E-11
H3org	1.20E-10	1.20E-10	7.30E-11	5.70E-11	4.20E-11	4.20E-11
I131el	1.80E-07	1.80E-07	1.00E-07	5.20E-08	3.40E-08	2.20E-08
I131ae	1.80E-07	1.80E-07	1.00E-07	5.20E-08	3.40E-08	2.20E-08
KR85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AC228	7.40E-09	2.80E-09	1.40E-09	8.70E-10	5.30E-10	4.30E-10
AG110M	2.40E-08	1.40E-08	7.80E-09	5.20E-09	3.40E-09	2.80E-09
AM241	3.70E-06	3.70E-07	2.70E-07	2.20E-07	2.00E-07	2.00E-07
AR41	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AS76	1.00E-08	1.10E-08	5.80E-09	3.40E-09	2.00E-09	1.60E-09
BA133	2.20E-08	6.20E-09	3.90E-09	4.60E-09	7.30E-09	1.50E-09
BA139	1.40E-09	8.40E-10	4.10E-10	2.40E-10	1.50E-10	1.20E-10
BA140	3.20E-08	1.80E-08	9.20E-09	5.80E-09	3.70E-09	2.60E-09
BI211	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BI212	3.20E-09	1.80E-09	8.70E-10	5.00E-10	3.30E-10	2.60E-10
BI214	1.40E-09	7.40E-10	3.60E-10	2.10E-10	1.40E-10	1.10E-10
BR82	3.70E-09	2.60E-09	1.50E-09	9.50E-10	6.40E-10	5.40E-10
BR84	1.00E-09	5.80E-10	2.80E-10	1.60E-10	1.10E-10	8.80E-11
C14inorg	1.40E-09	1.60E-09	9.90E-10	8.00E-10	5.70E-10	5.80E-10
C14org	1.40E-09	1.60E-09	9.90E-10	8.00E-10	5.70E-10	5.80E-10
CD109	2.10E-08	9.50E-09	5.50E-09	3.50E-09	2.40E-09	2.00E-09
CE139	2.60E-09	1.60E-09	8.60E-10	5.40E-10	3.30E-10	2.60E-10
CE141	8.10E-09	5.10E-09	2.60E-09	1.50E-09	8.80E-10	7.10E-10
CE144	6.60E-08	3.90E-08	1.90E-08	1.10E-08	6.50E-09	5.20E-09
CL38	1.40E-09	7.70E-10	3.80E-10	2.20E-10	1.50E-10	1.20E-10
CO57	2.90E-09	1.60E-09	8.90E-10	5.80E-10	3.70E-10	2.10E-10
CO58	7.30E-09	4.40E-09	2.60E-09	1.70E-09	1.10E-09	4.50E-10
CO60	5.40E-08	2.70E-08	1.70E-08	1.10E-08	7.90E-09	3.40E-09
CR51	3.50E-10	2.30E-10	1.20E-10	7.80E-11	4.80E-11	3.80E-11
CS134	2.60E-08	1.60E-08	1.30E-08	1.40E-08	1.90E-08	1.90E-08
CS136	1.50E-08	9.50E-09	6.10E-09	4.40E-09	3.40E-09	3.00E-09
CS137	2.10E-08	1.20E-08	9.60E-09	1.00E-08	1.30E-08	1.30E-08
CS138	1.10E-09	5.90E-10	2.90E-10	1.70E-10	1.20E-10	9.20E-11
CU64	5.20E-10	8.30E-10	4.20E-10	2.50E-10	1.50E-10	1.20E-10
EU152	1.60E-08	7.40E-09	4.10E-09	2.60E-09	1.70E-09	1.40E-09
EU154	2.50E-08	1.20E-08	6.50E-09	4.10E-09	2.50E-09	2.00E-09

Nuclide	Conversion factor for committed effective dose, ingestion (Sv/Bq), ING (i, age)					
	< 1 year	1 – 2	2 - 7	7 - 12	12 -17	> 17 years
FE55	7.60E-09	2.40E-09	1.70E-09	1.10E-09	7.70E-10	3.30E-10
FE59	3.90E-08	1.30E-08	7.50E-09	4.70E-09	3.10E-09	1.80E-09
H3	6.40E-11	4.80E-11	3.10E-11	2.30E-11	1.80E-11	1.80E-11
H3org	1.20E-10	1.20E-10	7.30E-11	5.70E-11	4.20E-11	4.20E-11
HF181	1.20E-08	7.40E-09	3.80E-09	2.30E-09	1.40E-09	1.10E-09
HG203	1.50E-08	1.10E-08	5.70E-09	3.60E-09	2.30E-09	1.90E-09
I124	1.20E-07	1.10E-07	6.30E-08	3.10E-08	2.00E-08	1.30E-08
I126	2.10E-07	2.10E-07	1.30E-07	6.80E-08	4.50E-08	2.90E-08
I130	2.10E-08	1.80E-08	9.80E-09	4.60E-09	3.00E-09	2.00E-09
I131aer	1.80E-07	1.80E-07	1.00E-07	5.20E-08	3.40E-08	2.20E-08
I131elem	1.80E-07	1.80E-07	1.00E-07	5.20E-08	3.40E-08	2.20E-08
I132aer	3.00E-09	2.40E-09	1.30E-09	6.20E-10	4.10E-10	2.90E-10
I132elem	3.00E-09	2.40E-09	1.30E-09	6.20E-10	4.10E-10	2.90E-10
I133aer	4.90E-08	4.40E-08	2.30E-08	1.00E-08	6.80E-09	4.30E-09
I133elem	4.90E-08	4.40E-08	2.30E-08	1.00E-08	6.80E-09	4.30E-09
I134aer	1.10E-09	7.50E-10	3.90E-10	2.10E-10	1.40E-10	1.10E-10
I134elem	1.10E-09	7.50E-10	3.90E-10	2.10E-10	1.40E-10	1.10E-10
I135aer	1.00E-08	8.90E-09	4.70E-09	2.20E-09	1.40E-09	9.30E-10
I135elem	1.00E-08	8.90E-09	4.70E-09	2.20E-09	1.40E-09	9.30E-10
K40	6.20E-08	4.20E-08	2.10E-08	1.30E-08	7.60E-08	6.20E-08
K42	5.10E-09	3.00E-09	1.50E-09	8.60E-10	5.40E-10	4.30E-10
KR85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR85M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR87	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR88	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR89	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LA140	2.00E-08	1.30E-08	6.80E-09	4.20E-09	2.50E-09	2.00E-09
MN54	5.40E-09	3.10E-09	1.90E-09	1.30E-09	8.70E-10	7.10E-10
MN56	2.70E-09	1.70E-09	8.50E-10	5.10E-10	3.20E-10	2.50E-10
MO90	1.70E-09	1.20E-09	6.30E-10	4.00E-10	2.70E-10	2.20E-10
MO99	5.50E-09	3.50E-09	1.80E-09	1.10E-09	7.60E-10	6.00E-10
NA22	2.10E-08	1.50E-08	8.40E-09	5.50E-09	3.70E-09	3.20E-09
NA24	3.50E-09	2.30E-09	1.20E-09	7.70E-10	5.20E-10	4.30E-10
NB94	1.50E-08	9.70E-09	5.30E-09	3.40E-09	2.10E-09	1.70E-09
NB95	4.60E-09	3.20E-09	1.80E-09	1.10E-09	7.40E-10	5.80E-10
NB95M	6.40E-09	4.10E-09	2.10E-09	1.20E-09	7.10E-10	5.60E-10
NB96	9.20E-09	6.30E-09	3.40E-09	2.20E-09	1.40E-09	1.10E-09
NB97	7.70E-10	4.50E-10	2.30E-10	1.30E-10	8.70E-11	6.80E-11
NI65	2.10E-09	1.30E-09	6.30E-10	3.80E-10	2.30E-10	1.80E-10
PA231	1.30E-05	1.30E-06	1.10E-06	9.20E-07	8.00E-07	7.10E-07
PA234	5.00E-09	3.20E-09	1.70E-09	1.00E-09	6.40E-10	5.10E-10
PA234M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PB211	3.10E-09	1.40E-09	7.10E-10	4.10E-10	2.70E-10	1.80E-10
PB212	1.50E-07	6.30E-08	3.30E-08	2.00E-08	1.30E-08	6.00E-09
PB214	2.70E-09	1.00E-09	5.20E-10	3.10E-10	2.00E-10	1.40E-10
PU238	4.00E-06	4.00E-07	3.10E-07	2.40E-07	2.20E-07	2.30E-07
PU239	4.20E-06	4.20E-07	3.30E-07	2.70E-07	2.40E-07	2.50E-07
RA226	4.70E-06	9.60E-07	6.20E-07	8.00E-07	1.50E-06	2.80E-07
RB83	1.10E-08	8.40E-09	4.90E-09	3.20E-09	2.20E-09	1.90E-09
RB88	1.10E-09	6.20E-10	3.00E-10	1.70E-10	1.20E-10	9.00E-11
RB89	5.40E-10	3.00E-10	1.50E-10	8.60E-11	5.90E-11	4.70E-11
RH105	4.00E-09	2.70E-09	1.30E-09	8.00E-10	4.60E-10	3.70E-10

Nuclide	Conversion factor for committed effective dose, ingestion (Sv/Bq), ING (i, age)					
	< 1 year	1 – 2	2 - 7	7 - 12	12 -17	> 17 years
RH106M	1.40E-09	9.70E-10	5.30E-10	3.30E-10	2.00E-10	1.60E-10
RN219	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RU103	7.10E-09	4.60E-09	2.40E-09	1.50E-09	9.20E-10	7.30E-10
RU106	8.40E-08	4.90E-08	2.50E-08	1.50E-08	8.60E-09	7.00E-09
SB122	1.80E-08	1.20E-08	6.10E-09	3.70E-09	2.10E-09	1.70E-09
SB124	2.50E-08	1.60E-08	8.40E-09	5.20E-09	3.20E-09	2.50E-09
SB125	1.10E-08	6.10E-09	3.40E-09	2.10E-09	1.40E-09	1.10E-09
SB126	2.00E-08	1.40E-08	7.60E-09	4.90E-09	3.10E-09	2.40E-09
SC46	1.10E-08	7.90E-09	4.40E-09	2.90E-09	1.80E-09	1.50E-09
SE75	2.00E-08	1.30E-08	8.30E-09	6.00E-09	3.10E-09	2.60E-09
SN113	7.80E-09	5.00E-09	2.60E-09	1.60E-09	9.20E-10	7.30E-10
SR85	7.70E-09	3.10E-09	1.70E-09	1.50E-09	1.30E-09	5.60E-10
SR89	3.60E-08	1.80E-08	8.90E-09	5.80E-09	4.00E-09	2.60E-09
SR90	2.30E-07	7.30E-08	4.70E-08	6.00E-08	8.00E-08	2.80E-08
SR91	5.20E-09	4.00E-09	2.10E-09	1.20E-09	7.40E-10	6.50E-10
SR92	3.40E-09	2.70E-09	1.40E-09	8.20E-09	4.80E-10	4.30E-10
SR93	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TC96	6.70E-09	5.10E-09	3.00E-09	2.00E-09	1.40E-09	1.10E-09
TC99M	2.00E-10	1.30E-10	7.20E-11	4.30E-11	2.80E-11	2.20E-11
TE129M	4.40E-08	2.40E-08	1.20E-08	6.60E-09	3.90E-09	3.00E-09
TE131M	2.00E-08	1.40E-08	7.80E-09	4.30E-09	2.70E-09	1.90E-09
TE132	4.80E-08	3.00E-08	1.60E-08	8.30E-09	5.30E-09	3.80E-09
TH227	3.00E-07	7.00E-08	3.60E-08	2.30E-08	1.50E-08	8.80E-09
TH231	3.90E-09	2.50E-09	1.20E-09	7.40E-10	4.20E-10	3.40E-10
TH232	4.60E-06	4.50E-07	3.50E-07	2.90E-07	2.50E-07	2.30E-07
U235	3.50E-07	1.30E-07	8.50E-08	7.10E-08	7.00E-08	4.70E-08

Tab. 6: The rate of removal from soil

Nuclide	Lambda d
	The removal rate constant for soil
AC228	0.00E+00
AG110M	0.00E+00
AM241	0.00E+00
AR41	0.00E+00
AS76	0.00E+00
BA133	0.00E+00
BA139	0.00E+00
BA140	0.00E+00
BI211	0.00E+00
BI212	0.00E+00
BI214	0.00E+00
BR82	0.00E+00
BR84	0.00E+00
C14inorg	0.00E+00
C14org	0.00E+00
CD109	0.00E+00
CE139	0.00E+00
CE141	0.00E+00
CE144	0.00E+00
CL38	0.00E+00
CO57	0.00E+00
CO58	0.00E+00
CO60	0.00E+00
CR51	0.00E+00
CS134	2.20E-09
CS136	2.20E-09
CS137	2.20E-09
CS138	2.20E-09
CU64	0.00E+00
EU152	0.00E+00
EU154	0.00E+00
FE55	0.00E+00
FE59	0.00E+00
H3	0.00E+00
H3org	0.00E+00
HF181	0.00E+00
HG203	0.00E+00
I124	0.00E+00
I126	0.00E+00
I130	0.00E+00
I131aer	0.00E+00
I131elem	0.00E+00
I132aer	0.00E+00
I132elem	0.00E+00
I133aer	0.00E+00
I133elem	0.00E+00
I134aer	0.00E+00
I134elem	0.00E+00
I135aer	0.00E+00
I135elem	0.00E+00
K40	0.00E+00
K42	0.00E+00
KR85	0.00E+00
KR85M	0.00E+00
KR87	0.00E+00
KR88	0.00E+00
KR89	0.00E+00
LA140	0.00E+00
MN54	0.00E+00
MN56	0.00E+00
MO90	0.00E+00
MO99	0.00E+00
NA22	0.00E+00
NA24	0.00E+00
NB94	0.00E+00
NB95	0.00E+00
NB95M	0.00E+00
NB96	0.00E+00
NB97	0.00E+00
NI65	0.00E+00
PA231	0.00E+00
PA234	0.00E+00
PA234M	0.00E+00
PB211	0.00E+00
PB212	0.00E+00
PB214	0.00E+00
PU238	0.00E+00
PU239	0.00E+00
RA226	0.00E+00
RB83	0.00E+00
RB88	0.00E+00
RB89	0.00E+00
RH105	0.00E+00
RH106M	0.00E+00
RN219	0.00E+00
RU103	0.00E+00
RU106	0.00E+00
SB122	0.00E+00
SB124	0.00E+00
SB125	0.00E+00
SB126	0.00E+00
SC46	0.00E+00
SE75	0.00E+00
SN113	0.00E+00
SR85	0.00E+00
SR89	0.00E+00
SR90	0.00E+00
SR91	0.00E+00
SR92	0.00E+00
SR93	0.00E+00
TC96	0.00E+00
TC99M	0.00E+00
TE129M	0.00E+00
TE131M	0.00E+00
TE132	0.00E+00
TH227	0.00E+00
TH231	0.00E+00
TH232	0.00E+00
U235	0.00E+00
W187	0.00E+00
XE125	0.00E+00
XE131M	0.00E+00
XE133	0.00E+00
XE133M	0.00E+00
XE135	0.00E+00
XE135M	0.00E+00
XE138	0.00E+00
Y88	0.00E+00
Y91M	0.00E+00
Y92	0.00E+00
Y93	0.00E+00
Y94	0.00E+00
ZN65	0.00E+00
ZN69M	0.00E+00
ZR89	0.00E+00
ZR95	0.00E+00
ZR97	0.00E+00

Note: in case of BNPP the constants and transfer factors will be updated and accommodated to specific subtropical and arid conditions, on the base of data tabulated and summarized in the IAEA-TECDOC-1616 and other IAEA data sources.

Tab. 7: Factors for transfer from water

Nuclide	COEF (water-sediment)	COEF (water-well)	COEF (water-meat)	COEF (water-milk)	COEF (water-fish)	COEF (feed-milk)
AC228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AG110M	4.00E-07	6.00E-01	1.70E-02	5.00E-02	1.10E+02	3.00E-02
AM241	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.20E-07
AR41	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AS76	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.80E+02	6.20E-05
BA133	0.00E+00	0.00E+00	3.20E-03	4.00E-04	4.70E+01	1.60E-04
BA139	0.00E+00	0.00E+00	3.20E-03	4.00E-04	4.70E+01	1.60E-04
BA140	0.00E+00	0.00E+00	3.20E-03	4.00E-04	4.70E+01	1.60E-04
BI211	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BI212	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BI214	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BR82	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.60E+02	0.00E+00
BR84	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.60E+02	0.00E+00
C14inorg	3.00E-06	0.00E+00	3.10E-02	1.20E-02	4.60E+03	1.50E-02
C14org	3.00E-06	0.00E+00	3.10E-02	1.20E-02	4.60E+03	1.50E-02
CD109	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.90E-04
CE139	5.00E-05	1.00E-01	1.20E-03	6.00E-04	1.20E+01	2.00E-05
CE141	5.00E-05	1.00E-01	1.20E-03	6.00E-04	1.20E+01	2.00E-05
CE144	5.00E-05	1.00E-01	1.20E-03	6.00E-04	1.20E+01	2.00E-05
CL38	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.50E+01	0.00E+00
CO57	5.00E-05	5.00E-01	4.00E-02	1.20E-03	4.00E+02	1.10E-04
CO58	5.00E-05	5.00E-01	4.00E-02	1.00E-03	4.00E+02	1.10E-04
CO60	5.00E-05	5.00E-01	4.00E-02	1.00E-03	4.00E+02	1.10E-04
CR51	5.00E-05	1.00E+00	2.40E-03	2.20E-03	2.10E+02	4.30E-04
CS134	5.00E-05	2.00E-01	4.00E-03	1.20E-02	3.00E+03	4.60E-03
CS136	5.00E-05	2.00E-01	4.00E-03	1.20E-02	3.00E+03	4.60E-03
CS137	5.00E-05	2.00E-01	4.00E-03	1.20E-02	3.00E+03	4.60E-03
CS138	5.00E-05	2.00E-01	4.00E-03	1.20E-02	3.00E+03	4.60E-03
CU64	0.00E+00	0.00E+00	8.00E-03	1.40E-02	2.70E+02	1.70E-03
EU152	5.00E-05	0.00E+00	0.00E+00	0.00E+00	1.50E+02	2.00E-05
EU154	5.00E-05	0.00E+00	4.00E-02	1.20E-03	1.00E+02	3.00E-04
FE55	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-05
FE59	0.00E+00	0.00E+00	4.00E-02	1.20E-03	1.40E+02	3.50E-05
H3	4.00E-07	1.00E+00	1.20E-02	1.00E-02	9.00E-01	1.40E-02
H3org	4.00E-07	1.00E+00	1.20E-02	1.00E-02	9.00E-01	1.40E-02
HF181	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.10E+03	2.00E-05
HG203	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.50E+03	0.00E+00
I124	4.00E-07	8.00E-01	2.90E-03	6.00E-03	6.50E+02	5.40E-03
I126	4.00E-07	8.00E-01	2.90E-03	6.00E-03	6.50E+02	5.40E-03
I130	4.00E-07	8.00E-01	2.90E-03	6.00E-03	6.50E+02	5.40E-03
I131aer	4.00E-07	8.00E-01	2.90E-03	6.00E-03	6.50E+02	5.40E-03
I131elem	4.00E-07	8.00E-01	2.90E-03	6.00E-03	6.50E+02	5.40E-03

Nuclide	COEF (water-sediment)	COEF (water-well)	COEF (water-meat)	COEF (water-milk)	COEF (water-fish)	COEF (feed-milk)
I132aer	4.00E-07	8.00E-01	2.90E-03	6.00E-03	6.50E+02	5.40E-03
I132elem	4.00E-07	8.00E-01	2.90E-03	6.00E-03	6.50E+02	5.40E-03
I133aer	4.00E-07	8.00E-01	2.90E-03	6.00E-03	6.50E+02	5.40E-03
I133elem	4.00E-07	8.00E-01	2.90E-03	6.00E-03	6.50E+02	5.40E-03
I134aer	4.00E-07	8.00E-01	2.90E-03	6.00E-03	6.50E+02	5.40E-03
I134elem	4.00E-07	8.00E-01	2.90E-03	6.00E-03	6.50E+02	5.40E-03
I135aer	4.00E-07	8.00E-01	2.90E-03	6.00E-03	6.50E+02	5.40E-03
I135elem	4.00E-07	8.00E-01	2.90E-03	6.00E-03	6.50E+02	5.40E-03
K40	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.00E+03	7.20E-03
K42	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.00E+03	7.20E-03
KR85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR85M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR87	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR88	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR89	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LA140	0.00E+00	0.00E+00	2.00E-04	5.00E-04	1.60E+01	2.00E-05
MN54	5.00E-05	9.00E-01	8.00E-04	2.50E-04	4.50E+02	4.10E-05
MN56	5.00E-05	9.00E-01	8.00E-04	2.50E-04	4.50E+02	4.10E-05
MO90	0.00E+00	0.00E+00	8.00E-03	7.50E-03	2.70E+01	1.10E-03
MO99	0.00E+00	0.00E+00	8.00E-03	7.50E-03	2.70E+01	1.10E-03
NA22	0.00E+00	0.00E+00	3.00E-02	4.00E-02	1.40E+02	1.30E-02
NA24	0.00E+00	0.00E+00	3.00E-02	4.00E-02	1.40E+02	1.30E-02
NB94	4.00E-07	0.00E+00	2.80E-01	2.50E-03	3.00E+04	4.10E-07
NB95	4.00E-07	0.00E+00	2.80E-01	2.50E-03	3.00E+04	4.10E-07
NB95M	4.00E-07	0.00E+00	2.80E-01	2.50E-03	3.00E+04	4.10E-07
NB96	4.00E-07	0.00E+00	2.80E-01	2.50E-03	3.00E+04	4.10E-07
NB97	4.00E-07	0.00E+00	2.80E-01	2.50E-03	3.00E+04	4.10E-07
NI65	0.00E+00	0.00E+00	5.30E-03	6.70E-03	7.10E+01	9.50E-04
PA231	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PA234	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PA234M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PB211	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.70E+02	1.90E-04
PB212	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.70E+02	1.90E-04
PB214	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.70E+02	1.90E-04
PU238	5.00E-05	0.00E+00	1.40E-05	2.00E-06	3.50E+00	1.00E-05
PU239	5.00E-05	0.00E+00	1.40E-05	2.00E-06	3.50E+00	1.00E-05
RA226	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.10E+02	3.80E-04
RB83	0.00E+00	0.00E+00	3.10E-02	3.00E-02	6.10E+03	1.20E-02
RB88	0.00E+00	0.00E+00	3.10E-02	3.00E-02	6.10E+03	1.20E-02
RB89	0.00E+00	0.00E+00	3.10E-02	3.00E-02	6.10E+03	1.20E-02
RH105	0.00E+00	0.00E+00	1.50E-03	1.00E-02	1.00E+01	1.00E-02
RH106M	0.00E+00	0.00E+00	1.50E-03	1.00E-02	1.00E+01	1.00E-02
RN219	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RU103	5.00E-05	1.00E-01	4.00E-01	1.00E-06	1.00E+01	9.40E-06
RU106	5.00E-05	1.00E-01	4.00E-01	1.00E-06	1.00E+01	9.40E-06

Nuclide	COEF (water-sediment)	COEF (water-well)	COEF (water-meat)	COEF (water-milk)	COEF (water-fish)	COEF (feed-milk)
SB122	4.00E-07	0.00E+00	0.00E+00	0.00E+00	7.10E+01	3.80E-05
SB124	4.00E-07	0.00E+00	0.00E+00	0.00E+00	7.10E+01	3.80E-05
SB125	4.00E-07	0.00E+00	0.00E+00	0.00E+00	7.10E+01	3.80E-05
SB126	4.00E-07	0.00E+00	0.00E+00	0.00E+00	7.10E+01	3.80E-05
SC46	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.30E+02	0.00E+00
SE75	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.80E+03	4.00E-03
SN113	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.20E-03
SR85	3.00E-06	5.00E-01	6.00E-04	8.00E-04	1.90E+02	1.30E-03
SR89	3.00E-06	5.00E-01	6.00E-04	8.00E-04	1.90E+02	1.30E-03
SR90	3.00E-06	5.00E-01	6.00E-04	8.00E-04	1.90E+02	1.30E-03
SR91	3.00E-06	5.00E-01	6.00E-04	8.00E-04	1.90E+02	1.30E-03
SR92	3.00E-06	5.00E-01	6.00E-04	8.00E-04	1.90E+02	1.30E-03
SR93	3.00E-06	5.00E-01	6.00E-04	8.00E-04	1.90E+02	1.30E-03
TC96	4.00E-07	0.00E+00	4.00E-01	2.50E-02	1.50E+01	2.30E-05
TC99M	4.00E-07	0.00E+00	4.00E-01	2.50E-02	1.50E+01	2.30E-05
TE129M	4.00E-07	0.00E+00	7.70E-02	1.00E-03	4.20E+02	3.40E-04
TE131M	4.00E-07	0.00E+00	7.70E-02	1.00E-03	4.20E+02	3.40E-04
TE132	4.00E-07	0.00E+00	7.70E-02	1.00E-03	4.20E+02	3.40E-04
TH227	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.90E+02	0.00E+00
TH231	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.90E+02	0.00E+00
TH232	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.90E+02	0.00E+00
U235	0.00E+00	0.00E+00	3.40E-04	5.00E-04	2.40E+00	1.80E-03
W187	0.00E+00	0.00E+00	1.30E-03	5.00E-04	1.20E+03	1.90E-04
XE125	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE131M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE133	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE133M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE135	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE135M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE138	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Y88	3.00E-06	0.00E+00	4.60E-03	1.00E-05	2.50E+01	2.00E-05
Y91M	3.00E-06	0.00E+00	4.60E-03	1.00E-05	3.10E+01	2.00E-05
Y92	3.00E-06	0.00E+00	4.60E-03	1.00E-05	3.10E+01	2.00E-05
Y93	3.00E-06	0.00E+00	4.60E-03	1.00E-05	3.10E+01	2.00E-05
Y94	3.00E-06	0.00E+00	4.60E-03	1.00E-05	3.10E+01	2.00E-05
ZN65	3.00E-06	4.00E-01	3.00E-02	3.90E-02	4.70E+03	2.70E-03
ZN69M	3.00E-06	4.00E-01	3.00E-02	3.90E-02	4.70E+03	2.70E-03
ZR89	5.00E-05	1.00E-01	3.40E-02	5.00E-06	9.50E+01	3.60E-06
ZR95	5.00E-05	1.00E-01	3.40E-02	5.00E-06	9.50E+01	3.60E-06
ZR97	5.00E-05	1.00E-01	3.40E-02	5.00E-06	9.50E+01	3.60E-06

Tab. 8: Factors for transfer from feed to agricultural product, F_f

Nuclide	COEF (feed-beef)	COEF (feed-poultry)	COEF (feed-eggs)
AC228	0.00E+00	0.00E+00	0.00E+00
AG110M	5.00E-03	5.00E-02	5.00E-03
AM241	5.00E-04	6.00E-04	3.00E-03
AR41	0.00E+00	0.00E+00	0.00E+00
AS76	2.00E-02	2.00E-02	2.00E-02
BA133	1.40E-04	1.90E-02	8.70E-01
BA139	1.40E-04	1.90E-02	8.70E-01
BA140	1.40E-04	1.90E-02	8.70E-01
BI211	0.00E+00	0.00E+00	0.00E+00
BI212	0.00E+00	0.00E+00	0.00E+00
BI214	0.00E+00	0.00E+00	0.00E+00
BR82	0.00E+00	0.00E+00	0.00E+00
BR84	0.00E+00	0.00E+00	0.00E+00
C14inorg	3.10E-02	3.10E-02	3.10E-02
C14org	3.10E-02	3.10E-02	3.10E-02
CD109	5.80E-03	1.70E+00	0.00E+00
CE139	2.00E-03	6.00E-04	3.10E-03
CE141	2.00E-03	6.00E-04	3.10E-03
CE144	2.00E-03	6.00E-04	3.10E-03
CL38	1.70E-02	0.00E+00	0.00E+00
CO57	4.30E-04	9.70E-01	3.30E-02
CO58	4.30E-04	9.70E-01	3.30E-02
CO60	4.30E-04	9.70E-01	3.30E-02
CR51	3.00E-02	1.00E-02	1.00E-03
CS134	2.20E-02	2.70E+00	4.00E-01
CS136	2.20E-02	2.70E+00	4.00E-01
CS137	2.20E-02	2.70E+00	4.00E-01
CS138	2.20E-02	2.70E+00	4.00E-01
CU64	9.00E-03	5.00E-01	5.00E-01
EU152	2.00E-03	2.00E-03	2.00E-03
EU154	2.00E-03	2.00E-03	2.00E-03
FE55	3.00E-02	3.00E-02	3.00E-03
FE59	2.20E-02	3.00E-02	1.80E+00
H3	1.20E-02	1.20E-02	1.20E-02
H3org	1.20E-02	1.20E-02	1.20E-02
HF181	4.00E-04	4.00E-04	4.00E-04
HG203	0.00E+00	0.00E+00	0.00E+00
I124	6.70E-03	8.70E-03	2.40E+00
I126	6.70E-03	8.70E-03	2.40E+00
I130	6.70E-03	8.70E-03	2.40E+00
I131aer	6.70E-03	8.70E-03	2.40E+00
I131elem	6.70E-03	8.70E-03	2.40E+00
I132aer	6.70E-03	8.70E-03	2.40E+00
I132elem	6.70E-03	8.70E-03	2.40E+00
I133aer	6.70E-03	8.70E-03	2.40E+00
I133elem	6.70E-03	8.70E-03	2.40E+00
I134aer	6.70E-03	8.70E-03	2.40E+00
I134elem	6.70E-03	8.70E-03	2.40E+00
I135aer	6.70E-03	8.70E-03	2.40E+00
I135elem	6.70E-03	8.70E-03	2.40E+00

Nuclide	COEF (feed-beef)	COEF (feed-poultry)	COEF (feed-eggs)
K40	2.00E-02	2.00E-02	1.00E+00
K42	2.00E-02	2.00E-02	1.00E+00
KR85	0.00E+00	0.00E+00	0.00E+00
KR85M	0.00E+00	0.00E+00	0.00E+00
KR87	0.00E+00	0.00E+00	0.00E+00
KR88	0.00E+00	0.00E+00	0.00E+00
KR89	0.00E+00	0.00E+00	0.00E+00
LA140	2.00E-03	1.00E-01	9.00E-03
MN54	6.00E-04	1.90E-03	4.20E-02
MN56	6.00E-04	1.90E-03	4.20E-02
MO90	1.00E-03	1.80E-01	6.40E-01
MO99	1.00E-03	1.80E-01	6.40E-01
NA22	1.50E-02	7.00E+00	4.00E+00
NA24	1.50E-02	7.00E+00	4.00E+00
NB94	2.60E-07	3.00E-04	1.00E-03
NB95	2.60E-07	3.00E-04	1.00E-03
NB95M	2.60E-07	3.00E-04	1.00E-03
NB96	2.60E-07	3.00E-04	1.00E-03
NB97	2.60E-07	3.00E-04	1.00E-03
NI65	5.00E-03	5.00E-03	5.00E-03
PA231	0.00E+00	0.00E+00	0.00E+00
PA234	0.00E+00	0.00E+00	0.00E+00
PA234M	0.00E+00	0.00E+00	0.00E+00
PB211	7.00E-04	0.00E+00	0.00E+00
PB212	7.00E-04	0.00E+00	0.00E+00
PB214	7.00E-04	0.00E+00	0.00E+00
PU238	1.10E-06	3.00E-04	1.20E-03
PU239	1.10E-06	3.00E-04	1.20E-03
RA226	1.70E-03	0.00E+00	0.00E+00
RB83	1.00E-02	1.00E-02	1.00E-02
RB88	1.00E-02	1.00E-02	1.00E-02
RB89	1.00E-02	1.00E-02	1.00E-02
RH105	1.50E-03	1.50E-03	1.50E-03
RH106M	1.50E-03	1.50E-03	1.50E-03
RN219	0.00E+00	0.00E+00	0.00E+00
RU103	3.30E-03	3.00E-04	4.00E-03
RU106	3.30E-03	3.00E-04	4.00E-03
SB122	1.20E-03	1.00E-03	1.00E-03
SB124	1.20E-03	1.00E-03	1.00E-03
SB125	1.20E-03	1.00E-03	1.00E-03
SB126	1.20E-03	1.00E-03	1.00E-03
SC46	0.00E+00	0.00E+00	0.00E+00
SE75	4.00E-05	9.70E+00	1.60E+01
SN113	1.00E-02	1.00E-02	1.00E-02
SR85	1.30E-03	2.00E-02	3.50E-01
SR89	1.30E-03	2.00E-02	3.50E-01
SR90	1.30E-03	2.00E-02	3.50E-01
SR91	1.30E-03	2.00E-02	3.50E-01
SR92	1.30E-03	2.00E-02	3.50E-01
SR93	1.30E-03	2.00E-02	3.50E-01
TC96	1.00E-06	3.00E-02	3.00E+00
TC99M	1.00E-06	3.00E-02	3.00E+00
TE129M	7.00E-03	6.00E-01	5.10E+00

Nuclide	COEF (feed-beef)	COEF (feed-poultry)	COEF (feed-eggs)
TE131M	7.00E-03	6.00E-01	5.10E+00
TE132	7.00E-03	6.00E-01	5.10E+00
TH227	2.30E-04	0.00E+00	0.00E+00
TH231	2.30E-04	0.00E+00	0.00E+00
TH232	2.30E-04	0.00E+00	0.00E+00
U235	3.90E-04	7.50E-01	1.10E+00
W187	4.00E-02	4.00E-02	4.00E-02
XE125	0.00E+00	0.00E+00	0.00E+00
XE131M	0.00E+00	0.00E+00	0.00E+00
XE133	0.00E+00	0.00E+00	0.00E+00
XE133M	0.00E+00	0.00E+00	0.00E+00
XE135	0.00E+00	0.00E+00	0.00E+00
XE135M	0.00E+00	0.00E+00	0.00E+00
XE138	0.00E+00	0.00E+00	0.00E+00
Y88	1.00E-03	1.00E-02	2.00E-03
Y91M	1.00E-03	1.00E-02	2.00E-03
Y92	1.00E-03	1.00E-02	2.00E-03
Y93	1.00E-03	1.00E-02	2.00E-03
Y94	1.00E-03	1.00E-02	2.00E-03
ZN65	1.60E-01	4.70E-01	1.40E+00
ZN69M	1.60E-01	4.70E-01	1.40E+00
ZR89	1.20E-06	6.00E-05	2.0E-02
ZR95	1.20E-06	6.00E-05	2.0E-02
ZR97	1.20E-06	6.00E-05	2.0E-02

Note: in case of BNPP the constants and transfer factors will be updated and accommodated to specific subtropical and arid conditions, on the base of data tabulated and summarized in the IAEA-TECDOC-1616 and other IAEA data sources.

Tab. 9: Fraction of deposited activity retained on plants

Nuclide	COEF r
	fraction of deposited activity retained on plants
AG110M	2.50E-01
AM241	2.50E-01
AC228	2.50E-01
AR41	0.00E+00
AS76	2.50E-01
BA133	2.50E-01
BA139	2.50E-01
BA140	2.50E-01
BI211	2.50E-01
BI212	2.50E-01
BI214	2.50E-01
BR82	2.50E-01
BR84	2.50E-01
C14inorg	0.00E+00
C14org	0.00E+00
CD109	2.50E-01
CE139	2.50E-01
CE141	2.50E-01
CE144	2.50E-01
CL38	2.50E-01
CO57	2.50E-01
CO58	2.50E-01
CO60	2.50E-01
CR51	2.50E-01
CS134	2.50E-01
CS136	2.50E-01
CS137	2.50E-01
CS138	2.50E-01
CU64	2.50E-01
EU152	2.50E-01
EU154	2.50E-01
FE55	2.50E-01
FE59	2.50E-01
H3	0.00E+00
H3org	0.00E+00
HF181	2.50E-01
HG203	2.50E-01
I124	1.00E+00
I126	1.00E+00
I131aer	1.00E+00
I131elem	1.00E+00
I132aer	1.00E+00
I132elem	1.00E+00

Nuclide	COEF r
	fraction of deposited activity retained on plants
I133aer	1.00E+00
I133elem	1.00E+00
I134aer	1.00E+00
I134elem	1.00E+00
I135aer	1.00E+00
I135elem	1.00E+00
I130	1.00E+00
K40	2.50E-01
K42	2.50E-01
KR85	0.00E+00
KR85M	0.00E+00
KR87	0.00E+00
KR88	0.00E+00
KR89	2.50E-01
LA140	2.50E-01
MN54	2.50E-01
MN56	2.50E-01
MO90	2.50E-01
MO99	2.50E-01
NA22	2.50E-01
NA24	2.50E-01
NB94	2.50E-01
NB95	2.50E-01
NB95M	2.50E-01
NB96	2.50E-01
NB97	2.50E-01
NI65	2.50E-01
PA231	2.50E-01
PA234	2.50E-01
PA234M	2.50E-01
PB211	2.50E-01
PB212	2.50E-01
PB214	2.50E-01
PU238	2.50E-01
PU239	2.50E-01
RA226	2.50E-01
RB83	2.50E-01
RB88	2.50E-01
RB89	2.50E-01
RH105	2.50E-01
RH106M	2.50E-01
RN219	2.50E-01
RU103	2.50E-01

Nuclide	COEF r
	fraction of deposited activity retained on plants
RU106	2.50E-01
SB122	2.50E-01
SB124	2.50E-01
SB125	2.50E-01
SB126	2.50E-01
SC46	2.50E-01
SE75	2.50E-01
SN113	2.50E-01
SR85	2.50E-01
SR89	2.50E-01
SR90	2.50E-01
SR91	2.50E-01
SR92	2.50E-01
SR93	2.50E-01
TC96	2.50E-01
TC99M	2.50E-01
TE129M	2.50E-01
TE131M	2.50E-01
TE132	2.50E-01
TH227	2.50E-01
TH231	2.50E-01
TH232	2.50E-01
U235	2.50E-01
W187	2.50E-01
XE125	2.50E-01
XE131M	0.00E+00
XE133	0.00E+00
XE133M	0.00E+00
XE135	0.00E+00
XE135M	0.00E+00
XE138	0.00E+00
Y88	2.50E-01
Y91M	2.50E-01
Y92	2.50E-01
Y93	2.50E-01
Y94	2.50E-01
ZN65	2.50E-01
ZN69M	2.50E-01
ZR89	2.50E-01
ZR95	2.50E-01
ZR97	2.50E-01

Note: in case of BNPP the constants and transfer factors will be updated and accommodated to specific subtropical and arid conditions, on the base of data tabulated and summarized in the IAEA-TECDOC-1616 and other IAEA data sources.

Tab. 10: Factors of transfer from soil to plants

Nuclide	COEF(soil-plant), Bq/kg per Bq/kg of soil						
	concentration factor Biv soil/pasture (feed)	concentration factor Biv (soil/grain)	concentration factor Biv (soil/vegetables)	concentration factor Biv (soil/leafy veg.)	concentration factor Biv (soil/fruits)	concentration factor Biv (soil/potatoes)	concentration factor Biv (soil/beet)
AC228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AG110M	1.00E+00	2.00E-01	5.12E-05	1.44E-05	1.30E-03	1.30E-03	1.69E-04
AM241	3.60E-04	1.936E-05	2.88E-05	2.16E-05	3.10E-05	5.25E-05	8.71E-05
AR41	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AS76	2.00E-01	8.00E-02	8.00E-02	8.00E-02	8.00E-02	8.00E-02	8.00E-02
BA133	0.00E+00	8.80E-04	4.00E-04	4.00E-04	0.00E+00	1.25E-03	6.50E-04
BA139	0.00E+00	8.80E-04	4.00E-04	4.00E-04	0.00E+00	1.25E-03	6.50E-04
BA140	2.00E-02	8.80E-04	4.00E-04	4.00E-04	2.00E-02	1.25E-03	6.50E-04
BI211	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BI212	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BI214	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BR82	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BR84	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C14inor	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C14org	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CD109	0.00E+00	7.744E-01	0.00E+00	0.00E+00	0.00E+00	3.75E-01	0.00E+00
CE139	8.88E-02	2.728E-03	1.90E-03	4.80E-04	5.30E-04	1.00E-03	7.80E-04
CE141	8.88E-02	2.728E-03	1.90E-03	4.80E-04	5.30E-04	1.00E-03	7.80E-04
CE144	8.88E-02	2.728E-03	1.90E-03	4.80E-04	5.30E-04	1.00E-03	7.80E-04
CL38	0.00E+00	3.168E+01	0.00E+00	2.08E+00	0.00E+00	0.00E+00	1.56E+00
CO57	1.08E-02	7.48E-03	1.12E-02	1.36E-02	4.80E-03	1.35E-02	1.43E-02
CO58	1.08E-02	7.48E-03	1.12E-02	1.36E-02	4.80E-03	1.35E-02	1.43E-02
CO60	1.08E-02	7.48E-03	1.12E-02	1.36E-02	4.80E-03	1.35E-02	1.43E-02
CR51	4.80E-04	1.76E-04	8.00E-05	8.00E-05	2.00E-02	1.25E-04	1.30E-04
CS134	6.00E-02	2.552E-02	1.68E-03	4.80E-03	5.80E-03	1.40E-02	5.46E-03
CS136	6.00E-02	2.552E-02	1.68E-03	4.80E-03	5.80E-03	1.40E-02	5.46E-03
CS137	6.00E-02	2.552E-02	1.68E-03	4.80E-03	5.80E-03	1.40E-02	5.46E-03
CS138	6.00E-02	2.552E-02	1.68E-03	4.80E-03	5.80E-03	1.40E-02	5.46E-03
CU64	8.00E-01	6.90E-01	1.30E-01	9.60E-02	4.80E-02	1.70E-01	1.80E-01
EU152	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EU154	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FE55	3.00E-03	7.00E-04	6.80E-04	2.40E-04	5.00E-04	4.00E-04	6.80E-04
FE59	4.80E-04	1.76E-04	8.00E-05	8.00E-05	5.00E-04	1.25E-04	1.30E-04
H3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
H3org	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
HF181	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
HG203	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I124	8.88E-04	5.544E-04	8.00E-03	5.20E-04	6.30E-03	2.50E-02	1.001E-03
I126	8.88E-04	5.544E-04	8.00E-03	5.20E-04	6.30E-03	2.50E-02	1.001E-03
I130	8.88E-04	5.544E-04	8.00E-03	5.20E-04	6.30E-03	2.50E-02	1.001E-03
I131aer	8.88E-04	5.544E-04	8.00E-03	5.20E-04	6.30E-03	2.50E-02	1.001E-03
I131elem	8.88E-04	5.544E-04	8.00E-03	5.20E-04	6.30E-03	2.50E-02	1.001E-03
I132aer	8.88E-04	5.544E-04	8.00E-03	5.20E-04	6.30E-03	2.50E-02	1.001E-03
I132elem	8.88E-04	5.544E-04	8.00E-03	5.20E-04	6.30E-03	2.50E-02	1.001E-03
I133aer	8.88E-04	5.544E-04	8.00E-03	5.20E-04	6.30E-03	2.50E-02	1.001E-03
I133elem	8.88E-04	5.544E-04	8.00E-03	5.20E-04	6.30E-03	2.50E-02	1.001E-03
I134aer	8.88E-04	5.544E-04	8.00E-03	5.20E-04	6.30E-03	2.50E-02	1.001E-03
I134elem	8.88E-04	5.544E-04	8.00E-03	5.20E-04	6.30E-03	2.50E-02	1.001E-03
I135aer	8.88E-04	5.544E-04	8.00E-03	5.20E-04	6.30E-03	2.50E-02	1.001E-03

Nuclide	COEF(soil-plant), Bq/kg per Bq/kg of soil						
	concentration factor Biv soil/pasture (feed)	concentration factor Biv (soil/grain)	concentration factor Biv (soil/vegetables)	concentration factor Biv (soil/leafy veg.)	concentration factor Biv (soil/fruits)	concentration factor Biv (soil/potatoes)	concentration factor Biv (soil/beet)
I135elem	8.88E-04	5.544E-04	8.00E-03	5.20E-04	6.30E-03	2.50E-02	1.001E-03
K40	1.752E-01	6.512E-01	8.80E-02	1.04E-01	3.30E-02	1.20E-01	1.20E-01
K42	1.752E-01	6.512E-01	8.80E-02	1.04E-01	3.30E-02	1.20E-01	1.20E-01
KR85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR85M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR87	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR88	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR89	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LA140	4.80E-03	1.76E-05	4.80E-04	4.56E-04	2.50E-05	9.75E-05	2.08E-04
MN54	1.536E-01	2.464E-01	2.48E-02	3.28E-02	4.80E-03	1.175E-02	5.46E-02
MN56	1.536E-01	2.464E-01	2.48E-02	3.28E-02	4.80E-03	1.175E-02	5.46E-02
MO90	8.00E-01	7.04E-01	1.30E-01	4.08E-02	4.80E-02	1.70E-01	4.16E-02
MO99	8.00E-01	7.04E-01	1.30E-01	4.08E-02	4.80E-02	1.70E-01	4.16E-02
NA22	2.40E-02	8.80E-03	2.40E-03	2.40E-03	4.80E-03	7.50E-03	3.90E-03
NA24	2.40E-02	8.80E-03	2.40E-03	2.40E-03	4.80E-03	7.50E-03	3.90E-03
NB94	4.80E-03	1.232E-02	6.40E-04	1.36E-03	2.00E-02	1.00E-03	2.21E-03
NB95	4.80E-03	1.232E-02	6.40E-04	1.36E-03	2.00E-02	1.00E-03	2.21E-03
NB95M	4.80E-03	1.232E-02	6.40E-04	1.36E-03	2.00E-02	1.00E-03	2.21E-03
NB96	4.80E-03	1.232E-02	6.40E-04	1.36E-03	2.00E-02	1.00E-03	2.21E-03
NB97	4.80E-03	1.232E-02	6.40E-04	1.36E-03	2.00E-02	1.00E-03	2.21E-03
NI65	0.00E+00	2.376E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PA231	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PA234	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PA234M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PB211	2.208E-02	9.68E-03	1.20E-03	6.40E-03	1.155E-03	3.75E-04	1.95E-03
PB212	2.208E-02	9.68E-03	1.20E-03	6.40E-03	1.155E-03	3.75E-04	1.95E-03
PB214	2.208E-02	9.68E-03	1.20E-03	6.40E-03	1.155E-03	3.75E-04	1.95E-03
Pu	1.32E-04	8.36E-06	5.20E-06	6.64E-06	1.40E-04	2.75E-05	5.07E-05
PU238	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PU239	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RA226	1.704E-02	1.496E-02	1.36E-03	7.28E-03	1.80E-03	2.75E-03	9.10E-03
RB83	9.00E-01	7.92E-01	1.40E-01	4.96E-02	5.40E-02	1.90E-01	1.17E-01
RB88	9.00E-01	7.92E-01	1.40E-01	4.96E-02	5.40E-02	1.90E-01	1.17E-01
RB89	9.00E-01	7.92E-01	1.40E-01	4.96E-02	5.40E-02	1.90E-01	1.17E-01
RH105	9.00E-01	7.70E-01	1.40E-01	1.10E-01	5.40E-02	1.90E-01	2.00E-01
RH106M	9.00E-01	7.70E-01	1.40E-01	1.10E-01	5.40E-02	1.90E-01	2.00E-01
RN219	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RU103	9.00E-02	2.64E-03	1.60E-03	7.20E-03	1.30E-03	1.25E-03	1.30E-03
RU106	9.00E-02	2.64E-03	1.60E-03	7.20E-03	1.30E-03	1.25E-03	1.30E-03
SB122	2.00E-01	1.584E-03	1.04E-05	7.52E-06	1.00E-03	5.00E-04	8.06E-05
SB124	2.00E-01	1.584E-03	1.04E-05	7.52E-06	1.00E-03	5.00E-04	8.06E-05
SB125	2.00E-01	1.584E-03	1.04E-05	7.52E-06	1.00E-03	5.00E-04	8.06E-05
SB126	2.00E-01	1.584E-03	1.04E-05	7.52E-06	1.00E-03	5.00E-04	8.06E-05
SC46	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SE75	2.50E-02	2.50E-02	2.50E-02	2.50E-02	2.50E-02	2.50E-02	2.50E-02
SN113	1.00E+00	3.00E-01	3.00E-01	3.00E-01	3.00E-01	3.00E-01	3.00E-01
SR85	3.12E-01	9.68E-02	2.88E-02	6.08E-02	1.70E-02	4.00E-02	9.36E-02
SR89	3.12E-01	9.68E-02	2.88E-02	6.08E-02	1.70E-02	4.00E-02	9.36E-02
SR90	3.12E-01	9.68E-02	2.88E-02	6.08E-02	1.70E-02	4.00E-02	9.36E-02
SR91	3.12E-01	9.68E-02	2.88E-02	6.08E-02	1.70E-02	4.00E-02	9.36E-02
SR92	3.12E-01	9.68E-02	2.88E-02	6.08E-02	1.70E-02	4.00E-02	9.36E-02

Nuclide	COEF(soil-plant), Bq/kg per Bq/kg of soil						
	concentration factor Biv soil/pasture (feed)	concentration factor Biv (soil/grain)	concentration factor Biv (soil/vegetables)	concentration factor Biv (soil/leafy veg.)	concentration factor Biv (soil/fruits)	concentration factor Biv (soil/potatoes)	concentration factor Biv (soil/beet)
SR93	3.12E-01	9.68E-02	2.88E-02	6.08E-02	1.70E-02	4.00E-02	9.36E-02
TC96	1.824E+01	1.144E+00	1.30E+01	1.44E+01	2.60E-01	5.75E-02	5.98E+00
TC99M	1.824E+01	1.144E+00	1.30E+01	1.44E+01	2.60E-01	5.75E-02	5.98E+00
TE131M	2.40E-01	8.80E-02	2.40E-02	2.40E-02	1.30E+00	5.00E-02	3.90E-02
TE132	2.40E-01	8.80E-02	2.40E-02	2.40E-02	1.30E+00	5.00E-02	3.90E-02
TH227	2.376E-02	1.848E-03	6.24E-05	9.60E-05	9.45E-04	5.00E-05	1.04E-04
TH231	2.376E-02	1.848E-03	6.24E-05	9.60E-05	9.45E-04	5.00E-05	1.04E-04
TH232	2.376E-02	1.848E-03	6.24E-05	9.60E-05	9.45E-04	5.00E-05	1.04E-04
U235	1.104E-02	5.456E-03	1.20E-03	1.60E-03	1.80E-03	1.25E-03	1.092E-03
W187	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE125	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE131M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE133	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE133M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE135	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE135M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE138	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Y88	1.20E-03	4.40E-04	1.60E-04	1.60E-04	6.00E-04	2.50E-04	2.60E-04
Y91M	1.20E-03	4.40E-04	1.60E-04	1.60E-04	6.00E-04	2.50E-04	2.60E-04
Y92	1.20E-03	4.40E-04	1.60E-04	1.60E-04	6.00E-04	2.50E-04	2.60E-04
Y93	1.20E-03	4.40E-04	1.60E-04	1.60E-04	6.00E-04	2.50E-04	2.60E-04
Y94	1.20E-03	4.40E-04	1.60E-04	1.60E-04	6.00E-04	2.50E-04	2.60E-04
ZN65	2.40E-01	1.584E+00	3.36E-02	1.92E-01	9.00E-02	7.50E-02	2.47E-01
ZN69M	2.40E-01	1.584E+00	3.36E-02	1.92E-01	9.00E-02	7.50E-02	2.47E-01
ZR89	2.40E-03	8.80E-04	3.20E-04	3.20E-04	0.00E+00	5.00E-04	5.20E-04
ZR95	2.40E-03	8.80E-04	3.20E-04	3.20E-04	1.80E-03	5.00E-04	5.20E-04
ZR97	2.40E-03	8.80E-04	3.20E-04	3.20E-04	1.80E-03	5.00E-04	5.20E-04

Note: in case of BNPP the constants and transfer factors will be updated and accommodated to specific subtropical and arid conditions, on the base of data tabulated and summarized in the IAEA-TECDOC-1616 and other IAEA data sources.

Tab. 11: Conversion factors for exposure to contaminated ground, CONV_FACTOR (depo, i)

Nuclide	Conversion factors for exposure to contaminated ground
	Sv/s / Bq/m2
AC228	0.00E+00
AG110M	2.40E-15
AM241	2.60E-17
AR41	0.00E+00
AS76	0.00E+00
BA133	0.00E+00
BA139	0.00E+00
BA140	1.40E-16
BI211	0.00E+00
BI212	0.00E+00
BI214	0.00E+00
BR82	0.00E+00
BR84	0.00E+00
C14inorg	0.00E+00
C14org	0.00E+00
CD109	0.00E+00
CE139	0.00E+00
CE141	8.00E-17
CE144	2.10E-17
CL38	0.00E+00
CO57	1.20E-16
CO58	8.40E-16
CO60	2.00E-15
CR51	3.20E-17
CS134	1.40E-15
CS136	0.00E+00
CS137	5.30E-16
CS138	1.90E-15
CU64	0.00E+00
EU152	0.00E+00
EU154	1.00E-15
FE59	9.70E-16
FE55	0.00E+00
H3	0.00E+00
H3org	0.00E+00
HF181	0.00E+00
HG203	0.00E+00
I124	0.00E+00
I126	0.00E+00
I130	0.00E+00
I131aer	3.80E-16
I131elem	3.80E-16
I132aer	2.00E-15
I132elem	2.00E-15

Nuclide	Conversion factors for exposure to contaminated ground
	Sv/s / Bq/m2
I133aer	5.60E-16
I133elem	5.60E-16
I134aer	2.20E-15
I134elem	2.20E-15
I135aer	1.30E-15
I135elem	1.30E-15
K40	0.00E+00
K42	0.00E+00
KR85	0.00E+00
KR85M	0.00E+00
KR87	0.00E+00
KR88	0.00E+00
KR89	0.00E+00
LA140	1.80E-15
MN54	7.00E-16
MN56	0.00E+00
MO90	0.00E+00
MO99	1.40E-16
NA22	1.90E-15
NA24	3.20E-15
NB94	0.00E+00
NB95	8.60E-16
NB95M	0.00E+00
NB96	0.00E+00
NB97	0.00E+00
NI65	0.00E+00
PA231	0.00E+00
PA234	0.00E+00
PA234M	0.00E+00
PB211	0.00E+00
PB212	0.00E+00
PB214	0.00E+00
PU238	2.20E-19
PU239	1.30E-19
RA226	0.00E+00
RB83	0.00E+00
RB88	5.20E-16
RB89	1.60E-15
RH105	0.00E+00
RH106M	0.00E+00
RN219	0.00E+00
RU103	4.50E-16
RU106	1.90E-16
SB122	0.00E+00

Nuclide	Conversion factors for exposure to contaminated ground
	Sv/s / Bq/m2
SB124	1.50E-15
SB125	4.00E-16
SB126	0.00E+00
SC46	0.00E+00
SE75	0.00E+00
SN113	0.00E+00
SR85	0.00E+00
SR89	1.10E-19
SR90	0.00E+00
SR91	0.00E+00
SR92	0.00E+00
SR93	0.00E+00
TC96	0.00E+00
TC99M	1.40E-16
TE129M	0.00E+00
TE131M	0.00E+00
TE132	0.00E+00
TH227	0.00E+00
TH231	0.00E+00
TH232	0.00E+00
U235	0.00E+00
W187	0.00E+00
XE125	0.00E+00
XE131M	0.00E+00
XE133	0.00E+00
XE133M	0.00E+00
XE135	0.00E+00
XE135M	0.00E+00
XE138	0.00E+00
Y88	0.00E+00
Y91M	0.00E+00
Y92	0.00E+00
Y93	0.00E+00
Y94	0.00E+00
ZN65	9.80E-16
ZN69M	0.00E+00
ZR89	0.00E+00
ZR95	9.40E-16
ZR97	0.00E+00

Tab. 12: Dose factors for external exposure to water, COEF(extern-water, i)

Nuclide	**Dose factors for external exposure to water, Sv/s / Bq/m3**						
	eff.dose equivalent	gonads	bone marrow	lung	thyroid	colon	skin
AC228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AG110M	2.70E-13	2.60E-13	2.90E-13	2.70E-13	2.30E-13	2.50E-13	3.90E-13
AM241	2.20E-15	1.90E-15	4.00E-15	1.70E-15	2.70E-15	0.00E+00	2.80E-15
AR41	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AS76	4.20E-14	4.50E-14	4.80E-14	4.30E-14	3.40E-14	3.60E-14	5.40E-14
BA133	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BA139	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BA140	1.50E-14	1.70E-14	1.80E-14	1.40E-14	0.00E+00	1.20E-14	4.10E-14
BI211	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BI212	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BI214	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BR82	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BR84	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C14inorg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C14org	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CD109	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CE139	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CE141	7.60E-15	8.70E-15	1.20E-14	6.70E-15	8.30E-15	5.10E-15	1.10E-13
CE144	1.90E-15	2.10E-15	3.00E-15	1.60E-15	2.20E-15	0.00E+00	6.70E-15
CL38	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CO57	1.40E-14	1.50E-14	2.30E-14	1.30E-14	1.60E-14	8.70E-15	1.70E-14
CO58	9.20E-14	9.60E-14	1.00E-13	9.10E-14	0.00E+00	8.40E-14	1.60E-13
CO60	2.50E-13	2.20E-13	2.70E-13	2.50E-13	2.30E-13	2.60E-13	3.60E-13
CR51	3.20E-15	3.90E-15	4.10E-15	3.00E-15	0.00E+00	2.50E-15	4.50E-15
CS134	1.50E-13	1.60E-13	1.70E-13	1.50E-13	0.00E+00	1.30E-13	2.20E-13
CS136	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CS137	5.70E-14	6.20E-14	6.50E-14	5.60E-14	0.00E+00	5.00E-14	9.10E-14
CS138	2.40E-13	2.20E-13	2.50E-13	2.40E-13	2.50E-13	2.60E-13	3.10E-13
CU64	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EU152	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EU154	1.20E-13	1.10E-13	1.30E-13	1.20E-13	1.10E-13	1.20E-13	1.80E-13
FE55	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FE59	1.20E-13	1.00E-13	1.30E-13	1.20E-13	1.10E-13	1.20E-13	1.70E-13
H3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
H3org	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
HF181	5.80E-14	6.60E-14	7.10E-14	5.30E-14	5.20E-14	4.60E-14	6.80E-14
HG203	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I124	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I126	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I130	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I131aer	3.90E-14	4.50E-14	4.80E-14	3.60E-14	0.00E+00	3.10E-14	6.40E-14
I131elem	3.90E-14	4.50E-14	4.80E-14	3.60E-14	0.00E+00	3.10E-14	6.40E-14
I132aer	2.20E-13	2.20E-13	2.50E-13	2.20E-13	1.90E-13	2.00E-13	3.40E-13
I132elem	2.20E-13	2.20E-13	2.50E-13	2.20E-13	1.90E-13	2.00E-13	3.40E-13
I133aer	6.00E-14	6.60E-14	6.90E-14	5.80E-14	0.00E+00	5.20E-14	1.10E-13
I133elem	6.00E-14	6.60E-14	6.90E-14	5.80E-14	0.00E+00	5.20E-14	1.10E-13
I134aer	2.50E-13	2.40E-13	2.80E-13	2.50E-13	2.10E-13	2.40E-13	3.80E-13
I134elem	2.50E-13	2.40E-13	2.80E-13	2.50E-13	2.10E-13	2.40E-13	3.80E-13
I135aer	1.60E-13	1.30E-13	1.70E-13	1.60E-13	1.50E-13	1.70E-13	2.10E-13

Nuclide	**Dose factors for external exposure to water, Sv/s / Bq/m3**						
	eff.dose equivalent	gonads	bone marrow	lung	thyroid	colon	skin
I135elem	1.60E-13	1.30E-13	1.70E-13	1.60E-13	1.50E-13	1.70E-13	2.10E-13
K40	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
K42	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR85M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR87	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR88	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR89	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LA140	2.30E-13	2.10E-13	2.50E-13	2.30E-13	2.30E-13	2.50E-13	3.70E-13
MN54	7.80E-14	8.00E-14	8.80E-14	7.80E-14	0.00E+00	7.30E-14	1.20E-13
MN56	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MO90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MO99	1.50E-14	1.60E-14	1.80E-14	1.50E-14	0.00E+00	1.30E-14	4.10E-14
NA22	2.20E-13	2.10E-13	2.40E-13	2.20E-13	2.00E-13	2.10E-13	3.10E-13
NA24	4.60E-13	4.50E-13	4.30E-13	4.40E-13	5.30E-13	5.10E-13	6.00E-13
NB94	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NB95	7.20E-14	7.50E-14	8.10E-14	7.20E-14	0.00E+00	6.60E-14	1.10E-13
NB95M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NB96	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NB97	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NI65	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PA231	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PA234	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PA234M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PB211	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PB212	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PB214	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PU238	3.70E-18	6.30E-18	6.20E-18	2.40E-18	0.00E+00	0.00E+00	6.60E-17
PU239	6.40E-18	7.30E-18	1.00E-17	5.20E-18	6.80E-18	0.00E+00	3.10E-16
RA226	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RB83	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RB88	6.90E-14	6.70E-14	6.80E-14	6.80E-14	7.00E-14	7.90E-14	2.90E-13
RB89	2.10E-13	1.80E-13	2.20E-13	2.10E-13	2.10E-13	2.30E-13	3.70E-13
RH105	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RH106M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RN219	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RU103	4.70E-14	5.30E-14	5.50E-14	4.40E-14	0.00E+00	3.80E-14	5.60E-14
RU106	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SB122	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SB124	1.80E-13	1.60E-13	2.00E-13	1.90E-13	1.80E-13	2.00E-13	2.40E-13
SB125	4.20E-14	4.70E-14	5.00E-14	3.90E-14	0.00E+00	3.40E-14	5.40E-14
SB126	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SC46	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SE75	4.70E-14	5.80E-14	6.30E-14	3.90E-14	4.80E-14	3.70E-14	5.40E-14
SN113	3.20E-14	3.70E-14	3.70E-14	2.50E-14	3.00E-14	2.70E-14	3.50E-14
SR85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SR89	1.30E-17	1.30E-17	1.40E-17	1.30E-17	0.00E+00	1.20E-17	3.00E-14
SR90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SR91	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SR92	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SR93	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Nuclide	Dose factors for external exposure to water, Sv/s / Bq/m3						
	eff.dose equivalent	gonads	bone marrow	lung	thyroid	colon	skin
TC96	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TC99M	1.30E-14	1.50E-14	2.00E-14	1.20E-14	1.50E-14	8.80E-15	1.50E-14
TE129M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TE131M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TE132	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TH227	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TH231	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TH232	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U235	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
W187	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE125	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE131M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE133	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE133M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE135	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE135M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE138	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Y88	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Y91M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Y92	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Y93	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Y94	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ZN65	5.60E-14	5.20E-14	6.00E-14	5.60E-14	4.80E-14	5.60E-14	7.90E-14
ZN69M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ZR89	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ZR95	7.00E-14	7.30E-14	7.90E-14	6.90E-14	0.00E+00	6.30E-14	1.10E-13
ZR97	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Tab. 13: Dose factors for external exposure to cloud

Nuclide	Dose factors for external exposure to cloud, Sv/s / Bq/m3, CLOUD(i)						
	eff. dose equivalent	gonads	bone marrow	lung	thyroid	colon	skin
AC228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AG110M	1.30E-13	1.20E-13	1.40E-13	1.20E-13	1.10E-13	1.20E-13	1.60E-13
AM241	8.40E-16	7.30E-16	1.60E-15	6.40E-16	1.10E-15	0.00E+00	1.10E-15
AR41	6.13E-14	5.30E-14	6.40E-14	6.10E-14	5.80E-14	6.40E-14	7.50E-14
AS76	1.80E-14	1.90E-14	2.00E-14	1.80E-14	1.40E-14	1.50E-14	2.30E-14
BA133	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BA139	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BA140	6.80E-15	7.80E-15	8.20E-15	6.40E-15	0.00E+00	5.50E-15	8.40E-15
BI211	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BI212	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BI214	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BR82	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BR84	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C14inorg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C14org	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CD109	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CE139	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CE141	3.50E-15	4.00E-15	5.40E-15	3.10E-15	3.90E-15	2.40E-15	4.30E-15
CE144	8.60E-16	9.40E-16	1.40E-15	7.40E-16	9.90E-16	0.00E+00	1.10E-15
CL38	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CO57	5.60E-15	6.10E-15	9.10E-15	5.40E-15	6.30E-15	3.50E-15	7.00E-15
CO58	4.30E-14	4.50E-14	4.90E-14	4.30E-14	0.00E+00	3.90E-14	5.70E-14
CO60	1.20E-13	1.00E-13	1.20E-13	1.20E-13	1.10E-13	1.20E-13	1.50E-13
CR51	1.50E-15	1.80E-15	1.90E-15	1.40E-15	0.00E+00	1.20E-15	1.8-15
CS134	7.00E-14	7.40E-14	7.90E-14	6.80E-14	0.00E+00	6.20E-14	9.00E-14
CS136	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CS137	2.70E-14	2.90E-14	3.10E-14	2.60E-14	0.00E+00	2.40E-14	3.40E-14
CS138	1.10E-13	1.00E-13	1.20E-13	1.10E-13	1.10E-13	1.20E-13	1.40E-13
CU64	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EU152	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EU154	5.60E-14	5.30E-14	6.20E-14	5.50E-14	4.90E-14	5.30E-14	7.20E-14
FE55	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FE59	5.40E-14	4.90E-14	5.80E-14	5.50E-14	4.90E-14	5.50E-14	7.00E-14
H3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
H3org	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
HF181	2.40E-14	2.80E-14	3.00E-14	2.20E-14	2.20E-14	1.90E-14	2.80E-14
HG203	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I124	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I126	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I130	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I131aer	1.80E-14	2.10E-14	2.20E-14	1.70E-14	0.00E+00	1.40E-14	2.20E-14
I131elem	1.80E-14	2.10E-14	2.20E-14	1.70E-14	0.00E+00	1.40E-14	2.20E-14
I132aer	1.00E-13	1.00E-13	1.20E-13	1.00E-13	8.70E-14	9.50E-14	1.30E-13
I132elem	1.00E-13	1.00E-13	1.20E-13	1.00E-13	8.70E-14	9.50E-14	1.30E-13
I133aer	2.80E-14	3.10E-14	3.20E-14	2.70E-14	0.00E+00	2.40E-14	3.50E-14
I133elem	2.80E-14	3.10E-14	3.20E-14	2.70E-14	0.00E+00	2.40E-14	3.50E-14
I134aer	1.20E-13	1.10E-13	1.30E-13	1.20E-13	1.00E-13	1.10E-13	1.60E-13
I134elem	1.20E-13	1.10E-13	1.30E-13	1.20E-13	1.00E-13	1.10E-13	1.60E-13
I135aer	7.20E-14	6.30E-14	7.80E-14	7.40E-14	7.00E-14	7.80E-14	9.30E-14

Nuclide	Dose factors for external exposure to cloud, Sv/s / Bq/m3, CLOUD(i)						
	eff. dose equivalent	gonads	bone marrow	lung	thyroid	colon	skin
I135elem	7.20E-14	6.30E-14	7.80E-14	7.40E-14	7.00E-14	7.80E-14	9.30E-14
K40	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
K42	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR85	2.55E-16	1.40E-16	1.60E-16	1.20E-16	0.00E+00	0.00E+00	1.30E-16
KR85M	6.83E-15	9.20E-15	1.20E-14	7.20E-15	8.30E-15	5.80E-15	9.20E-15
KR87	3.94E-14	3.60E-14	4.20E-14	3.90E-14	3.90E-14	4.40E-14	4.70E-14
KR88	9.72E-14	9.70E-14	9.70E-14	9.70E-14	1.00E-13	1.20E-13	1.20E-13
KR89	9.00E-14	8.00E-14	9.30E-14	8.90E-14	1.00E-13	9.70E-14	1.10E-13
LA140	1.10E-13	9.60E-14	1.20E-13	1.10E-13	1.10E-13	1.20E-13	1.30E-13
MN54	3.60E-14	3.70E-14	4.10E-14	3.60E-14	0.00E+00	3.40E-14	5.00E-14
MN56	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MO90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MO99	7.10E-15	7.70E-15	8.50E-15	7.00E-15	0.00E+00	6.30E-15	9.40E-15
NA22	1.00E-13	1.00E-13	1.10E-13	1.00E-13	9.30E-14	9.70E-14	1.30E-13
NA24	2.20E-13	2.10E-13	2.00E-13	2.00E-13	2.50E-13	2.40E-13	2.50E-13
NB94	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NB95	3.40E-14	3.50E-14	3.80E-14	3.30E-14	0.00E+00	3.10E-14	4.50E-14
NB95M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NB96	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NB97	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NI65	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PA231	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PA234	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PA234M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PB211	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PB212	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PB214	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PU238	1.60E-18	2.70E-18	2.70E-18	1.00E-18	0.00E+00	0.00E+00	3.10E-17
PU239	2.90E-18	3.30E-18	4.60E-18	2.40E-18	3.20E-18	0.00E+00	1.40E-17
RA226	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RB83	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RB88	3.20E-14	3.10E-14	3.20E-14	3.20E-14	3.20E-14	3.70E-14	3.60E-14
RB89	9.70E-14	8.60E-14	1.00E-13	9.90E-14	9.70E-14	1.10E-13	1.30E-13
RH105	9.40E-15	1.00E-14	1.10E-14	9.10E-15	0.00E+00	8.20E-15	1.20E-14
RH106M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RN219	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RU103	2.20E-14	2.50E-14	2.60E-14	2.10E-14	0.00E+00	1.80E-14	2.70E-14
RU106	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SB122	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SB124	8.50E-14	7.40E-14	9.40E-14	8.70E-14	8.30E-14	9.20E-14	1.10E-13
SB125	1.80E-14	1.20E-14	2.10E-14	1.40E-14	1.80E-14	1.60E-14	1.90E-14
SB126	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SC46	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SE75	1.90E-14	2.40E-14	2.60E-14	1.60E-14	2.00E-14	1.50E-14	2.20E-14
SN113	1.30E-14	1.60E-14	1.60E-14	1.10E-14	1.30E-14	1.10E-14	1.50E-14
SR85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SR89	5.90E-18	5.90E-18	6.50E-18	6.00E-18	0.00E+00	5.60E-18	8.20E-18
SR90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SR91	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SR92	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SR93	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Nuclide	Dose factors for external exposure to cloud, Sv/s / Bq/m3, CLOUD(i)						
	eff. dose equivalent	gonads	bone marrow	lung	thyroid	colon	skin
TC96	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TC99M	6.10E-15	6.80E-15	9.40E-15	5.40E-15	6.70E-15	4.10E-15	7.30E-15
TE129M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TE131M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TE132	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TH227	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TH231	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TH232	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U235	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
W187	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE125	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE131M	3.70E-16	5.60E-16	6.40E-16	2.80E-16	0.00E+00	0.00E+00	7.90E-16
XE133	1.39E-15	1.80E-15	3.10E-15	1.30E-15	2.00E-15	0.00E+00	2.20E-15
XE133M	1.27E-15	1.90E-15	2.10E-15	1.20E-15	0.00E+00	0.00E+00	2.00E-15
XE135	1.11E-14	1.60E-14	1.70E-14	1.10E-14	0.00E+00	0.00E+00	1.50E-14
XE135M	1.85E-14	2.30E-14	2.40E-14	1.90E-14	0.00E+00	0.00E+00	2.40E-14
XE138	5.44E-14	4.70E-14	5.80E-14	5.60E-14	5.30E-14	6.10E-14	6.80E-14
Y88	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Y91M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Y92	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Y93	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Y94	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ZN65	2.60E-14	2.40E-14	2.80E-14	2.60E-14	2.20E-14	2.60E-14	3.50E-14
ZN69M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ZR89	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ZR95	3.30E-14	3.40E-14	3.70E-14	3.20E-14	0.00E+00	3.00E-14	4.30E-14
ZR97	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Tab. 14: Other constants of the program

Note: in case of BNPP the constants and transfer factors will be updated and accommodated to specific subtropical and arid conditions, on the base of data tabulated and summarized in the IAEA-TECDOC-1616 and other IAEA data sources.

Other constants of the program:			
CONST_IRR	3.28E-08	[m/s]	IRR, irrigation rate
CONST_tIRR	5.18E+06	[s]	t_{IRR} ...the time interval during which the plants are irrigated, in [s], 6 months, 8 hours per day
CONST_ro_sediment	40	[kg/m2]	effective surface density of sediment
CONST_tb_sediment	3.15E+07	[s]	the length of time the sediment is exposed to the contaminated water, 1 year
CONST_ts_meat	1.73E+06	[s]	t_s , the average time from slaughter to consumption
CONST_t_e_milk	2.59E+06	[s]	t_e ...is the time interval during which the plants are exposed to contamination (during the growing season), pathway plant (pasture) → cow → milk → human
CONST_t_e_plant	5.18E+06	[s]	t_e ...is the time interval during which the plants are exposed to contamination (during the growing season), pathway plant → human
CONST_tb_soil	4.72E+08	[s]	t_b ... is the time interval during which the activity is uprooted from soil/sediment through roots to edible parts of the plant (this value is connected with the time period over which the accumulation of radiological impacts is evaluated; operating lifetime of the facility, e.g. 30 years)
CONST_p_soil	2.40E+02	[kg/m2]	p, the effective surface density for soil in the root zone
CONST_t_h_pasture_animal	0.00E+00	[s]	t_h, the holdup time between harvest and consumption, pathway pasture - animal
CONST_t_h_stable_animal	7.78E+06	[s]	t_h, 90 days, the holdup time between harvest and consumption, pathway stable - animal
CONST_t_h_leafy_human	8.64E+04	[s]	t_h, 1 day, the holdup time between harvest and consumption of leafy vegetables
CONST_t_h_veg_human	5.18E+06	[s]	t_h, 60 days, the holdup time between harvest and consumption, pathway other agricultural products - human
CONST_t_h_average_col	1.21E+06	[s]	t_h, 14 days, the holdup time between harvest and consumption, all products, collective doses
CONST_Q_cow	5.00E+01	[kg/day]	Q_F , the amount of feed consumed by the cow per day
CONST_Q_goat	6.00E+00	[kg/day]	Q_F , the amount of feed consumed by the goat per day
CONST_Q_poultry	2.00E-01	[kg/day]	Q_F , the amount of feed consumed by the poultry per day
CONST_Q_water_cow_milk	6.00E+01	[l/day]	daily water consumption, milk cow
CONST_Q_water_cow_meat	5.00E+01	[l/day]	daily water consumption, beef cattle
CONST_Q_water_goat	8.00E+00	[l/day]	daily water consumption, goat
CONST_Q_water_poultry	1.00E-01	[l/day]	daily water consumption, poultry
CONST_t_F_milk	1.73E+05	[s]	t_F , 2 days, is the average transport time of the activity from the feed into the milk
CONST_f_L_leafy	1.00E+00	[-]	fraction of leafy vegetables intake for individuals that is grown in local gardens
CONST_f_G_veg	7.60E-01	[-]	fraction of other agricultural products for individuals that is grown in local gardens
CONST_f_p_pasture	5.00E-01	[-]	6/12, fraction of the year (or period of time) that beef cattle or goats are on pasture
CONST_f_s_feed	1.00E+00	[-]	100%, fraction of daily feed intake that is from pasture while beef cattle or goats are on pasture
Breathing rate(0-1)	3.17E-05	[m3/s]	1000/(365*24*3600), breathing rate

Other constants of the program:			
Breathing rate(1-2)	6.34E-05	[m3/s]	2000/(365*24*3600), breathing rate
Breathing rate(2-7)	1.27E-04	[m3/s]	4000/(365*24*3600), breathing rate
Breathing rate (7-12)	1.90E-04	[m3/s]	6000/(365*24*3600), breathing rate
Breathing rate(12-17)	2.54E-04	[m3/s]	8000/(365*24*3600), breathing rate
Breathing rate(>17)	2.69E-04	[m3/s]	8500/(365*24*3600), breathing rate
CONST_T_swimming	1.40E+04	[s]	annual swimming exposure time
CONST_T_boating	3.60E+05	[s]	annual boating usage time (fisherman)
CONST_T_shoreline	7.20E+05	[s]	annual shoreline usage time (fisherman)
CONST_fi_humidity	9.00E-03	[kg/m3]	average absolute humidity, over the growing season
CONST_WATER_(0-1)	2.50E+02	[l/yr]	drinking water intake, age category 0-1 year
CONST_WATER_(1-2)	2.50E+02	[l/yr]	drinking water intake, age category 1-2 years
CONST_WATER_(2-7)	4.50E+02	[l/yr]	drinking water intake, age category 2-7 years
CONST_WATER_(7-12)	4.50E+02	[l/yr]	drinking water intake, age category 7-12 years
CONST_WATER_(12-17)	4.50E+02	[l/yr]	drinking water intake, age category 12-17 years
CONST_WATER_(>17)	7.00E+02	[l/yr]	drinking water intake, age category > 17 years
CONST_t_SWIMMING_(0-1)	0.00E+00	[s]	$T_{SWIMMING}$ ... annual swimming exposure time, age category 0-1 year
CONST_t_SWIMMING_(1-2)	0.00E+00	[s]	$T_{SWIMMING}$ ... annual swimming exposure time, age category 1-2 years
CONST_t_SWIMMING_(2-7)	1.40E+04	[s]	$T_{SWIMMING}$ ... annual swimming exposure time, age category 2-7 years
CONST_t_SWIMMING_(7-12)	1.40E+04	[s]	$T_{SWIMMING}$ ... annual swimming exposure time, age category 7-12 years
CONST_t_SWIMMING_(12-17)	1.40E+04	[s]	$T_{SWIMMING}$ ... annual swimming exposure time, age category 12-17 years
CONST_t_SWIMMING_(>17)	1.40E+04	[s]	$T_{SWIMMING}$ ... annual swimming exposure time, age category > 17 years
CONST_t_BOATING_(0-1)	0.00E+00	[s]	$T_{BOATING}$ ... annual boating usage time, age category 0-1 year
CONST_t_BOATING_(1-2)	0.00E+00	[s]	$T_{BOATING}$ ... annual boating usage time, age category 1-2 years
CONST_t_BOATING_(2-7)	3.60E+05	[s]	$T_{BOATING}$ ... annual boating usage time, age category 2-7 years
CONST_t_BOATING_(7-12)	3.60E+05	[s]	$T_{BOATING}$ ... annual boating usage time, age category 7-12 years
CONST_t_BOATING_(12-17)	3.60E+05	[s]	$T_{BOATING}$ ... annual boating usage time, age category 12-17 years
CONST_t_BOATING_(>17)	3.60E+05	[s]	$T_{BOATING}$ ... annual boating usage time, age category above 17 years
CONST_t_SHORELINE_(0-1)	0.00E+00	[s]	T_{SHORE} ...annual shoreline usage time, age category 0-1 years
CONST_t_SHORELINE_(1-2)	0.00E+00	[s]	T_{SHORE} ...annual shoreline usage time, age category 1-2 years
CONST_t_SHORELINE_(2-7)	7.20E+05	[s]	T_{SHORE} ...annual shoreline usage time, age category 2-7 years
CONST_t_SHORELINE_(7-12)	7.20E+05	[s]	T_{SHORE} ...annual shoreline usage time, age category 7-12 years
CONST_t_SHORELINE_(12-17)	7.20E+05	[s]	T_{SHORE} ...annual shoreline usage time, age category 12-17 years
CONST_t_SHORELINE_(>17)	7.20E+05	[s]	T_{SHORE} ...annual shoreline usage time, age category > 17 years
CONST_accumulation_T	9.46E+08	[s]	time period over which the accumulation of radiological impacts is evaluated; operating lifetime of the facility (e.g. 30 years)

6. EQUATIONS

6.1 External dose from ground deposits

$$D_{depo} = a_d(i)\ .\ CONV\_FACTOR\ (depo,\ i)\ [Sv] \cdot \frac{1 - e^{-\lambda(i) \cdot t}}{\lambda(i)}$$

where:

$a_d(i)$ ... a deposition of nuclide *(i)*, [Bq/m^2] per hr (deposition caused by 1 h release to the atmosphere)

CONV_FACTOR (depo, i) ... [Sv.s^{-1}/Bq.m^{-2}]
... is the dose conversion factor for ground deposits for nuclide (i)
... see the Table 12

e.g. in case of Cs-137: CONV_FACTOR (depo, i) = 5.3 . 10^{-16} . 3600

t ... (=CONST_accumulation_T, see the Table 16 with constants) is the time period over which the accumulation of radiological impacts is evaluated, e.g. 40 years

$\lambda(i)$ ... [s^{-1}], is the radiological decay constant for nuclide (i), see the Table 1

6.2 External dose from cloud, D^{CLOUD}, [Sv]

1) $D^{CLOUD}(i) = a(i) \,.\, CLOUD(i)$

where:

a(i) ... TIC, $Bq.s.m^{-3}$, is the time integral of concentration of nuclide (i) in the air

CLOUD(i) ... dose conversion factor for external exposure to cloud, $[Sv.s^{-1}.Bq^{-1}.m^{3}]$

... see the Table 14

2) if $D^{CLOUD}(i) < D^{CLOUD}$*(i, specific factors for calculation up to the distance of 3 km),*

then:

$D^{CLOUD}(i) \equiv D^{CLOUD}$*(i, specific factors for calculation up to the distance of 3 km)*,

otherwise:

$D^{CLOUD}(i) \equiv D^{CLOUD}(i)$

6.3 Dose from inhalation, D^{INH}

The dose from inhalation of nuclide (i) for the age category (age):

$D^{INH}(i, age) = a(i) \cdot INH(i, age) \cdot Breathing\ rate(age)$

where:

a(i) ... TIC, Bq.s.m^{-3}, is the time integral of concentration of nuclide (i) in the air

INH(i, age) ... conversion factor for committed effective dose by inhalation (Sv/Bq) for nuclide (i) and (age), see the Table 5

Breathing rate(age) ... breathing rate, [m^3/s], see the Table 16 with constants

6.4 Ingestion Dose, D^{ING}

$D^{ING}(i, age, milk(cow\ or\ goat))$

$D^{ING}(i, age, meat)$

$D^{ING}(i, age, leafy\ veg.)$

$D^{ING}(i, age, other\ products)$

i ... nuclide

age ... age category 0-1, 1-2, 2-7, 7-12, 12-17, adults

sum cow milk = $\sum_i D(i, age, milk\ (cow))$

sum goat milk = $\sum_i D(i, age, milk\ (goat))$

sum meat = $\sum_i D(i, age, meat)$

sum leafy = $\sum_i D(i, age, leafy\ veg.)$

sum other products = $\sum_i D(i, age, other\ products.)$

6.4.1 Milk

D(i, age, milk (cow)) = c(milk cow, i) . ING(i, age) . U(milk cow, age) ... the dose from nuclide (i), for age category (*age*), from ingestion of cow milk

where:

c(milk cow, i) ... activity of nuclide "i" in cow milk

ING (i, age) ... ... conversion factor for committed effective dose by ingestion (Sv/Bq) for nuclide (i) and (age), see the Table 6

U(milk cow, age) ... cow milk consumption rate for the age category (age)

Similarly D(i, age, milk goat)

6.4.2 Meat

D(i, age, meat) = c(meat, i) . ING(i, age) . U(meat, age) . $\boldsymbol{f_G}$

where:

c(meat, i) ... activity in meat, nuclide “i”

ING (i, age) ... ... conversion factor for committed effective dose by ingestion (Sv/Bq) for nuclide (i) and (age), see the Table 6

U(meat, age) ... meat consumption rate for the age category (age)

f_G ... fraction of the product consumption coming from animals bred locally

6.4.3 Leafy vegetables

D(i, age, leafy) = c(leafy, i) . ING(i, age) . U(leafy, age) . $\boldsymbol{f_L}$

where:

c(leafy, i) ... activity in leafy vegetables, nuclide “i”

ING (i, age) ... ... conversion factor for committed effective dose by ingestion (Sv/Bq) for nuclide (i) and (age), see the Table 6

U(leafy, age) ... cow milk consumption rate for the age category (age)

f_L ... fraction of leafy vegetables consumption growing in local garden (for example $f_L \equiv 1.0$)

6.4.4 Other products

D(i, age, other products) = c(others, i) . ING(i, age) . U(others, age) . $\boldsymbol{f_G}$

where:

c(others, i) ... activity of nuclide “i” in the product

ING (i, age) ... ... conversion factor for committed effective dose by ingestion (Sv/Bq) for nuclide (i) and (age), see the Table 6

U(others, age) ... that product consumption rate for the age category (age)

f_G ... fraction of the product consumption growing in local garden (for example f_G = 0,75)

6.5 Deposit on irrigated soil due to irrigation

$$d_{\mathrm{SOILIRR}}(i) = A_{WATER}(i,x) \cdot IRR$$

where:

$d_{SOIL\ IRR}$ *(i)* ... [Bq.m^{-2}.s^{-1}], deposit on irrigated soil due to irrigation

A_{WATER} ... [Bq.m^{-3}], volume activity of water, nuclide “i” at the place “x” of input into irrigation system

IRR ... [m.s^{-1}], irrigation rate ... for example =$3{,}28 \cdot 10^{-8}$ m/s, see the Table 16 (constants)

6.6 Tritium, H-3 (airborne pathway)

Concentration of H-3 in plant (it is assumed that tritium is uniformly distributed throughout the plant at one-half of the tritium concentration found in atmospheric moisture water):

$$A_M\left(plant, H\text{-}3, ATM\right) = A_V\left(air, H\text{-}3\right) \cdot 0{,}75 \cdot 0{,}5 \cdot \left(\varphi^{-1}\right)$$

where:

$A_M\left(plant, H\text{-}3, ATM\right)$... [Bq/kg] ... the tritium concentration in plant

$A_V\left(air, H\text{-}3\right)$... [Bq/m^3] ... the tritium concentration in air

0,75 ... the fraction of total plant mass that is water

0,5 ... [kg/m^3], the ratio of tritium concentration in plant water to the tritium concentration in atmospheric moisture

φ ... the absolute humidity in air during the growing season, for example = 0,009 [kg/m^3]

6.7 Activity in agricultural products (leafy, non-leafy veg., other plants)

The activity of the nuclide (i) in the product (v) (average, Bq/kg or Bq/l):

$$C(v,i) = d(i) \cdot \left\{ \frac{r \cdot \left(1 - e^{-\lambda_E(i) \cdot t_e}\right)}{y_v \cdot \lambda_E(i)} + \frac{B_{iv} \cdot \left(1 - e^{-\lambda(i) \cdot t_b}\right)}{p \cdot \lambda(i)} \right\} \cdot e^{-\lambda(i) \cdot t_h}$$

The equation is applied for the following exposure pathways:

1) leafy vegetables → human (direct ingestion)
2) other agricultural products → human (direct ingestion)
3) cow fed on fresh pasture → milk → human
4) cow fed in stable → milk → human
5) cow fed on fresh pasture → cow → meat → human
6) cow fed in stable → cow → meat → human

where:

C(v,i) ... [Bq/kg], activity of the nuclide (i) in the product (v)

$d(i)$ ... is the deposition of radionuclide (i) at given point, [Bq/m^2], the average value in given period of time

r ... fraction of deposited activity retained on the plant (e.g on leaves, ...)

r = 1.0 (for all iodines)

r = 0.25 (for all aerosols)

r = 0.0 (for all noble gases)

t_e ...is the time interval during which the plants are exposed to contamination (during the growing season)

t_e = *720 hours (= 30 days)* for the pathway plant (pasture) → cow → milk → human

t_e = *1440 hours (= 60 days)* for the pathway plant → human

t_b ... is the time interval during which the activity is uprooted from soil/sediment through roots to edible parts of the plant (this value is connected with the time period over which the accumulation of radiological impacts is evaluated; operating lifetime of the facility, e.g. 30 years)

example: 15 years: t_b *= 1.31E+05 hours, or 30 years:* t_b *= 2.63E+05 hours*

p ... is the effective "surface density" for soil, in kg (dry soil)/m^2

p = 240 kg/m^2

t_h ... is a holdup time that represents the time interval between the harvest and consumption

$t_h = 0$ ... for fresh pasture (pathway pasture → animal)

t_h = *2160 hours (= 90 days stored)* ... for stabled animals (pathway pasture → animal)

t_h = *24 hours*... for leafy vegetables (pathway leafy veg. → human)

t_h = *1440 hours*... for other agricultural products (pathway other agricultural products → human)

t_h = *336 hours*... average for collective doses

y_v ... yield of the product, [kg/m²],

... default can be for example: $\underline{y_v = 0.7}$ kg/m² for pasture

$\underline{y_v = 2.0}$ kg/m² for all other agricultural products

$\lambda(i)$ ... is the radioactive decay constant of nuclide "i", see Table 1

$\lambda_E(i)$ ... is the effective removal rate constant for radionuclide (i) from plants, in hr^{-1}or in s^{-1}

$$\lambda_E(i) = \underbrace{\lambda(i) + 0.0021}_{\text{corresponds to effective half-time = 14 days}} \; [h^{-1}]$$

B_{iv} ... the transfer factor for soil → pasture (fresh and forage)

soil → grain

soil → non-leafy vegetables

soil → leafy vegetables

soil → potatoes

soil → beet

soil → fruit

6.7.1 Activity in irrigated plants

The activity of the nuclide (i) in the product (v) (average, Bq/kg or Bq/l):

$$C(v,i) = d(i) \cdot \left\{ \frac{r \cdot \left(1 - e^{-\lambda_E(i).t_e}\right)}{y_v \cdot \lambda_E(i)} + f_i \cdot \frac{B_{iv} \cdot \left(1 - e^{-\lambda(i) \cdot t_b}\right)}{p \cdot \lambda(i)} \right\} \cdot e^{-\lambda_{(i)} \cdot t_h}$$

where:

f_i ... is the fraction of the year the plants are irrigated

$$f_i = \frac{t_{IRR}}{number\_of[s]during\_year}$$

t_{IRR} ... the time period when the plants are irrigated, in [s]

all the other parameters are the same as in equation 3.7

6.7.2 Activity in milk

Note:

c(plant, i) ...is the activity in a plant in the cow's or goat's feed

the equation is applied for the following exposure pathways:

pathway No.3 ... cow (or goat) fed on fresh pasture → milk → human

pathway No.4 ... cow (or goat) fed in stable → milk → human

c(milk cow, i) = $F_m(i)$. {f_p . f_s . c(plant, i, t_h = 0, pathway 3) + (1 - f_p) . c(plant, i, t_h = 90 days, pathway 4) + f_p (1 – f_s) . c(plant, i, t_h = 90 days, pathway 4)} . Q_F . $e^{-\lambda(i)\cdot(t_F)}$

where:

c(milk cow, i) ... is the volume activity in cow or goat milk, nuclide "i"

F_m(i, cow) ...is the average fraction of the animal's daily intake of radionuclide (i) which appears in each liter of cow milk, in days/liter (see the Table E-1, R.Guide 1.109 - 37)

F_m(i, goat) ... is the average fraction of the animal's daily intake of radionuclide (i) which appears in each liter of goat milk, in days/liter

Q_F ... is the amount of feed consumed by the animal per day (pasture or forage), see Table 16

Q_F (cow) = 50 kg/day

Q_F (goat) = 6 kg/day

t_F ... is the average transport time of the activity from the feed into the milk, (e.g. = 2 days), see Table 16

$\lambda(i)$ ...is the radiological decay constant of nuclide (i), see the Table 1

6.7.3 Activity in meat

Note:

Note:

“meat” here means beef, lamb, poultry, eggs

c(plant, i) ...is the activity in a plant in the cow’s or goat’s feed

the equation is applied for the following exposure pathways:

pathway No.3 ... cow (or goat) fed on fresh pasture → meat → human

pathway No.4 ... cow (or goat) fed in stable → meat → human

$$c(meat, i) = F_f(i) \,.\, Q_F \,.\, e^{-\lambda(i).(t_s)} \,.\, \{f_p \,.\, f_s \,.\, c(plant, i, t_h = 0, pathway\ 3) + (1 - f_p) \,.\, c(plant, i, t_h = 90, pathway\ 4) + f_p \,.\, (1 - f_s) \,.\, c(plant, i, t_h = 90, pathway\ 4)\}$$

where:

c(meat, i) ... is the volume activity in meat, nuclide “i”

F_f ... is the fraction of the animal’s daily intake of nuclide (i) which appears in each kg of flesh, in days/kg, see Table 9

Q_f ... is the amount of feed consumed by the animal per day, in kg/day, see Table 16

t_s ... is the average time from slaughter to consumption, see Table 16

t_s = 20 days

6.8 Boating ("fishermen")

$$D_{BOATING}(i) = 1 \cdot 10^{-6} \cdot A_V(water, i, r) \cdot g_2 \cdot T_{BOATING} \cdot COEF(extern - water, i)$$

where:

$D_{BOATING}(i)$ ... [Sv], annual (or during another time interval T) dose caused by radionuclide (i) from external exposure during boating

$A_V(water, i, r)$ ... volume activity of water, nuclide (i), location (r), [Bq/m^3]

g_2 ... = 0.5; geometry factor of external exposure from boating

$T_{BOATING}$ ... = changeable constant
≡ 0 for age category 0-1 year
≡ 3,6.10^5 [s] (≅ 100 hours) ... annual boating usage time

$COEF(extern - water, i)$ ... dose factor for external exposure to water, for nuclide (i), see Table 13

6.9 Swimming

$$D_{SWIMMING}(i) = 1 \cdot 10^{-6} \cdot A_V(water, i, r) \cdot g_1 \cdot T_{SWIMMING} \cdot COEF(extern - water, i)$$

where:

$D_{SWIMMING}(i)$ ... [Sv], annual (or during another time interval *T*) dose from radionuclide (i) from external exposure during swimming

$A_V(water, i, r)$ ... volume activity of water, nuclide (i), location (r), [Bq/m^3]

g_1 ... = 1; geometry factor of external exposure from swimming

$T_{SWIMMING}$ ... = changeable constant
≡ 0 for age category 0-1 year
≡ 1,4.10^4 [s] (≅ 4 hours) ... (the other age categories) annual swimming exposure time, in the water with average volume activity A_V

$COEF(extern - water, i)$ ... dose factor for external exposure to water, for nuclide (i), see Table 13

6.10 Stay on the shore ("fisherman")

$$D_{SHORE}(i) = A_S(sed,i,r) \cdot g_3 \cdot T_{SHORE} \cdot COEF(extern - SED,i)$$

where:

$D_{SHORE}(i)$ ... [Sv], annual (or during another period of time T) dose from radionuclide (i) from external exposure during shoreline activities (fisherman)

A_S ... [Bq/m^2], the concentration of nuclide (i) in shoreline sediment, at place „r"

g_3 ... = 0.3; geometry factor of shoreline exposure

T_{SHORE} ... = changeable constant, see Table 16
≡ 0 for age category 0-1 year
≡ 7,2.10^5 [s] (≅ 200 hours per year) ... (the other age categories) annual exposure time to shoreline for an individual (a fisherman)

$COEF(extern - SED, i)$ ... dose factor for external exposure to shoreline sediment, for nuclide (i), see Table 12

6.11 Calculation of activity concentration in sea water

Input parameters:

Q(i,m) … discharge for nuclide (i) in month (m) into the Persian Gulf. Unit: Bq/s.

U … sea current (in m/s). It is a vector field for a prescribed boxing of the Persian Gulf. The user can input the sea current in two ways:
i) Loading file which consists of data describing the monthly average of the water current of the Persian Gulf for the prescribed boxing of the gulf (if available).
ii) Inserting the monthly average of the coastal current of the adjacent part of the gulf near the site. i.e. for a single point. The program, in the next step, extends the inserted single value to the whole computational region.
If no value is inserted the program assumes default coastal current velocity equal to U = 0.1 m/s.

Algorithm:

The algorithm uses a PTM-like model. Using the current vector field the center of each puff is moved, and at the same time the puffs evolve using the given dispersion constants. Each shift of the puff represents its defined movement in time. After each shift we evaluate the corresponding value of concentration for all boxes.

The dispersion is described by formulas:

$$\varepsilon\_x = 4.66 \times 10^{-6} \times (d / U)^{1.34}$$
$$\varepsilon\_y = 3.44 \times 10^{-7} \times (d / U)^{1.34}$$

where t = d / U is the total time of the puff movement, ε_x and ε_y are the longitudinal and lateral dispersion coefficient. The relations are based:

Okubo, A. 1971. “Oceanic Diffusion Diagrams.” Deep Sea Research 18: 789–802.

Further, the model considers assumptions:

a) The puffs move along trajectories given by the vector field of the sea current. The longitudinal and lateral direction is preserved concerning the initial flow direction all the time of puff movement which is assumed to change little near the coast.
b) The dispersion is given by solution of the advection-diffusion equation, whose lateral part is proportional to

$$f_y (y,t) = \mathrm{Exp}\{ - y^2 / (4\ \varepsilon\_y\ \ t) \} / \mathrm{Sqrt}\{ 4 . \pi . \varepsilon\_y .\ t \}$$

and the longitudinal part is proportional to

$$f_x (x,t) = \mathrm{Exp}\{ - (x - U t)^2 / (4\ \varepsilon\_x\ \ t) \} / \mathrm{Sqrt}\{ 4 . \pi . \varepsilon\_x .\ t \} .$$

c) For boxes are larger than 1 km, we assume well-mixed situation in vertical direction all the time.
d) We include reflection term from the coast.

Moving the puffs, the activity concentration for nuclide (i) in each box is determined as time-averaged (over one month) value for all months.

6.12 Activity concentration in shore/beach sediment

Activity concentration in the surface layer of shore sediment for a particular box is evaluated as:

$$A_{shore}(i) = \frac{0.1 \times 0.001 \times K_d(i) \times 60 \times c_{w,tot}(i)}{1 + 0.001 S_s K_d(i)} \times \frac{1 - e^{-\lambda(i) T_e}}{\lambda(i) T_e}$$

where:

A_{shore}(i) … surface concentration for nuclide (i). Unit: Bq/m2.

$c_{w,tot}$(i) … radionuclide concentration in water for the given box. Unit: Bq/m3.

K_d(i) … distribution coefficient for nuclide (i), defined as the ratio of particulate concentration per unit mass and concentration per unit maas of water. Unit: kg/kg to kg/kg or Bq/kg to Bq/kg. Source of constant: TRS 422 – Sediment Distribution Coefficients and Concentration Factors for Biota in the Marine Environment, IAEA, 2004.

0.1 … dimensionless factor defining the apparent K_d for bottom sediment.

T_e … effective accumulation time. T_e = 1 year = 3.15 x 10^7 s.

λ(i) ... decay constant for nuclide (i), see Table 1. Unit: s^{-1}.

S_s … suspended sediment concentration in water. Unit: kg/m3.

0.001 … conversion factor for K_d from unit L/kg to unit m3/kg.

60 … top layer density of sediment (about 5 cm). Unit: kg/m2.

6.13 Dose by stay on the shore

Dose by stay on the shore (received during shoreline activities) is evaluated as:

$D_{shore}(i,age) = A_{shore}(i) \, . \, gf \, . \, T_{shore}(age) \, . \, Df_{shore}(i,age)$

Where:

$D_{shore}(i,age)$ … dose by stay on the shore for nuclide (i) in case of age category (age). Unit: Sv.

$A_{shore}(i)$ … surface concentration for nuclide (i). Unit: Bq/m2.

gf … = 0.3; geometry factor of shoreline exposure

$T_{shore}(age)$ … changeable constant, see Table 16, values can be changed.

≡ 0 for age category 0-1 year

≡ $7{,}2.10^5$ [s] (≅ 200 hours per year)... (the other age categories) annual exposure time to shoreline for an individual.

$Df_{shore}(i,age)$ **…** Dose factor for external exposure to shoreline sediment in case of the age category (age) and nuclide (i). It is defined in the Table 12. Unit: $Sv.s^{-1}/Bq.m^{-2}$.

6.14 Activity in marine animals

Activity concentration in marine animals for a particular box is calculated using the relation:

$$c(i,product) = Cf_{marine}(i,product) \cdot c(i) / 1000$$

where:

c(i,product) … concentration of nuclide (i) in the marine organism (product). Unit: Bq/kg.

c(i) … activity of nuclide (i) in the given box of sea. Unit: Bq/m3.

Cf_{marine}(i,product) … concentration factors for transfer from water to marine animals (product) and nuclide (i). Unit: Bq/kg wet weight of animal to Bq/kg sea water. The factors include cases of fish, crustaceans, macroalgae, zooplankton, phytoplankton. Source of constants: TRS 422 – Sediment Distribution Coefficients and Concentration Factors for Biota in the Marine Environment, IAEA, 2004.

1000 … conversion of m3 to kg (= dm3).

6.15 Dose by ingestion of sea food (marine animals)

Dose by ingestion of marine animal products for a particular box is calculated using the relation:

$D_{marine}(i,age,product) = f_c \,.\, Cf_{ing}(i,age) \,.\, c(i,product) \,.\, CR(age, product)$

Where:

***D_{marine}(i,age,product)* …** the ingestion dose from consumption of marine organisms (product) for nuclide (i) in case of age category (age). Unit: Sv.

***Cf_{ing}(i,age)* …** ingestion conversion coefficient for the age category (age) and nuclide (i). It is defined in the Table 6. Unit: Sv/Bq.

***c(i,product)* …** activity of nuclide (i) in marine organism (product), in Bq/kg.

***CR(age, product)* …** the annual consumption of the seafood (product) by the age category (age). Unit: kg. The data are loaded from annual statistics.

***f_c* …**0.5... the fraction of seafood from the sector consumed by the critical individual.

7. TESTS AND COMPARISONS

The testing processes and comparisons between ESTE AI system and other similar codes (NRC Dose, PC Cosyma and PC-CREAM) which are being using for calculations of impacts of routine airborne and liquid effluents from NPP were performed.

7.1 Tests and comparisons with U.S. NRC tool „NRC Dose"

NRC Dose is the Code System for Evaluating Routine Radioactive Effluents from Nuclear Power Plants of **U.S. Nuclear Regulatory Commission**. The dose conversion factors are taken from Regulatory Guide 1.109, NUREG-0172 and ICRP-60/72.

Modules:

- "US NRC program GASPAR II" – calculation of doses from atmospheric release
- "US NRC program LADTAP II" – calculation of doses from hydrospheric release
- "US NRC program XOQDOQ" (Regulatory Guide 1.111) – atmospheric transport module

All comparisons were done after modification (unification) of factors (inhalation factor, ground deposition factor, ingestion factor, transfer constants..) because default factors are different (for example due to different state law and requirements).

Meteorological condition for atmospheric release are supposed to be stable whole year for calculation:

- wind direction – 180° from the site (i.e. to the N)
- wind speed – 3m/s
- precipitation – 0 mm
- stability category/class - D

Models for atmospheric transport implemented in ESTE AI and NRC Dose slightly vary, mainly in shorter distances, what causes differences of doses in these distances.
For hydrospheric release we suppose release to the river with flow rate = 150 m3/s and average speed of flow = 0.9 m/s.

7.1.1 Results of the comparison

In the next tables, “adult” means person > 17 years old, “teen” means person 11 – 17 years old.

Tab 7.1.1: Comparison of doses from atmospheric release – **I131 = 1 E+10 Bq** (50/50 % aerosol and gas form of iodine), METEO condition – wind speed 3 m/s, stability class D, precipitation 0 mm at different points of interest (6, 12 and 17km distant from source of release)

I131	Ground deposition [Sv]		Inhalation - adult [Sv]		Inhalation – teen [Sv]		Ingestion of cow milk – adult [Sv]		Ingestion of cow milk –teen [Sv]	
	ESTE AI	NRC Dose	ESTE AI	NRC Dose	ESTE AI	NRC Dose	ESTE AI	NRC Dose	ESTE AI	NRC Dose
6km	1.1E-08	1.5E-08	5.8E-09	2.6E-08	8.2E-09	3.6E-08	2.5E-08	5.0E-07	5.2E-08	1.0E-06
12km	7.6E-09	3.4E-09	4.1E-09	6.8E-09	5.7E-09	9.4E-09	1.7E-08	1.2E-07	3.5E-08	2.5E-07
17km	5.8E-09	1.8E-09	3.2E-09	3.7E-09	4.5E-09	5.2E-09	1.3E-08	6.2E-08	2.6E-08	1.3E-07

Tab 7.1.2: Comparison of doses from atmospheric release – **Cs 137 = 1 E+10,** METEO condition – wind speed 3 m/s, stability class D, precipitation 0 mm at different points of interest (6, 12 and 17km distant from source of release)

Cs 137	Ground deposition [Sv]		Inhalation - adult [Sv]		Inhalation – teen [Sv]		Ingestion of cow milk – adult [Sv]		Ingestion of cow milk –teen [Sv]	
	ESTE AI	NRC Dose	ESTE AI	NRC Dose	ESTE AI	NRC Dose	ESTE AI	NRC Dose	ESTE AI	NRC Dose
6km	1.4E-06	2.2E-05	3.8E-09	1.4E-08	3.4E-09	1.2E-08	1.4E-07	9.3E-07	1.9E-07	1.3E-06
12km	1.0E-06	5.3E-06	2.8E-09	3.5E-09	2.5E-09	3.2E-09	1.0E-07	2.2E-07	1.4E-07	3.0E-07
17km	8.1E-07	2.8E-06	2.2E-09	1.9E-09	2.0E-09	1.7E-09	8.1E-08	1.2E-07	1.1E-07	1.6E-07

Tab 7.1.3: Comparison of doses from atmospheric release – **C14 = 1 E+10 Bq** (anorganic form), METEO condition – wind speed 3 m/s, stability class D, precipitation 0 mm at different points of interest (6, 12 and 17km distant from source of release)

C14	Ingestion of cow milk – adult [Sv]		Ingestion of cow milk –teen [Sv]		Sum of all pathways [Sv]	
	ESTE AI	NRC Dose	ESTE AI	NRC Dose	ESTE AI	NRC Dose
6km	1.9E-09	1.8E-08	2.4E-09	2.4E-08	1.3E-08	6.8E-08
12km	1.4E-09	4.9E-09	1.8E-09	6.4E-09	9.2E-09	1.8E-08
17km	1.1E-09	2.7E-09	1.5E-09	3.5E-09	7.5E-09	9.9E-09

Tab 7.1.4: Comparison of doses from hydrospheric release – **H3 = 1 E+10 Bq,** at different points of interest (1, 7, 16 and 37 km downstream distance from source of release)

H3	Drinking water - adult [Sv]		Drinking water - teen [Sv]		Ingestion of fish meat - adult [Sv]		Ingestion of fish meat - teen [Sv]	
	ESTE AI	NRC Dose	ESTE AI	NRC Dose	ESTE AI	NRC Dose	ESTE AI	NRC Dose
1km	4.8E-12	5.3E-12	3.1E-12	3.4E+12	2.9E-14	3.2E-14	2.0E-14	2.2E-14
7km	2.7E-11	2.4E-11	1.7E-11	1.6E-11	1.6E-13	1.5E-13	1.1E-13	1.0E-13
16km	2.7E-11	2.7E-11	1.7E-11	1.7E-11	1.6E-13	1.6E-13	1.1E-13	1.1E-13
37km	2.7E-11	2.7E-11	1.7E-11	1.7E-11	1.6E-13	1.6E-13	1.1E-13	1.1E-13

Tab 7.1.5 Comparison of doses from hydrospheric release – **Cs 137 = 1 E+10 Bq,** at different points of interest (1, 7, 16 and 37 km downstream distance from source of release)

Cs137	**Drinking water - adult [Sv]**		**Drinking water - teen [Sv]**		**Ingestion of fish meat - adult [Sv]**		**Ingestion of fish meat - teen [Sv]**		**Swimming [Sv]**	
	ESTE AI	**NRC Dose**	**ESTE AI**	**NRC Dose**	**ESTE AI**	**NRC Dose**	**ESTE AI**	**NRC Dose**	**ESTE AI**	**NRC Dose**
1km	3.5E-09	3.8E-09	2.2E-09	2.5E-09	4.7E-08	5.2E-08	3.2E-08	3.5E-08	1.0E-11	1.8E-11
7km	1.9E-08	1.8E-08	1.2E-08	1.1E-08	2.6E-07	2.4E-07	1.8E-07	1.6E-07	5.5E-11	8.4E-11
16km	1.9E-08	1.9E-08	1.2E-08	1.2E-08	2.6E-07	2.6E-07	1.8E-07	1.8E-07	5.5E-11	9.2E-11
37km	1.9E-08	1.9E-08	1.2E-08	1.2E-08	2.6E-07	2.6E-07	1.8E-07	1.8E-07	5.5E-11	9.2E-11

Tab 7.1.6: Comparison of doses from hydrospheric release – **I131 = 1 E+10 Bq Bq** (50/50 % aerosol nad gas form of iodine)**,** at different points of interest (1, 7, 16 and 37 km downstream distance from source of release)

I131	**Drinking water - adult [Sv]**		**Drinking water - teen [Sv]**		**Ingestion of fish meat - adult [Sv]**		**Ingestion of fish meat - teen [Sv]**		**Swimming [Sv]**	
	ESTE AI	**NRC Dose**	**ESTE AI**	**NRC Dose**	**ESTE AI**	**NRC Dose**	**ESTE AI**	**NRC Dose**	**ESTE AI**	**NRC Dose**
1km	5.9E-09	6.2E-09	5.8E-09	6.2E-09	5.9E-10	6.1E-10	6.2E-10	6.3E-10	6.8E-12	1.2E-11
7km	3.2E-08	2.8E-08	3.2E-08	2.8E-08	3.2E-09	2.7E-09	3.4E-09	2.9E-09	3.7E-11	5.5E-11
16km	3.2E-08	2.8E-08	3.2E-08	2.8E-08	3.2E-09	2.7E-09	3.4E-09	2.9E-09	3.7E-11	5.5E-11
37km	3.1E-08	3.0E-08	3.1E-08	3.0E-08	3.1E-09	2.9E-09	3.3E-09	3.0E-09	3.6E-11	5.9E-11

7.2 Tests and comparisons with PC Cosyma

PC Cosyma code is a probabilistic accident consequence assessment system, for use in calculating the risk posed by potential nuclear accidents involving a release to the atmosphere. Cosyma was developed by the **NRPB (United Kingdom) and Forschungszentrum Karlsruhe (Germany).**

ESTE AI was compared with PC Cosyma in tests of ground deposit and TIC.

7.2.1 Results of the comparison

Tab. 7.2.1: Ground deposit and TIC (time integral of volume activity) from release of **Cs 137 = 1 Bq**, height of release – 125 m, METEO condition – wind speed 2.5 m/s at 10m above the terrain, stability class D, precipitation 0 mm, at different points of interest

Cs-137 (aerosol)				
[m]	**Deposit [Bq/m^2]**		**TIC [Bq.s.m^{-3}]**	
	ESTE AI	**PC COSYMA**	**ESTE AI**	**PC COSYMA**
2500	1.26E-09	1.20E-09	6.27E-07	1.20E-06
4000	1.14E-09	7.40E-10	5.70E-07	7.40E-07
6000	9.85E-10	4.40E-10	4.90E-07	4.40E-07
8500	8.22E-10	2.70E-10	4.11E-07	2.70E-07
12500	6.34E-10	1.60E-10	3.17E-07	1.60E-07
17500	4.82E-10	1.10E-10	2.41E-07	1.20E-07

Tab. 7.2.2: Ground deposit and TIC (time integral of volume activity) from release of **I 131 = 1 Bq**, height of release – 125 m, METEO condition – wind speed 2.5 m/s at 10m above the terrain, stability class D, precipitation 0 mm, at different points of interest

I-131, gas form				
[m]	**Deposit [Bq/m^2]**		**TIC [Bq.s.m^{-3}]**	
	ESTE AI	**PC COSYMA**	**ESTE AI**	**PC COSYMA**
2500	1.21E-08	1.20E-08	6.04E-07	1.20E-06
4000	1.07E-08	7.20E-09	5.32E-07	7.20E-07
6000	8.87E-09	4.30E-09	4.42E-07	4.30E-07
8500	7.04E-09	2.60E-09	3.51E-07	2.60E-07
12500	5.04E-09	1.50E-09	2.51E-07	1.50E-07
17500	3.52E-09	1.00E-09	1.76E-07	1.10E-07

Conclusion: Results are in very good agreement. Differences are caused due different model of atmospheric transport.

7.3 Tests and comparisons with UK Public Health England tool "PC-CREAM" for the purposes of UNSCEAR

PC-Cream is a code for performing radiological impact assessments of routine, continuous discharges of radionuclides to the environment developed by **Public Health of England**. With PC-Cream also **UNSCEAR** (**United Nations Scientific Committee on the Effect of Atomic Radiation**) is performing the assessment of routine continuous discharges of NPPs.

7.3.1 Discharges applied to the calculation

Discharges of global nuclides to the atmosphere and hydrosphere from Slovak and Czech nuclear power plants (year 2014) are reported in Table 7.3.2. Activity of C-14 in liquid effluents is not reported (not monitored up to now) in the effluents reports which were used for this study ([3], [4], [5], [6]).

Impacts to the population of Europe (European Union + Switzerland + Lichtenstein + Norway + Island) from operational effluents of global nuclides to the atmosphere and hydrosphere from NPP Bohunice (Slovakia, PWR/VVER440, 2 reactors), Mochovce NPP (Slovakia, PWR/VVER440, 2 reactors), Temelin NPP (Czech, PWR/VVER1000, 2 reactors) and Dukovany NPP (Czech, PWR/VVER440, 4 reactors) were evaluated by system ESTE AI.

Models applied to the calculation of collective effective doses to the inhabitants of Europe are described in [1].

Number of European inhabitants by age (2014) was taken from EUROSTAT [2] and is reported in Table 7.3.1:

Table 7.3.1: Number of inhabitants by age, 2014 (EUROSTAT, [2])

	TOTAL	age 0-4yr	age 5-9yr	age 10-14yr	age 15-19yr	age 20-64yr	age 65+yr
EU28+ IS+ LI+ NO+ CH	520 434 910	27 054 476	27 550 491	27 046 336	28 103 485	314 472 919	96 207 201

Table 7.3.2: Operational effluents [Bq] of global nuclides form NPPs in Slovakia and Czech Republic, 2014, [3], [4], [5], [6].

NPP	H-3 ATMO	H-3 HYDRO	C-14 ANORG ATMO	C-14 ORG ATMO	C-14 HYDRO	Kr-85
Bohunice	**6,99E+11**	**7,36E+12**	**1,57E+10**	**4,43E+11**	**N.R.**	**9,57E+10**
Mochovce	**6,90E+11**	**1,10E+13**	**3,10E+10**	**4,50E+11**	**N.R.**	**3,20E+11**
Temelin	**1,58E+12**	**5,27E+13**	**6,00E+10**	**6,70E+11**	**N.R.**	**5,20E+09**
Dukovany	**9,50E+11**	**2,04E+13**	**3,40E+10**	**6,50E+11**	**N.R.**	**N.R.**
sum	**3,92E+12**	**9,15E+13**	**1,41E+11**	**2,21E+12**	**-**	**4,21E+11**

N.R. = not reported

7.3.2 Collective effective doses (2014), global impacts

Collective effective doses to the population of Europe as a result of global circulation of discharged global nuclides to the atmosphere and hydrosphere from Slovak and Czech nuclear power plants (year 2014), as calculated by SW "**ESTE Annual Impacts**", are reported in Table 7.3.3.

Table 7.3.3: Collective effective doses [manSv] to the population of Europe as a result of global circulation of discharged global nuclides form NPPs in Slovakia and Czech Republic, 2014,

	Bohunice	Mochovce	Temelin	Dukovany	sum
C-14	2.16E-01	2.27E-01	3.45E-01	3.23E-01	1.11E+00
H-3	1.15E-05	1.66E-05	7.73E-05	3.04E-05	1.36E-04
Kr-85	5.05E-07	1.69E-06	2.75E-08	-	2.22E-06

7.3.3 Collective effective doses (2014), impacts inside the 100 km zone

Table 7.3.4: Collective effective doses [manSv] by global nuclides to the population living in the 100 km zone around NPPs in Slovakia and Czech Republic, 2014.

	sum over all 4 NPPs
C-14 (atmo)	3,57E-02
H-3 (atmo)	3,13E-03
H-3 (hydro)	1,48E-02
Kr-85	1,00E-06

Note: Impacts in the 100 km zone around the site of NPP (around the point of effluents discharges) are evaluated by completely different approach. Impacts inside the 100 km zone are calculated as site specific.

7.3.4 Collective effective doses (2014), global impacts over the Europe + site specific impacts inside the 100 km zone

Table 7.3.5: Collective effective doses [manSv] to the population of Europe as a result of discharges of global nuclides from NPPs in Slovakia and Czech Republic, 2014.
Global circulation impacts to the population of Europe + site specific collective doses inside the 100 km zone around the point of discharges.

	sum over 4 NPPs, global	**sum over 4 NPPs, site specific**	**sum** [manSv]
C-14	1.11E+00	3,57E-02	1.15E+00
H-3	1.36E-04	1,79E-02	1.80E-02
Kr-85	2.22E-06	1,00E-06	3.22E-06

7.3.5 Results of the comparison

Tab. 7.3.6: Comparison of ESTE and UNSCEAR (PC Cream) for global circulation model results only. Bohunice (similar results were gained for other sites)

	ESTE	UNSCEAR (PC-Cream)
H-3	1.15E-05	1.55E-05
C-14	2.16E-01	2.80E-01
Kr-85	5.05E-07	1.70E-06

Tab. 7.3.7: ESTE and UNSCEAR (PC Cream) results [manSv] after including the "site specific results" of ESTE. ESTE "site specific results" are influenced by realistic input assumptions.

	ESTE – sum over 4 NPPs	UNSCEAR (PC-Cream) – sum over 4 NPPs
H-3	1.80E-02	6.17E-01
C-14	1.15E-00	1.49E-01
Kr-85	1.60E-06	3.22E-06

[1] ABmerit: ESTE Annual Impacts (short abstract):System for calculation of radiological impacts of airborne and liquid discharges from normal operation of nuclear facilities, Document Code: ABmerit/2014/MODARIA/02, 2014

[2] EUROSTAT: http://ec.europa.eu/eurostat/web/population-demography-migration-projections/population-data

[3] NPP Bohunice: 2004/2/EURATOM –Discharges to the atmosphere and hydrosphere from NPP Bohunice in the year 2014

[4] NPP Mochovce: 2004/2/EURATOM –Discharges to the atmosphere and hydrosphere from NPP Mochovce in the year 2014

[5] NPP Temelin: 2004/2/EURATOM –Discharges to the atmosphere and hydrosphere from NPP Temelin in the year 2014

[6] NPP Dukovany: 2004/2/EURATOM –Discharges to the atmosphere and hydrosphere from NPP Dukovany in the year 2014

7.4 MODARIA working group 5, Comparison of ESTE AI and Symbiose software (IRSN France) and other SW tools on the base of "Chinon scenario" and "EMRAS II" and "INPRO" projects

7.4.1 Results of the CHINON Exercise

Institute: ABmerit, Trnava, Slovakia.

Scenario: Realistic scenario from a French NPP - CHINON.

Code: ESTE AI (Annual Impacts).

7.4.2 Deterministic approach

Selection of values (environmental parameters, habit data – source of information) - In the calculation we used the data as follows:

a) **Loire river environment:**

i) Width and depth of the river – as defined in the scenario.

ii) Mean annual flow rate – as defined in the scenario.

iii) Mean dissolved inorganic carbon concentration – as defined in the scenario.

iv) Liquid discharges for year 2011. The discharges were assumed to be discharged equally during the whole year, and we assumed an instantaneous dissolution in the river. All nuclides used as defined, except Te-123m (it was omitted).

v) The results were extracted in the following way:

- drinking water: impact at the distance of 9 km from the discharge point.
- fishing: impact at the distance of 0.2 km from the discharge point.
- irrigation: impact at the distance of 2.5 km from the discharge point.

We diverge from the points given in the scenario (0.5 km for fishing and 3 km for irrigation), but in our model with an instantaneous dissolution with the calculated flow speed of 0.7 m/s, these shifts introduce very negligible differences. For most radionuclides practically it is absolutely negligible, the only exception is C14, even here the conservativism in these shifts is only on the level 1-2%.

b) **Atmospheric releases:** atmospheric discharges for year 2011. The discharges were assumed to be discharged equally during the whole year. All nuclides were included in the calculation. Concerning the meteorological data, we used the wind field and speed, rainfall, and we transformed the height of the planetary boundary layer to weather category stability. All nuclides used as defined in the scenario.

c) **Intake rates:** we used the local food consumption rate provided by the scenario

d) **Difference from the scenario:** Irrigation rate (used as default in ESTE AI) was 2.83 $L.m^{-2}.d^{-1}$ (default value in ESTE AI, close to 4 $L.m^{-2}.d^{-1}$ as in the scenario for garden vegetable). We applied it only for garden vegetable practically - fresh leafy vegetable, fresh fruit vegetable, potatoes. The person stays outdoors during the whole year (conservative approach).

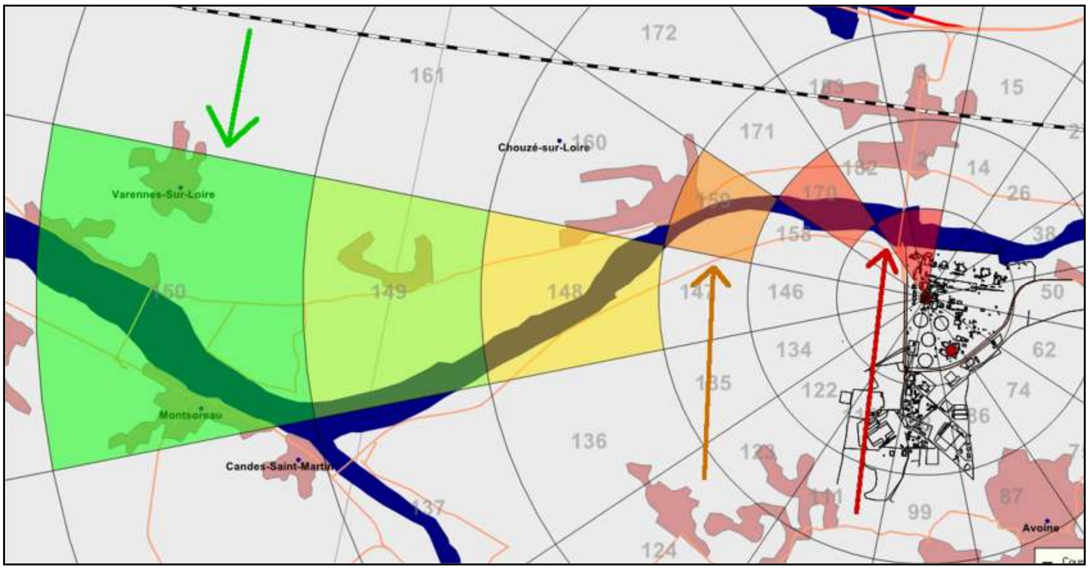
e) **Parameters and constants:** the mean values of the parameters are used (e.g. the mean values of transfer factors as given in IAEA TECDOC-1616).

f) We consider **1 year of release**.

7.4.2.1 Results – liquid releases

Map of the river Loire near Chinon NPP- the map shows the river flow and the way how the impacts were evaluated. The 0.5 km point occurs in the red region, the 3 km point occurs in the orange region, and the 9 km point in the green region.

Nuclide comparison – city of Montsoreau:



	Ag110m	C14	Co58	Co60	Cs134	Cs137	H3
Total dose [Sv]	1.04E-10	1.15E-08	1.22E-11	1.98E-10	1.66E-10	1.35E-10	8.28E-08
Dose [%]	0.109	12.105	0.013	0.208	0.175	0.142	87.158

	I131	Mn54	Sb124	Sb125	Ni63
Total dose [Sv]	5.95E-11	6.44E-12	4.09E-12	6.96E-12	6.84E-13
Dose [%]	0.063	0.007	0.004	0.007	0.001

Absolutely, the major contributors are H3 and C14, together 99.3 %. A similar result would be obtained for other locations along the river.

Results by pathways:

	H3	Co60	I131	C14	All nuclides
Concentration [Bq/m3]	7.01E+03	9.32E-03	1.42E-03	-**	-**
Dose, fishing at 0.5 km [Sv]	1.75E-10	1.95E-11	3.13E-11	1.16E-08	1.20E-08
Dose, drinking water, at 9.0 km [Sv]	6.91E-08	1.73E-11	1.69E-11	1.36E-09	7.06E-08
Dose, irrigation (at 3 km) - leafy vegetable [Sv]	3.05E-09	8.20E-12	1.10E-11	7.40E-10	3.84E-09
Dose, irrigation (at 3 km) - non-leafy vegetable [Sv]	7.21E-09	1.88E-11	1.51E-13	1.38E-09	8.66E-09
Dose, irrigation (at 3 km) - total dose [Sv]	1.31E-08	3.68E-11	1.16E-11	2.34E-09	1.56E-08
Dose, shoreline activities [Sv]	-*	1.22E-10	9.63E-16	-*	1.56E-10

* - the evaluated dose is extremely low or negligible.
** - the value depends on the distance from the discharge point.

Results for C14 (inorganic-mineral form) as function of distance:

	0.2 km	2.5 km	9.0 km
Concentration [Bq/m3]	5.92E+00	5.59E+00	4.28E+00
Dose, fish [Sv]	1.16E-08	1.10E-08	8.38E-09
Dose, water [Sv]	1.88E-09	1.78E-09	1.36E-09
Dose, irrigation -leafy vegetable [Sv]	7.77E-10	7.40E-10	5.63E-10

Analysis of results:

The major contributors are doses through drinking water and irrigation:

- drinking water: it represents about 72 % of the total dose. 98 % of that dose is due to tritium and about 1.9 % of it is due to C14.

- irrigation: it represents about 16 % of the total dose. The total dose by irrigation consists of many contributing pathways, mainly leafy vegetable, non-leafy vegetable and fruits. The main contributors are tritium (about 84 %) and C14 (about 15%).

- irrigation of leafy vegetable (as part of irrigation): it represents about 4 % of the total (= all pathways and all nuclides) dose.

- irrigation of non-leafy vegetable (as part of irrigation): it represents about 9 % of the total (= all pathways and all nuclides) dose.

If we had used the irrigation rate 4 $L.m^{-2}.d^{-1}$, the total dose by irrigation would have represented 19% of the total dose.

- fishing: it represents about 12 % of the total dose. 97.5 % of dose by fishing is due to C14 and about 1.5 % of it is due to tritium.

- shoreline activities: represent only 0.1% of the total dose. The main contributor is Co60 (about 78 %).

- a minor part is the dose by consumption of animal product where the animals were fed by water from the river. This dose (almost 100 % due to tritium) represents about 0.4 % of the total dose.

7.4.2.2 Results – atmospheric releases

Result for the western part of Néman, in a point which is located 1.5 km eastwards from the stack of the units 1-2 (see the map below). This location was determined to be the most impacted inhabited location by the discharges to the atmosphere.

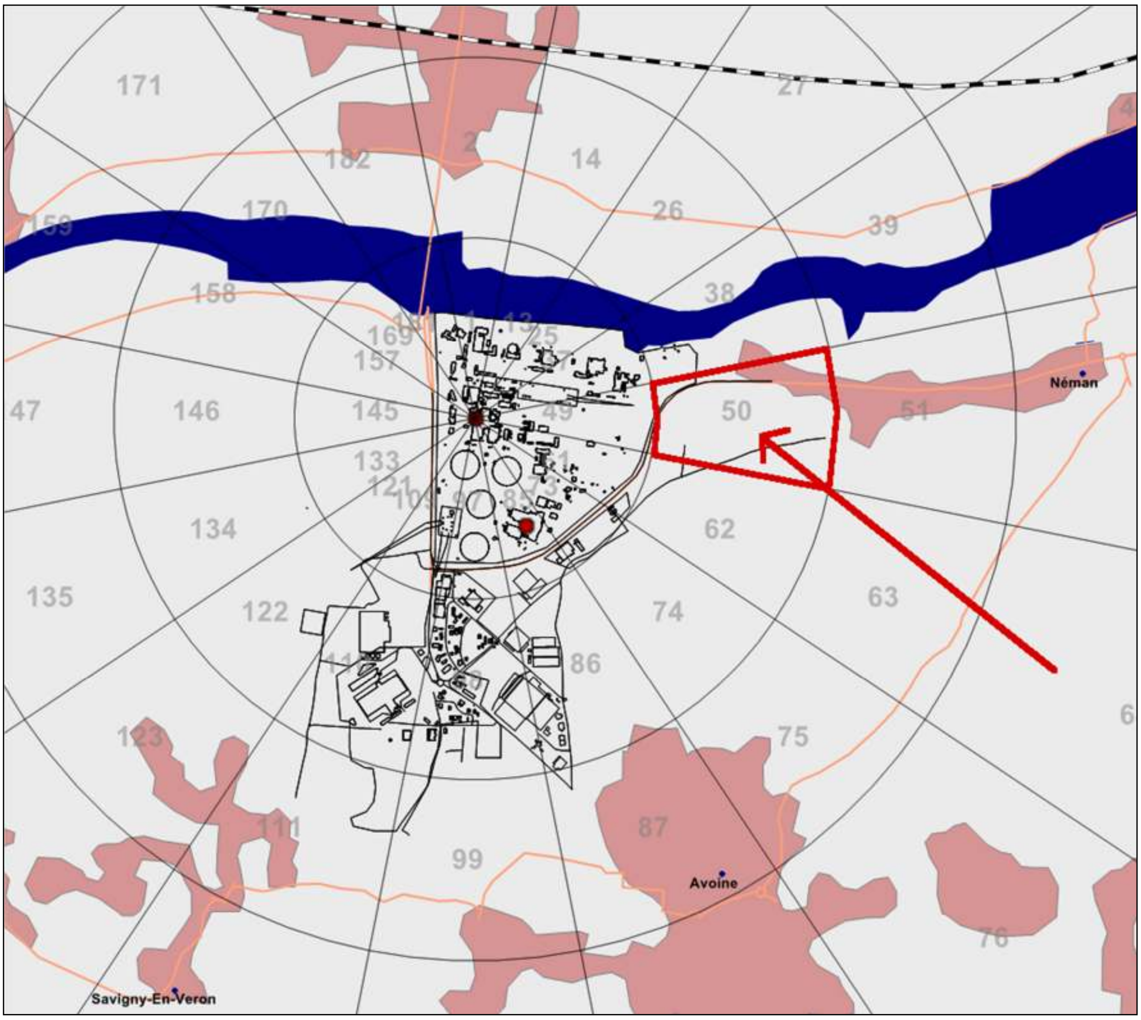


Table of impacts in Néman for 4 nuclides + total (all nuclides) result and for the most important pathways:

	H3	C14mineral, C14organic	Co60	I131	Total
Dose by inhalation [Sv]	1.27E-08	1.63E-08 6.52E-08	2.84E-13	1.97E-12	9.42E-08
Dose by deposition [Sv]	-*	-* -*	3.77E-11	8.79E-12	7.91E-11
Dose by cloudshine [Sv]	-*	-* -*	4.65E-15	1.95E-14	8.51E-10
Dose by ingestion [Sv]	1.12E-09	1.37E-08 -*	4.48E-13	1.13E-11	1.48E-08
Dose by leafy veg. [Sv]	2.61E-10	1.78E-09 -*	9.91E-14	1.06E-11	2.05E-09
Dose by non-leafy veg. [Sv]	6.16E-10	4.19E-09 -*	2.23E-13	1.54E-13	4.81E-09
Dose by potatoes [Sv]	2.18E-10	6.07E-09 -*	9.95E-14	6.69E-14	6.29E-09
Dose by milk [Sv]	1.30E-11	3.83E-10 -*	1.05E-16	3.73E-13	3.97E-10
Dose by pork [Sv]	3.85E-13	6.76E-10 -*	2.20E-14	-*	6.76E-10
Dose by beef [Sv]	6.99E-12	4.97E-10 -*	-*	6.11E-14	5.04E-10

* - the evaluated dose is extremely low or negligible and therefore its contribution is practically zero.

<u>Analysis of results:</u>

1. Here we displayed results for discharges from both stacks.

2. We modified the meteorological data: ESTE AI assumes always a non-zero wind speed. In the provided meteorological data there was in many cases (about 6% of measurements) zero wind speed. In such cases the program considers wind speed of 0.2m/s and the wind direction was set to equal to the direction of last non-zero wind speed measurement. In this setup we reproduced that the most impacted inhabited sector is the sector which was set by the working group (western part of Néman village, about 1km from the NPP). Another processing of meteorological data contained in estimation of weather stability category (this parameter was not provided), which we estimated from the height of PBL given in data set.

3. The two most important pathways are dose by inhalation (about 85%, mainly due to organic C14 and H3) and dose by ingestion (about 13 %, mainly due to mineral C14). Finally, the dose by cloudshine (due to Ar41, Xe133 and Xe135) and dose by deposition (mainly due to Co60 and Cs137) represent together less than 1 %.

4. Dose by ingestion - nuclides: Essentially, mineral C14 (dominantly) and tritium are the main contributors. Other nuclides contribute very little.

5. Dose by ingestion – pathways: The most important pathways are ingestion of non-leafy vegetables (or fruit vegetables) and potatoes, about 32 % and 42 %. Also leafy vegetable is an important pathway (about 14 %). Concerning the animal product, the consumption of beef, pork and milk (with similar weights) represent the most important pathways.

A great impact on the evaluated doses for each pathway has the local consumption rate. In our calculation, the high fresh fruit vegetables consumption rate (237.51 g/day, compared with 100.61 g/day for leafy-vegetable) results in the highest dose contribution to the total dose by ingestion.

7.4.2.3 Summary of deterministic approach

Table: Summary of doses for each pathway (sum through all nuclides).

Liquid discharge	Dose by the pathway [Sv]
Fishing at 0.5 km	1.20E-08
Drinking water, at 9.0 km	7.06E-08
Irrigation, at 3 km	1.56E-08
Shoreline activities	1.56E-10
Total - sum	9.84E-08
Atmospheric discharges	
Inhalation, in Neman	9.42E-08
Deposition, in Neman	7.91E-11
Cloudshine, in Neman	8.51E-10
Ingestion, in Neman	1.48E-08
Total – sum	1.10E-07
All discharges – sum	2.08E-07

7.4.3 Probabilistic approach

Selection of values (environmental parameters, habit data – source of information):

In the calculation we used the data provided by the description of the scenario:

a) Loire river environment – the same as for deterministic approach.

b) Sectorization - the same as for deterministic approach

c) Atmospheric releases – we evaluate the impact only for the discharge from the stack of units 1-2, otherwise the same as for deterministic approach.

d) Intake rates - the same as for deterministic approach.

e) Parameters and constants: beside the mean values of the parameters we applied the parameters which described their distribution.

i) transfer factors – their distributions are lognormal, we used the geometric standard deviations as given in IAEA TECDOC-1616. They are the factors of transfer from soil to pasture, to cereals (grain), to non-leafy vegetable, to leafy vegetable, to fruits, to potatoes, to beets, and from water or feed to meat (beef, pork, poultry), to milk, to fish and to eggs. In case when no value of geometric standard deviation is given for the particular nuclide and transfer factor in TECDOC-1616, we assumed zero distribution. The full list of parameters with applied distributions are at the end of the report.

ii) delay times and feeding ratios - their distributions are triangular. Here the mode of distribution is equal to the value used in the deterministic calculation. The upper and lower ranges were added either by reasonable estimate of human activities (e.g. time between slaughter and consumption or time between harvest and consumption), or analysing measured data (absolute humidity in veg. period), or by default estimate of 10% dispersion of values (feeding and water intake). The list includes the following factors:
- time between slaughter and consumption.
- growing time pasture, and growing time for other products.
- time between harvest and consumption: pasture, feed for stabled animals, leafy vegetable, and other products.
- feeding ratio for goat, poultry, pork and cow.
- water intake for cow (kept for milk), cow (meat), goat, poultry.
- transport time (feed -> milk).
- absolute humidity in veg. period.
- natural carbon content in water (DIC + TOC).

The full list of parameters with applied distributions are at the end of the report.

f) We consider 1 year of release.

7.4.3.1 Results – atmospheric releases

Result for the western part of Néman, in a point which is located 1.5 km eastwards from the stack of the units 1-2 (see the map below). This location was determined to be the most impacted inhabited location by the discharges to the atmosphere

The introduction of probabilistic distribution functions for transfer factors, delay times and feeding rates has impact only on the dose by ingestion. Therefore the doses by inhalation, deposition and cloudshine remain intact.

Deterministic approach (discharges only from the stack of units1-2):

	H3	**C14mineral, C14organic**	**Co60**	**I131**	**Total**
Dose by inhalation [Sv]	6.57E-09	8.43E-09 3.37E-08	1.48E-13	1.05E-12	4.87E-08
Dose by deposition [Sv]	-*	-* -*	2.01E-11	4.81E-12	4.23E-11
Dose by cloudshine [Sv]	-*	-* -*	2.13E-15	9.47E-15	4.02E-10
Dose by ingestion [Sv]	5.91E-10	7.23E-09 -*	2.49E-13	6.09E-12	7.83E-09
Dose by leafy veg. [Sv]	1.38E-10	9.40E-10 -*	5.50E-14	5.74E-12	1.08E-09
Dose by non-leafy veg. [Sv]	3.26E-10	2.22E-09 -*	1.24E-13	8.31E-14	2.55E-09
Dose by potatoes [Sv]	1.16E-10	3.21E-09 -*	5.52E-14	3.61E-14	3.33E-09
Dose by milk [Sv]	6.90E-12	2.03E-10 -*	5.82E-17	2.01E-13	2.10E-10
Dose by pork [Sv]	2.04E-13	3.58E-10 -*	1.22E-14	1.79E-17	3.58E-10
Dose by beef [Sv]	3.70E-12	2.63E-10 -*	1.42E-16	3.30E-14	2.67E-10

* - the evaluated dose is extremely low and therefore its contribution is practically zero.
Here we present the median (the numerical value separating the higher half of a data sample from the lower half; in case of log-normal distribution it is the geometric mean), arithmetic mean, the upper and lower bound of 95%-interval of confidence.

Median of distributed values, dose by ingestion, probabilistic approach:

	H3	**C14 min**	**Co60**	**I131**	**Total**
Dose by ingestion [Sv]	5.74E-10	7.38E-09	2.57E-13	6.28E-12	7.96E-09
Dose by leafy veg. [Sv]	1.34E-10	9.42E-10	5.57E-14	5.73E-12	1.08E-09
Dose by non-leafy veg. [Sv]	3.17E-10	2.21E-09	1.25E-13	8.03E-14	2.53E-09
Dose by potatoes [Sv]	1.12E-10	3.22E-09	5.60E-14	3.49E-14	3.33E-09
Dose by milk [Sv]	6.67E-12	2.03E-10	5.70E-17	1.98E-13	2.10E-10
Dose by pork [Sv]	1.96E-13	3.57E-10	1.23E-14	4.40E-19	3.57E-10
Dose by beef [Sv]	3.58E-12	2.63E-10	1.41E-16	3.21E-14	2.67E-10

Ratio of the median and the result of deterministic approach:

	H3	C14 min	Co60	I131	Total
Dose by ingestion [Sv]	0.97	1.02	1.03	1.03	1.02
Dose by leafy veg. [Sv]	0.97	1.00	1.01	1.00	1.00
Dose by non-leafy veg. [Sv]	0.97	1.00	1.01	0.97	0.99
Dose by potatoes [Sv]	0.97	1.00	1.01	0.97	1.00
Dose by milk [Sv]	0.97	1.00	0.98	0.99	1.00
Dose by pork [Sv]	0.96	1.00	1.01	0.02	1.00
Dose by beef [Sv]	0.97	1.00	0.99	0.97	1.00

Arithmetic mean of distributed values, dose by ingestion, probabilistic approach:

	H3	C14 min	Co60	I131	Total
Dose by ingestion [Sv]	5.73E-10	7.44E-09	2.72E-13	6.81E-12	8.02E-09
Dose by leafy veg. [Sv]	1.34E-10	9.84E-10	5.66E-14	5.73E-12	1.12E-09
Dose by non-leafy veg. [Sv]	3.16E-10	2.32E-09	1.21E-13	5.18E-13	2.63E-09
Dose by potatoes [Sv]	1.12E-10	3.27E-09	5.76E-14	2.25E-13	3.38E-09
Dose by milk [Sv]	6.69E-12	2.08E-10	6.91E-17	2.68E-13	2.15E-10
Dose by pork [Sv]	1.99E-13	3.59E-10	1.30E-14	1.19E-17	3.59E-10
Dose by beef [Sv]	3.59E-12	2.70E-10	1.84E-16	6.51E-14	2.74E-10

Ratio of the arithmetic mean and the result of deterministic approach:

	H3	C14 min	Co60	I131	Total
Dose by ingestion [Sv]	0.97	1.03	1.09	1.12	1.02
Dose by leafy veg. [Sv]	0.97	1.05	1.03	1.00	1.04
Dose by non-leafy veg. [Sv]	0.97	1.05	1.01	6.23	1.03
Dose by potatoes [Sv]	0.97	1.02	1.04	6.23	1.02
Dose by milk [Sv]	0.97	1.02	1.19	1.33	1.02
Dose by pork [Sv]	0.98	1.00	1.07	0.66	1.00
Dose by beef [Sv]	0.97	1.03	1.30	1.97	1.03

The upper bound for 95%-interval of distributed values, probabilistic approach:

	H3	C14 min	Co60	I131	Total
Dose by ingestion [Sv]	6.49E-10	9.41E-09	3.80E-13	1.27E-11	9.98E-09
Dose by leafy veg. [Sv]	1.52E-10	1.64E-09	6.58E-14	6.11E-12	1.78E-09
Dose by non-leafy veg. [Sv]	3.60E-10	3.92E-09	1.29E-13	4.71E-12	4.24E-09
Dose by potatoes [Sv]	1.33E-10	4.39E-09	7.25E-14	2.04E-12	4.50E-09
Dose by milk [Sv]	8.00E-12	3.19E-10	1.86E-16	8.94E-13	3.26E-10
Dose by pork [Sv]	2.67E-13	4.28E-10	2.04E-14	1.07E-16	4.28E-10
Dose by beef [Sv]	4.29E-12	4.13E-10	5.89E-16	3.40E-13	4.17E-10

Ratio of the upper bound for 95%-interval and the result of deterministic approach:

	H3	C14 min	Co60	I131	Total
Dose by ingestion [Sv]	1.10	1.30	1.53	2.09	1.27
Dose by leafy veg. [Sv]	1.10	1.74	1.20	1.06	1.65
Dose by non-leafy veg. [Sv]	1.10	1.77	1.04	56.68	1.66
Dose by potatoes [Sv]	1.15	1.37	1.31	56.51	1.35
Dose by milk [Sv]	1.16	1.57	3.20	4.45	1.55
Dose by pork [Sv]	1.31	1.20	1.67	5.98	1.20
Dose by beef [Sv]	1.16	1.57	4.15	10.30	1.56

The lower bound for 95%-interval of distributed values, probabilistic approach:

	H3	C14 min	Co60	I131	Total
Dose by ingestion [Sv]	4.98E-10	5.83E-09	2.41E-13	5.65E-12	6.40E-09
Dose by leafy veg. [Sv]	1.16E-10	5.37E-10	5.24E-14	5.36E-12	6.80E-10
Dose by non-leafy veg. [Sv]	2.74E-10	1.27E-09	1.18E-13	1.42E-15	1.58E-09
Dose by potatoes [Sv]	9.26E-11	2.38E-09	5.22E-14	6.16E-16	2.49E-09
Dose by milk [Sv]	5.48E-12	1.30E-10	1.75E-17	4.56E-14	1.37E-10
Dose by pork [Sv]	1.44E-13	2.99E-10	1.09E-14	3.55E-23	2.99E-10
Dose by beef [Sv]	2.94E-12	1.69E-10	3.39E-17	2.83E-15	1.73E-10

Ratio of the lower bound for 95%-interval and the result of deterministic approach:

	H3	**C14 min**	**Co60**	**I131**	**Total**
Dose by ingestion [Sv]	0.84	0.81	0.97	0.93	0.82
Dose by leafy veg. [Sv]	0.84	0.57	0.95	0.93	0.63
Dose by non-leafy veg. [Sv]	0.84	0.57	0.98	0.02	0.62
Dose by potatoes [Sv]	0.80	0.74	0.95	0.02	0.75
Dose by milk [Sv]	0.79	0.64	0.30	0.23	0.65
Dose by pork [Sv]	0.71	0.84	0.89	0.00	0.84
Dose by beef [Sv]	0.79	0.64	0.24	0.09	0.65

Analysis of results:

1. Median vs. arithmetic mean: When comparing both statistical variables with deterministic approach, we see that the median copies more or less the result of deterministic approach, better than arithmetic mean. This observation is a reflection of the fact that the deterministic approach uses the geometric mean of the transfer factors, which are described by lognormal distribution where geometric mean is equal to median. The arithmetic mean of such distribution could differ much from the geometric mean, especially if the geometric standard deviation is large.

2. Tritium H3 and carbon C14 (mineral): These two nuclides produce almost all the impacts. They are described by specific activity models. i.e. we assume the same concentration of C14 and tritium in plants as in the environment (there is some equilibrium because of active exchange of these elements in both directions). Thus in our calculations for both nuclides, the water content and carbon content are important parameters which introduce an important part of the variations in the uncertainty analysis. In case of tritium we also introduced probabilistic distribution for absolute humidity of the air, because it is an important parameter in description of transfer to plant. Analysing the results, we see that the confidence intervals in case of plants for H3 and C14 are related actually to the water and carbon content distribution widths and distribution width of humidity, respectively. In case of animal product pathways, other parameters like feeding ratios with their distributions enlarge the confidence intervals further.

3. Other nuclides beside H3 and C14 (although some of them have very large intervals of distributions) have negligible effect on the total dose and the probabilistic approach does not change their effect on the global result.

Nevertheless, when we inspect only a particular nuclide with an introduced non-trivial distribution (e.g. Co60 or I131, unlike to C14) for a given pathway, we can get a quite large interval of distributed values, although it has a negligible effect on the total dose.

Table of doses by ingestion of I131 for various pathways:

	Deterministic approach	**Median**	**Arithmetic Mean**	**Bottom of 95 % interval**	**Top of 95 % interval**
Dose by leafy vegetable [%]	5.7E-12	5.7E-12	5.7E-12	5.4E-12	6.1E-12
Dose by leafy vegetable [%]	8.3E-14	8.0E-14	5.2E-13	1.4E-15	4.7E-12
Dose by milk [%]	2.0E-13	2.0E-13	2.7E-13	4.6E-14	8.9E-13
Dose by beef [%]	3.3E-14	3.2E-14	6.5E-14	2.8E-15	3.4E-13

Table of ratios of the variables and the result of deterministic approach:

	Deterministic approach	**Median**	**Arithmetic mean**	**Bottom of 95 % interval**	**Top of 95 % interval**
Dose by leafy vegetable [%]	1.00	1.00	1.00	0.93	1.06
Dose by leafy vegetable [%]	1.00	0.97	6.23	0.02	56.68
Dose by milk [%]	1.00	0.99	1.33	0.23	4.45
Dose by beef [%]	1.00	0.97	1.97	0.09	10.30

Figure: Distributions of doses for various pathways in case of atmospheric discharges (all-nuclides results). For each pathway the distribution is normalized to have the same height of maximal value of distribution, equal to 0.5. The medians are shown as well.

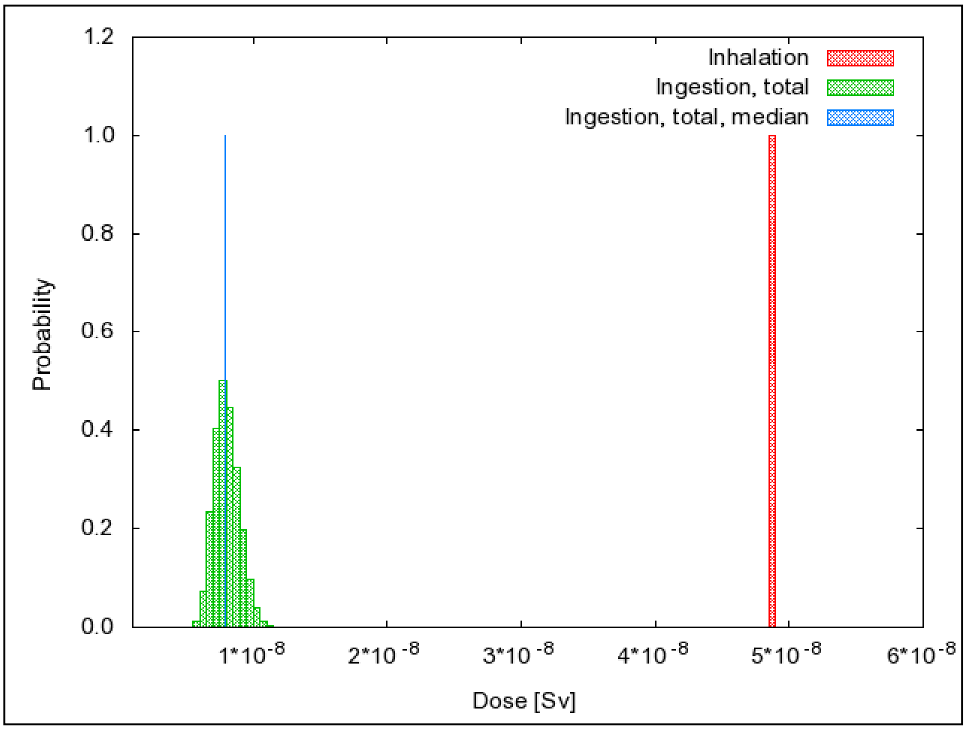
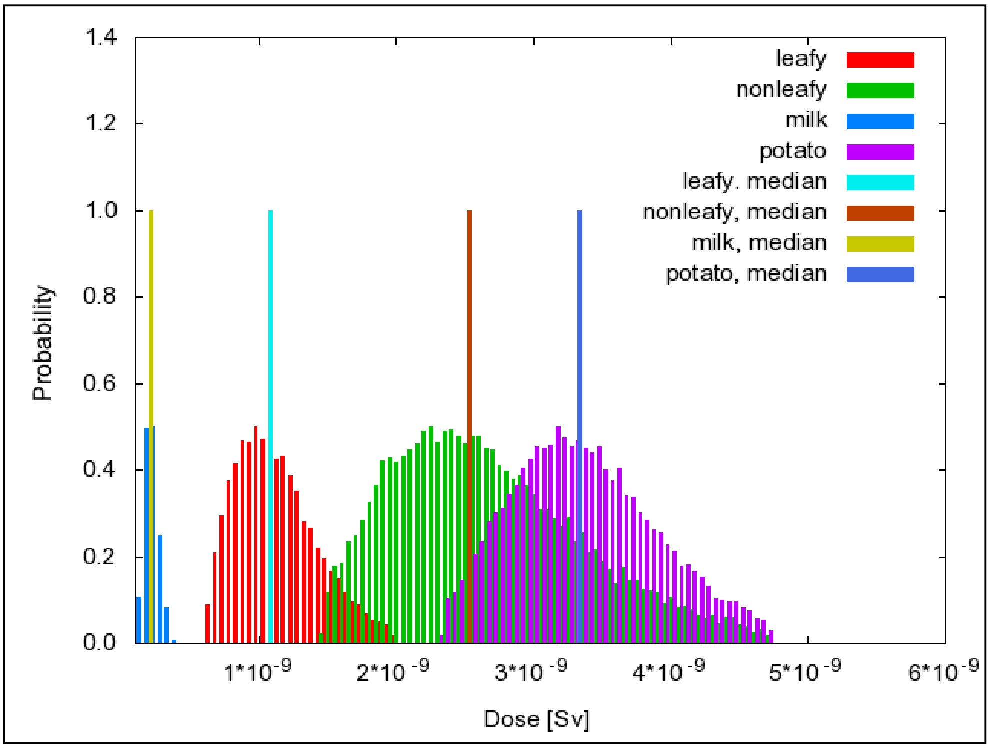


Figure: Distributions of doses for various contributions into ingestion dose in case of atmospheric discharges (all-nuclides results). For each pathway the distribution is normalized to have the same height of maximal value of distribution, equal to 0.5.



7.4.3.2 Results – liquid releases

Median of distributed values, dose by ingestion, probabilistic approach:

	H3	**Co60**	**I131**	**C14**	**All nuclides**
Dose, fishing at 0.5 km [Sv]	1.75E-10	1.96E-11	3.14E-11	1.16E-08	1.22E-08
Dose, drinking water, at 9 km [Sv]	6.91E-08	1.73E-11	1.69E-11	1.36E-09	7.06E-08
Dose, irrigation at 3 km - leafy vegetable [Sv]	3.05E-09	8.20E-12	1.10E-11	7.40E-10	3.84E-09
Dose, irrigation at 3 km - non-leafy vegetable [Sv]	7.21E-09	1.88E-11	1.51E-13	1.38E-09	8.66E-09

Ratio of the median and the result of deterministic approach:

	H3	**Co60**	**I131**	**C14**	**All nuclides**
Dose, fishing at 0.5 km [Sv]	1.00	1.01	1.00	1.00	1.02
Dose, drinking water, at 9 km [Sv]	1.00	1.00	1.00	1.00	1.00
Dose, irrigation at 3 km - leafy vegetable [Sv]	1.00	1.00	1.00	1.00	1.00
Dose, irrigation at 3 km - non-leafy vegetable [Sv]	1.00	1.01	1.00	1.00	1.02

Arithmetic mean of distributed value, dose by ingestion, probabilistic approach:

	H3	**Co60**	**I131**	**C14**	**All nuclides**
Dose, fishing at 0.5 km [Sv]	1.75E-10	2.14E-11	3.81E-11	1.18E-08	1.23E-08
Dose, drinking water, at 9 km [Sv]	6.91E-08	1.73E-11	1.69E-11	1.36E-09	7.06E-08
Dose, irrigation at 3 km - leafy vegetable [Sv]	3.05E-09	8.23E-12	1.10E-11	7.40E-10	3.84E-09
Dose, irrigation at 3 km - non-leafy vegetable [Sv]	7.21E-09	1.95E-11	9.54E-13	1.38E-09	8.66E-09

Ratio of the arithmetic mean and the result of deterministic approach:

	H3	**Co60**	**I131**	**C14**	**All nuclides**
Dose, fishing at 0.5 km [Sv]	1.00	1.10	1.22	1.02	1.03
Dose, drinking water, at 9 km [Sv]	1.00	1.00	1.00	1.00	1.00
Dose, irrigation at 3 km - leafy vegetable [Sv]	1.00	1.00	1.00	1.00	1.00
Dose, irrigation at 3 km - non-leafy vegetable [Sv]	1.00	1.04	6.32	1.00	1.00

The upper bound for 95%-interval of distributed values, probabilistic approach:

	H3	**Co60**	**I131**	**C14**	**All nuclides**
Dose, fishing at 0.5 km [Sv]	1.75E-10	4.31E-11	1.06E-10	1.64E-08	1.69E-08
Dose, drinking water, at 9 km [Sv]	6.91E-08	1.73E-11	1.69E-11	1.36E-09	7.06E-08
Dose, irrigation at 3 km - leafy vegetable [Sv]	3.21E-09	8.93E-12	1.17E-11	7.41E-10	3.99E-09
Dose, irrigation at 3 km - non-leafy vegetable [Sv]	7.58E-09	2.66E-11	7.60E-12	1.38E-09	9.04E-09

Ratio of the upper bound for 95%-interval and the result of deterministic approach:

	H3	**Co60**	**I131**	**C14**	**All nuclides**
Dose, fishing at 0.5 km [Sv]	1.00	2.21	3.39	1.41	1.41
Dose, drinking water, at 9 km [Sv]	1.00	1.00	1.00	1.00	1.00
Dose, irrigation at 3 km - leafy vegetable [Sv]	1.05	1.09	1.06	1.00	1.04
Dose, irrigation at 3 km - non-leafy vegetable [Sv]	1.05	1.41	50.33	1.00	1.04

The lower bound for 95%-interval of distributed values, probabilistic approach:

	H3	Co60	I131	C14	All nuclides
Dose, fishing at 0.5 km [Sv]	1.75E-10	8.83E-12	9.19E-12	8.26E-09	8.74E-09
Dose, drinking water, at 9 km [Sv]	6.91E-08	1.73E-11	1.69E-11	1.36E-09	7.06E-08
Dose, irrigation at 3 km - leafy vegetable [Sv]	2.90E-09	7.83E-12	1.03E-11	7.40E-10	3.69E-09
Dose, irrigation at 3 km - non-leafy vegetable [Sv]	6.85E-09	1.79E-11	2.59E-15	1.38E-09	8.31E-09

Ratio of the lower bound for 95%-interval and the result of deterministic approach:

	H3	Co60	I131	C14	All nuclides
Dose, fishing at 0.5 km [Sv]	1.00	0.45	0.29	0.71	0.73
Dose, drinking water, at 9 km [Sv]	1.00	1.00	1.00	1.00	1.00
Dose, irrigation at 3 km - leafy vegetable [Sv]	0.95	0.95	0.94	1.00	0.96
Dose, irrigation at 3 km - non-leafy vegetable [Sv]	0.95	0.95	0.02	1.00	0.96

Analysis:

1. Median vs. arithmetic mean: Again the median copies more or less the result of deterministic approach, better than arithmetic mean, although the difference between the median and arithmetic mean is very small.

2. Drinking water (most important pathways): there is no difference between the deterministic and probabilistic approach, meaning that all inspected variables of probabilistic approach give the same value. The main contributor is tritium (about 98 % of the dose by drinking water). The only variable which could touch the value of calculated dose is the consumption rate (linear dependence), but it was fixed by the scenario and we have not varied it. We also assume that the concentration of drinking water is equal to the concentration in the river, i.e. there is no filtering process.

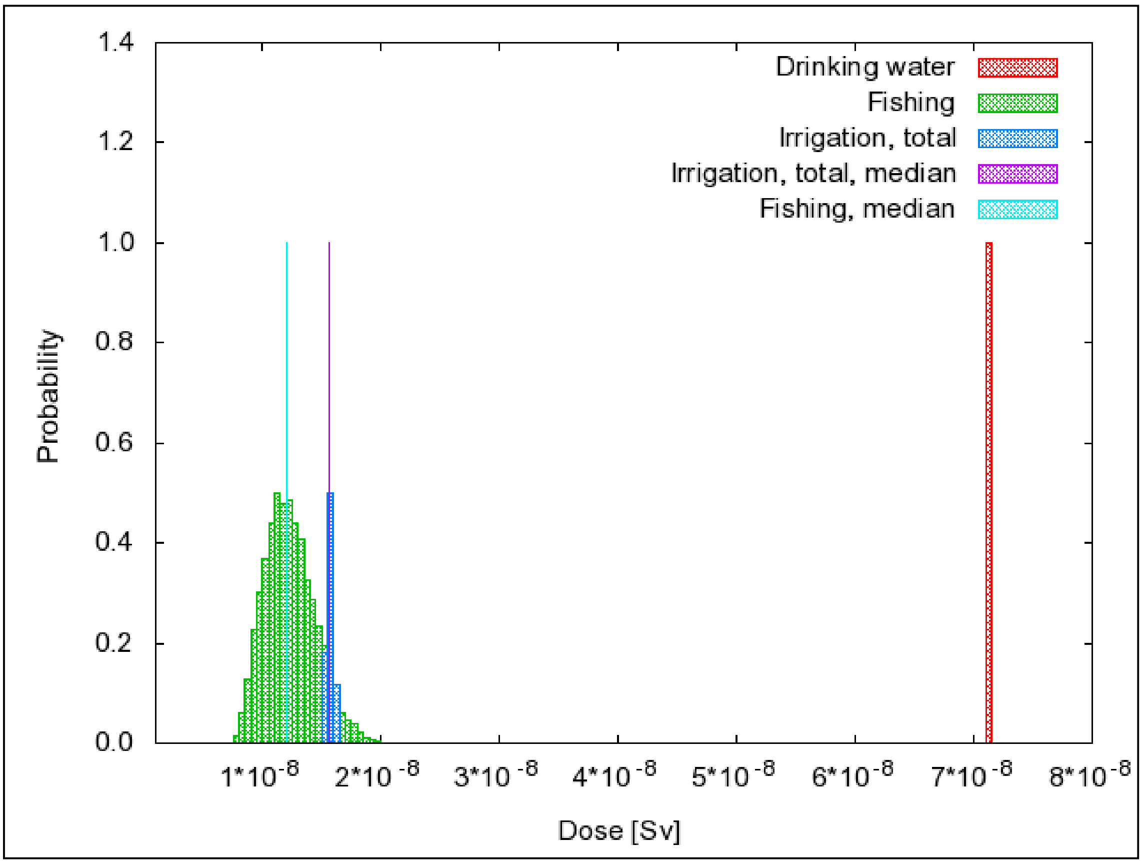
3. Irrigation: the main contributor is again tritium (about 81 %), sensitive to probabilistic approach as a consequence of the fact we use specific activity model and we have introduced the pdf for water content in the plants.

C14 is the next most important contributor (about 17%). The reason why the probabilistic approach is insensitive on C14 is that we do not have distributions for parameters playing role in case of irrigation for C14.

Other nuclides show some differences between deterministic and probabilistic approach – the upper and lower bounds could differ much, especially for I131 like we could see for atmospheric discharges. But because they are only minor contributors, they have very small final effect on the total results.

4. Fishing: this is the most sensitive part on probabilistic analysis. Tritium is not the main contributor (and again we use specific activity model). The sensitivity on the probabilistic approach is a consequence of the fact we introduced a distribution for the carbon content in the river although it was not specified in the scenario. In addition, we use distribution for carbon content in fish.

Figure: Distributions of doses for various pathways in case of liquid discharges (all-nuclides results). For each pathway the distribution is normalized to have the same height of maximal value of distribution, equal to 0.5. The medians are shown as well.



7.4.4 Summary

- the relevant contributors are practically tritium and C14. For these nuclides we use specific activity model, which is not ideal or not appropriate approach for probabilistic analysis. In such models the transfer factors are not used. Only variables describing e.g. water or carbon content, or meteorological conditions (like humidity or carbon content in river) or human activities (like irrigation vs. precipitation) could be reasonable for probabilistic approach.

- the median (with some exception the arithmetic mean too) reproduces the deterministic approach.

- atmospheric discharges: we focused our attention on dose by ingestion. Here the main contributor, dose by inhalation, was out of the scope of study because it is mainly affected by dispersion model, not by quantities with introduced distribution functions. Dose by ingestion is again dominated absolutely by tritium and C14, therefore for the total dose we found only moderate impact of probabilistic approach. On the other hand, some minor contributing pathways or nuclides could be very sensitive on such an analysis, e.g. for I131 and Co60 and in case of dose by beef or leafy vegetable we found even an order of magnitude between the bounds of 95% interval and deterministic approach.

- liquid discharges: the main contributor – dose by drinking water – is not influenced by probabilistic approach. The dose by irrigation shows a similar result as dose by ingestion for atmospheric discharges, i.e. some minor pathways are sensitive when one introduces pdf-s and compares the bounds of 95% interval and deterministic approach. But the irrigation in global is not so strongly impacted. On the contrary, the dose by eating fish is affected strongly (on the level of 30-40%), in the way that the upper bound for 95% interval is on the level of dose for ingestion.

7.4.5 Parameters applied in calculations

1. Water and carbon content in plants (source – TECDOC-1616, page 554 and page 564) **and in fish:**

	Water		**Carbon**	
Plant	**Geometric mean**	**Geometric standard deviation**	**Geometric mean**	**Geometric standard deviation**
Pasture	0.76	1.07	0.10	1.3
Leafy Veg.	0.92	1.03	0.03	1.4
Non-leafy Veg.	0.92	1.03	0.03	1.4
Cereals	0.12	1.17	0.39	1.1
Potato	0.75	1.08	0.10	1.2
Fruit	0.85	1.06	0.62	1.3
Root	0.87	1.05	0.046	1.5
Other Plants	0.75	-*	0.11	-*
Fish	0.78	-*	480**	1.2

* - the parameter does not have value describing the distribution, therefore is not varied.
** - the dimension is gram of carbon in 1 kg of dry weight.

2a. Soil-to-plant transfer factor– Mean value

	Pasture	**Cereals (grain)**	**Non-leaf veg.**	**Leafy veg.**	**Fruits**	**Potatoes**	**Roots**
Ag	1.00E+0x	2.00E-1x	1.28E-4*	1.36E-5*	1.30E-3x	1.30E-3x	2.21E-4*
Co	2.06E-2*	1.23E-2*	1.12E-2*	2.00E-2*	4.80E-3**	2.00E-2*	1.82E-2*
Cs	6.96E-2*	3.43E-2*	2.80E-3*	9.60E-3*	1.50E-2*	2.33E-2*	8.06E-3*
I	4.32E-4*	5.10E-3*	8.00E-3**	3.20E-3*	6.30E-3**	2.50E-2**	2.99E-3*
Mn	2.33E-1*	2.99E-1*	2.48E-2**	6.80E-2*	3.90E+0**	2.03E-2*	1.69E-1*
Sb	2.00E-1x	1.06E-3*	1.04E-5**	1.76E-5*	1.00E-3x	5.00E-4**	8.06E-5**
Ni		3.26E-2*					

2b. Soil-to-plant transfer factor– Geometric standard deviation

	Pasture	**Cereals (grain)**	**Non-leaf veg.**	**Leafy veg.**	**Fruits**	**Potatoes**	**Roots**
Ag							2.4*
Co	3.0*	6.0*		2.4*		3.0*	2.7*
Cs	4.1*	3.3*	4.1*	4.1*	1.6*	3.0*	2.5*
I	2.1*				1.6**		1.5*
Mn	1.5*	3.3*	4.1*	1.8*		2.2*	2.4*
Sb		3.7*	6.7**				1.5**
Ni		2.4*					

* - Data from TECDOC 1616, for sandy soil.
** - Data from TECDOC 1616 for general soil type.
x - Data from older data sources.
Remarks: as in other cases, we used truncated log-normal distribution, where we omitted data larger than (GM * GSD*GSD) and data smaller than (GM / GSD*GSD). The truncation avoids to use improbable small or large values. This truncation means to use roughly 95% of log-normal distribution (we omit both 2.5-% tails of the distribution).
We applied (where possible) data for sandy type of soil. If there was no data of that type, we applied data for general soil type (or used data from other sources but without distribution).

3a. Parameters with triangular distribution:

- time between slaughter and consumption: mode (or peak) – 20 days, lower limit – 1 day, upper limit – 40 days.

- growing time of pasture: mode – 30 days, lower limit – 15 days, upper limit – 45 days.

- growing time for other products: mode – 60 days, lower limit – 50 days, upper limit – 90 days.

- time between harvest and consumption for pasture: mode – 0 days, lower limit – 0 days, upper limit – 0 days.

- time between harvest and consumption for feed for stabled animals: mode – 90 days, lower limit – 60 days, upper limit – 270 days.

- time between harvest and consumption for leafy vegetable: mode – 1 day, lower limit – 1 hour, upper limit – 2 days.

- time between harvest and consumption for other product: mode – 60 days, lower limit – 1 day, upper limit – 120 days.

- feeding ratio for goat, poultry, pork and cow.

- water intake for cow (kept for milk), cow (meat), goat, poultry: general rule – lower limit is equal to 0.9 * mode; upper limit is equal to 1.1 * mode.

- transport time (feed -> milk) : mode – 2 days, lower limit – 1 day, upper limit – 3 days.

For all these parameters, the upper and lower limits are based on some expert estimation, not on statistical data. The limits were chosen to reflect human habits which can be consider normal or probable, not as an extremely improbable behaviour. The triangular distribution was chosen as an optimal distribution shape which introduces a similar uncertainty in the probabilistic approach as the choice of upper and lower limits. In real situation, one should study some e.g. site-specific statistical data or other sources to estimate/evaluate limits and distribution shapes to perform the correct uncertainty evaluation.

3b. Parameters with triangular distribution:

- absolute humidity in veg. period: mode – 0.009 kg/m^3, lower limit – 0.008 kg/m^3, upper limit – 0.011 kg/m^3.
Remarks: Mode – TECDOC 1616, page 552, absolute humidity for Munich. Limits were estimated either on i) TECDOC 1616 – data for London is a guide what are the variances for absolute humidity in a mesoscale (500-900 km). ii) We also tried to estimate the variation for some Slovak localities.

- natural carbon content in water : lower limit is equal to 0.8 * mode, upper limit is equal to 1.2 * mode. Analysing carbon content of other rivers we estimated 20% as a reasonable factor for variation in total carbon content in water. Additionally, we analysed the variability of carbon content in Loire, which was provided as part of scenario description. These data show large fluctuations, so at the end we chose a reasonable width for distribution based on data for other rivers.

4. **Bioaccumulation factor for freshwater (L/kg) and transfer coefficients to animal product ($d.kg^{-1}$ or $d.L^{-1}$)** – Mean value

	Water to fish	Feed to milk	Feed to cow meat	Feed to pig meat	Feed to poultry	Feed to eggs
Ag	1.10E+02*	3.00E-02**	5.00E-03**	5.00E-02**	5.00E-02**	5.00E-03**
Co	4.00E+02*	1.10E-04*	4.30E-04*	2.50E-01**	9.70E-01*	3.30E-02*
Cs	3.00E+03*	4.60E-03*	2.20E-02*	2.00E-01*	2.70E+00*	4.00E-01*
I	6.50E+02*	5.40E-03*	6.70E-03*	4.10E-02*	8.70E-03*	2.40E+00*
Mn	4.50E+02*	4.10E-05*	6.00E-04*	5.30E-03*	1.90E-03*	4.20E-02*
Sb	7.10E+01*	3.80E-05*	1.20E-03*	1.00E-03**	1.00E-03**	1.00E-03**
Ni	7.10E+01*	9.50E-04*	5.00E-03**	5.00E-03**	5.00E-03**	5.00E-03**

4b. Bioaccumulation factor for freshwater (L/kg) and transfer coefficients to animal product ($d.kg^{-1}$ or $d.L^{-1}$) – Geometric standard deviation

	Water to fish	Feed to milk	Feed to cow meat	Feed to pig meat	Feed to poultry	Feed to eggs
Ag	1.3*					
Co	1.6*	2.0*	2.3*			
Cs	2.6*	2.0*	2.4*	1.5*	1.6*	1.5*
I	2.1*	2.4*	3.2*		2.0*	1.3*
Mn	4.0*	4.9*				1.4*
Sb	8.8*	2.5*				
Ni	2.1*					

* - Data from TECDOC 1616.
** - Data from older data sources.
Remarks: as in other cases, we used truncated log-normal distribution, where we omitted data larger than (GM * GSD*GSD) and data smaller than (GM / GSD*GSD). The truncation avoids to use improbable small or large value. This truncation means to use 95% of log-normal distribution (we omit both 2.5-% tails of the distribution).

8. PAPERS AND WORKSHOPS

[1] Carny, P., et al.: ESTE Annual Impacts, Consultancy Meeting on Developing a technical solution for assessing the radiological consequences of a nuclear accident or radiological emergency, IAEA Vienna, June 23, 2010

[2] Smejkalova, E., Liptak, L., Carny, P.: ESTE Annual Impacts – Impacts of updated (new) transfer factors of the IAEA, Conference of the Czech and Slovak Radiological Society, DRO2010, Trebon, Nov. 2010

[3] Smejkalova, E., Carny, P., Suchon, D.: System ESTE Annual Impacts for Temelin NPP – System for evaluation of normal operational impact for the purposes of the Czech Regulatory Body, Conference of the Czech and Slovak Radiological Society, DRO2012, Trebon, Nov. 2012

[4] Carny, P., Suchon, D., Smejkalova, E., Liptak, L.: ESTE Annual Impacts – Radiological impacts of operational effluents from nuclear installations to atmosphere and hydrosphere, IAEA Technical Meeting on MOdelling and DAta for Radiological Impact Assessments (MODARIA), IAEA Vienna, November 2013

[5] Suchon, D., Carny, P., Smejkalova, E., Liptak, L.: Operational effluents impacts calculation – characteristics of the SW tool ESTE AI (Annual Impacts), ESTE workshop, High Tatras, Slovakia, April 2014

[6] Smejkalova, E., Carny, P., Liptak, L.: Case study- application of remote sensing: From satellite data to classified areas with agricultural crops up to final use in ESTE Annual Impacts, IAEA Technical Meeting on MOdelling and DAta for Radiological Impact Assessments (MODARIA), 2014 Interim Meeting of Working Group 5, Bratislava, Slovakia, May 2014

[7] Smejkalova, E., Liptak, L., Carny, P.: The scenario for hypothetical NPP based on information from EMRAS II and INPRO projects - results using ESTE AI, IAEA Technical Meeting on MOdelling and DAta for Radiological Impact Assessments (MODARIA), IAEA Vienna, November 2014

[8] Liptak, L., Chyly, M., Smejkalova, E., Carny, P.: The realistic scenario from a French NPP, Chinon
- results using ESTE AI, IAEA Technical Meeting on MOdelling and DAta for Radiological Impact Assessments (MODARIA), 2015 Interim Meeting of Working Group 5, Lyon, France, April 2015

[9] Report of the IAEA MODARIA Working Group 5: “UNCERTAINTY AND VARIABILITY ANALYSIS FOR ASSESSMENTS OF RADIOLOGICAL IMPACTS ARISING FROM ROUTINE DISCHARGES OF RADIONUCLIDES”, MOdelling and DAta for Radiological Impact Assessments (MODARIA) programme of the IAEA, 2015

9. REFERENCES

1. ABmerit: User Manual "ESTE Annual Impacts".
2. **US NRC Regulatory Guide 1.109**, rev.1. Calculation of Annual Doses for Man from Routine Releases of Reactor Effluents.
3. **US NRC Regulatory Guide 1.113**, rev.1. Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases.
4. **TRS 422** – Sediment Distribution Coefficients and Concentration Factors for Biota in the Marine Environment, IAEA, 2004.
5. **RadDecay,** verzia 3.0, Nuclide Information and Decay Software (author: Grove Software, Inc., USA)
6. **Conversion factors for external irradiation** from cloud up to the distance of 3 km from the breathing stack, ABmerit, Microshield (Grove Software, Inc., USA), MCNP
7. Gering, F., Muller, H.: **Deposition calculation in RODOS** PV 4.0, doc. RODOS (WG3) – TN(99)22, 1999.
8. **IAEA-TECDOC-1616**, Quantification of Radionuclide Transfer in Terrestrial and Freshwater Environments for Radiological Assessments, International Atomic Energy Agency, May 2009.
9. **IAEA Technical Reports Series No.472**: Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Terrestrial and Freshwater Environments, March 2010.
10. Metody rasčeta rasprostranenija radioaktivnych veščestv s AES i oblučenija okružajuščego naselenija, NTD Interatomenergo 38.220.56-84, Moskva, Energoatomizdat, 1984.
11. **IAEA – Safety Series No. 57**: Generic Models and Parameters for Assessing the Environmental Transfer of Radionuclides from Routine Releases. IAEA, Vienna, 1982.
12. Hoffman, F.O., Baes III, Ch.F.: A Statistical Analysis of Selected Parameters for Predicting Food Chain Transport and Internal Dose of Radionuclides. ORNL, Oak Ridge, 1979.
13. Carter, M.W., Harley, J.H., Schmidt, G.D., Silini, G.: Radionuclides in the Food Chain. Springer Verlag, Berlin, 1988.
14. Voigt, G. a kol.: Experimental Determination of Transfer Coefficients of ^{137}Cs and ^{131}I from Fodder into Milk of Cows and Sheep after Chernobyl Accident. Health Physics 57(6), 1989, s. 967-973.
15. Carter, M.W., Harley, J.H., Schmidt, G.D., Silini, G.: Radionuclides in the Food Chain. Springer Verlag, Berlin, 1988.
16. Nair, S.: Models for the Evaluation of Ingestion Doses from the Consumption of Terrestrial Foods Following an Atmospheric Radioactive Release. Central Electricity Board, Berkeley, 1984.
17. Ng, Y.C.: A Review of Transfer Factors for Assessing the Dose from Radionuclides in Agricultural Products, Nucl. Safety, Vol. 2, No. 1, January-February 1982.
18. McColl, N.P., Prosser, S.L.: NRPB Emergency Data Handbook, NRPB-W19, last revision 2006. Tab. 16.
19. EUR 16239: PC Cosyma (Version 2): An Accident Consequent Assessment Package

10. ABOUT THE ESTE SYSTEMS

- **ESTE** is the name given to the group of programs which serve as instruments for the source term evaluation and calculation of radiological impacts in case of nuclear accident or as instruments for impacts evaluation of NPP normal operational radiological discharges.
- **ESTE** in its emergency response version has many modifications: **ESTE EU, ESTE Dukovany NPP, ESTE Temelin NPP**, **ESTE Mochovce NPP**, **ESTE Bohunice NPP, ESTE Kozloduy NPP**.
- **ESTE** in its normal (discharges) operation version is "**ESTE AI**" and up to now is assimilated to and implemented at Bohunice NPP (Slovakia), and at the Czech State Office for Nuclear Safety, Prague, assimilated to the conditions of Temelin NPP (Czech) and Dukovany NPP (Czech). **ESTE AI** (=Annual Impacts) is program for calculation of radiation doses caused by normal operational NPP effluents to the atmosphere and to the hydrosphere. Doses to the members of critical groups of inhabitants in the vicinity of NPP are calculated and as a result, critical group is determined. Program enables to calculate collective doses as well. Collective doses to the inhabitants living in the vicinity of the NPP are calculated. Program calculates doses to the whole population of the country of implementation (e.g. Slovakia), and to the population of neighboring countries (e.g. Austria, Hungary, Germany, Czech Republic or Slovakia) from the effluents of the specific plant. In this calculation, global nuclides are included and assumed, too.

ESTE implementations:

- Czech Nuclear Regulatory Body SUJB Prague - ESTE Dukovany NPP, ESTE Temelin NPP, ESTE EU;
- Czech Nuclear Regulatory Body SUJB Prague – ESTE Annual Impacts Temelin NPP, ESTE Annual Impacts Dukovany NPP;
- SE a.s. (ENEL, Slovakia) – ESTE Mochovce NPP, ESTE Bohunice NPP, Simulator ESTE SIM Mochovce 12, Simulator ESTE SIM Mochovce 34, ESTE Annual Impacts Bohunice NPP;
- JAVYS a.s. (decommissioned Bohunice site, Slovakia) - ESTE Annual Impacts Bohunice;
- Kozloduy NPP (Bulgaria) – ESTE Kozloduy NPP;
- Bulgarian Nuclear Regulatory Body NRA, Sofia – ESTE EU, ESTE Kozloduy NPP;
- Austrian Ministry of Environment (BMLFUW, Vienna) – ESTE EU with module for Dukovany NPP and Temelin NPP;
- IAEA, Vienna, Safety Assessment Section – ESTE EU, ESTE Fukushima;
- Czech Technical University FJFI ČVUT Prague – school version of ESTE EU;
- Slovak Technical University FEI STU Bratislava – school version of ESTE EU.