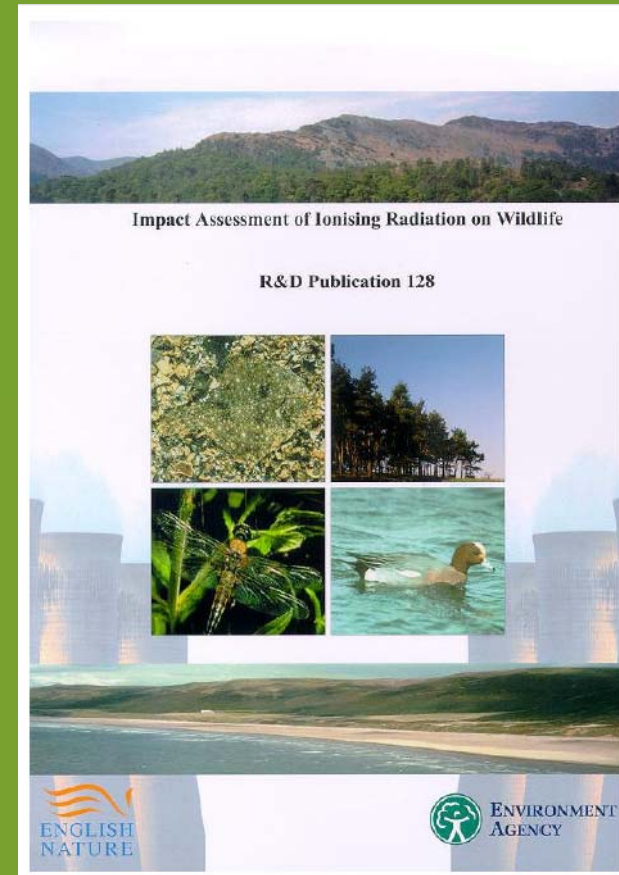


# Exercise 3 – R&D128 analogue approach

David Coplestone & Laura Newsome  
January 2010

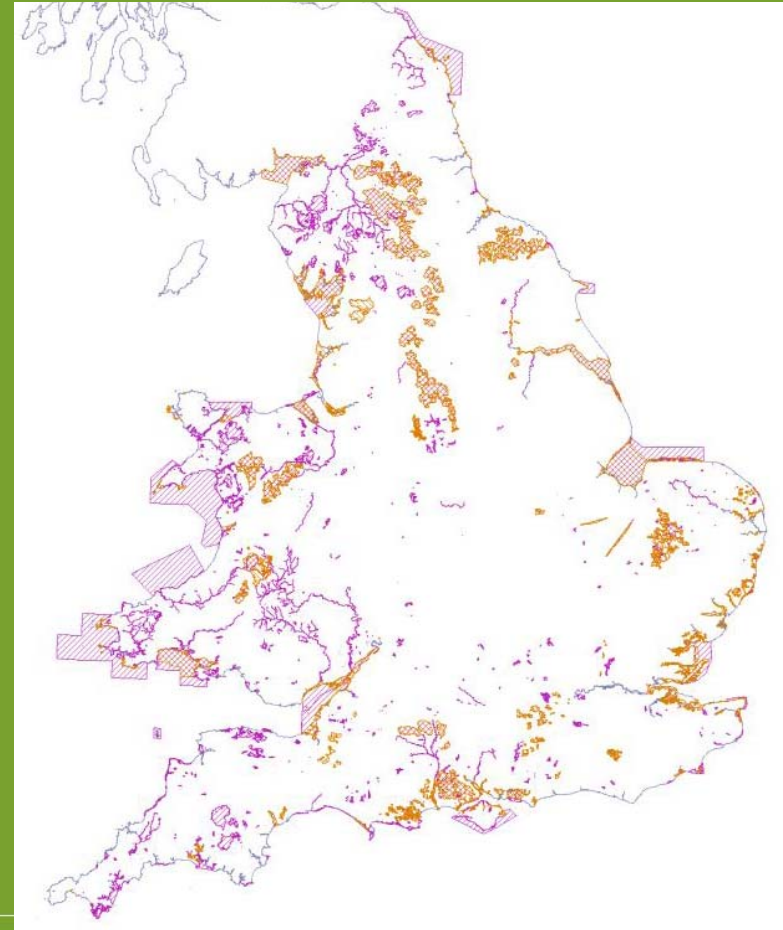
# R&D128

- ➔ Provides an approach for the impact assessment of ionising radiation on wildlife
- ➔ 3 ecosystems – terrestrial, estuarine & freshwater
- ➔ Published in 2001 and since superseded by ERICA
- ➔ Remains the basis of the Environment Agency's radiological assessments



# Screening tier will be main level of assessment?

- Example - England & Wales 'Habitats' [Natura2000] assessments
- Assessed 715 radioactive discharge authorisations
- Screening level of 5  $\mu\text{G}/\text{h}$  used
- 600 authorisations did not require assessment more detailed than initial conservative level (i.e. estimate  $< 5 \mu\text{G}/\text{h}$ )



# R&D128 - Radionuclides

➔ Selected based on a potentially high radiobiological significance to wildlife

## ➔ Freshwater:

H-3, C-14, P-32, Co-60, Sr-90, Tc-99, Ru-106, I-129, I-131, Cs-137, Po-210, Th-234, Pa-234m, U-238, Pu-239, Pu-240.

## ➔ Terrestrial:

H-3, C-14, P-32, S-35, Ar-41, Co-60, Kr-85, Sr-90, Ru-106, I-129, I-131, Cs-137, Po-210, Ra-226, Th-234, Pa-234m, U-238, Pu-239, Pu-240, Am-241

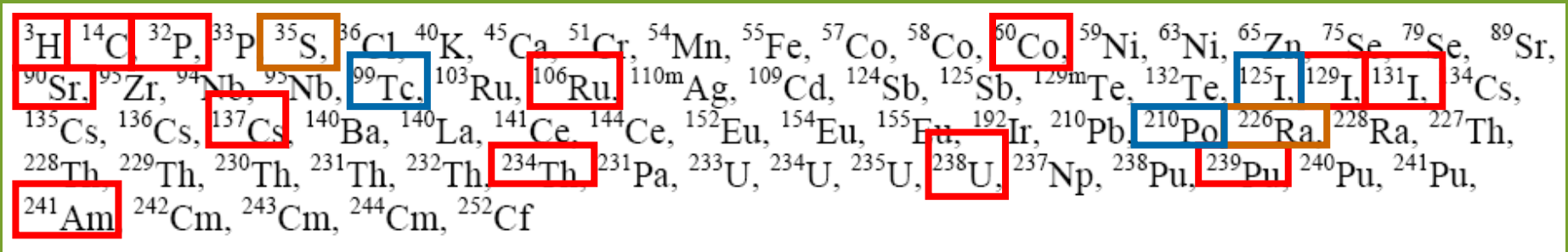
# R&D128 - Assessment spreadsheets

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1				Concentration factors, organism:water ----->											
2	<b>Nuclide</b>	<b>Water conc.</b>	<b>Sediment</b>	<b>Bacteria</b>	<b>Phytoplankton</b>	<b>Zooplankton</b>	<b>Macrophyte</b>	<b>Benthic mollusc</b>	<b>Small b. crust.</b>	<b>Large b. crust.</b>	<b>Amphibian</b>	<b>Pelagic fish</b>	<b>Benthic fish</b>	<b>Aqu. mammal</b>	<b>Duck</b>
3		<b>Bq m<sup>-3</sup></b>	<b>m<sup>3</sup> kg<sup>-1</sup></b>	<b>m<sup>3</sup> kg<sup>-1</sup></b>	<b>m<sup>3</sup> kg<sup>-1</sup></b>	<b>m<sup>3</sup> kg<sup>-1</sup></b>	<b>m<sup>3</sup> kg<sup>-1</sup></b>	<b>m<sup>3</sup> kg<sup>-1</sup></b>	<b>m<sup>3</sup> kg<sup>-1</sup></b>	<b>m<sup>3</sup> kg<sup>-1</sup></b>	<b>m<sup>3</sup> kg<sup>-1</sup></b>	<b>m<sup>3</sup> kg<sup>-1</sup></b>	<b>m<sup>3</sup> kg<sup>-1</sup></b>	<b>m<sup>3</sup> kg<sup>-1</sup></b>	<b>m<sup>3</sup> kg<sup>-1</sup></b>
5	<sup>3</sup> H		1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
6	<sup>14</sup> C		2.0E+00	2.0E+00	1.8E+00	4.0E+00	4.6E+00	7.3E+00	7.3E+00	7.3E+00		4.6E+00	4.6E+00		
7	<sup>32</sup> P				2.0E+00	2.0E+00	1.0E+01					5.0E+01	5.0E+01		
8	<sup>60</sup> Co		5.0E+00	5.0E+00	1.0E+00	4.0E-01	1.0E+00	2.0E+00	2.0E+00	2.0E+00		3.0E-01	3.0E-01		
9	<sup>90</sup> Sr		1.0E+00	1.0E+00	4.0E-02	2.0E-02	1.2E+00	2.5E-01	2.7E-01	2.7E-01		4.3E-02	4.3E-02		
10	<sup>99</sup> Tc		5.0E-03	5.0E-03	8.0E-03	2.0E-02	1.3E+00	2.4E-02	1.3E-02	1.3E-02		4.5E-02	4.5E-02		
11	<sup>106</sup> Ru		1.0E-01	1.0E-01	1.0E+01	6.0E+00						1.0E-02	1.0E-02		
12	<sup>125</sup> I		1.0E-02	1.0E-02	2.0E-01	6.0E-01	4.0E-01	1.7E-01	1.7E-01	1.7E-01		4.0E-02	4.0E-02		
13	<sup>129</sup> I		1.0E-02	1.0E-02	2.0E-01	6.0E-01	4.0E-01	1.7E-01	1.7E-01	1.7E-01		4.0E-02	4.0E-02		
14	<sup>131</sup> I		1.0E-02	1.0E-02	2.0E-01	6.0E-01	4.0E-01	1.7E-01	1.7E-01	1.7E-01		4.0E-02	4.0E-02		
15	<sup>137</sup> Cs		1.0E+00	1.0E+00	1.8E-01	2.0E-02	2.3E+00	5.8E-01	5.2E+00	6.3E-01		1.1E+01	1.1E+01		
16	<sup>210</sup> Po	0.00E+00	2.7E+00	2.7E+00	6.0E+00	6.0E+00	1.4E+00	1.0E+02	1.0E+02	1.0E+02		5.0E-02	5.0E-02		
17	<sup>234</sup> Th		1.0E+01	1.0E+01	4.0E+00	2.0E+00	3.0E+00	1.0E-01	1.0E-01	1.0E-01		1.0E-01	1.0E-01		
18	<sup>238</sup> U	0.00E+00	5.0E-02	5.0E-02	4.0E-03	1.0E-03	6.5E+00	1.8E-01	1.8E-01	1.8E-01		1.0E-02	1.0E-02		
19	<sup>239</sup> Pu	0.00E+00	1.0E+02	1.0E+02	1.8E-01	2.0E-02	1.8E+00	8.2E-01	1.4E-01	1.4E-01		6.9E-02	6.9E-02	2.3E-01	2.0E-03
20	<sup>241</sup> Am		5.0E+00	5.0E+00	4.0E+01	4.0E-01	3.0E+00	1.0E-01	1.0E-01	1.0E-01		3.0E-02	3.0E-02		
21															
22		<b>Habitat factors:</b>													
23		<b>f sediment</b>		1.0E+00	0.0E+00	0.0E+00	1.0E+00	0.0E+00	0.0E+00	0.0E+00	4.0E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00
24		<b>f sediment surface</b>		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00	1.0E+00	3.0E-01	1.0E-01	9.0E-01	2.0E-01	3.0E-01
25		<b>f water</b>		0.0E+00	1.0E+00	1.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.0E-01	9.0E-01	1.0E-01	6.0E-01	5.0E-01
26															
27		<b>Radiation weighting factors:</b>													
28															
29		<b>Low energy beta</b>	3.0E+00	<b>Sediment concentration factor is Bq kg<sup>-1</sup> sediment (dry wt) per Bq m<sup>-3</sup> water (solution phase)</b>											
30		<b>beta and photon</b>	1.0E+00												
31		<b>Alpha</b>	2.0E+01	<b>Biota concentration factors are Bq kg<sup>-1</sup> whole organism (fresh wt) per Bq m<sup>-3</sup> water (solution phase)</b>											
32															
33															
34															
35															
36															

**Sheet "Concentrations and CFs"**  
 This is the data input sheet

# Exercise 3 – Radionuclides

## ➔ Radionuclides in R&D128



- Terrestrial & freshwater
- Freshwater
- Terrestrial

# Exercise 3 – R&D128 results

Radionuclide/Organism	Internal DCF	External DCF (water)	External DCF (In-Soil)	External DCF (On-Soil/On-Shore)	External DCF (Sediment)	
<sup>32</sup> P	Duck	3.96E-04	1.47E-05		8.20E-06	
	Frog	3.82E-04	1.85E-05		4.45E-05	
	Salmonid egg	1.35E-04	2.66E-04			5.33E-05
	Rat	3.91E-04		9.88E-06	9.06E-06	
	Earthworm (elongated)	2.74E-04		1.26E-04	1.16E-04	
<sup>35</sup> S	Duck	2.82E-05			9.03E-09	
	Frog	2.81E-05			6.25E-08	
	Salmonid egg					
	Rat	2.82E-05		9.71E-09	8.90E-09	
	Earthworm (elongated)	2.80E-05		2.11E-07	1.93E-07	
<sup>137</sup> Cs	Duck	5.83E-05	1.63E-07		3.27E-08	
	Frog	5.82E-05	2.24E-07		4.48E-08	
	Salmonid egg	5.31E-05	5.36E-06			1.07E-06
	Rat					
	Earthworm (elongated)					
<sup>138</sup> Ru	Duck	7.55E-04	1.80E-04		7.86E-05	
	Frog	7.35E-04	2.00E-04		1.76E-04	
	Salmonid egg	1.23E-04	8.12E-04			1.63E-04
	Rat	7.75E-04		1.61E-04	8.04E-05	
	Earthworm (elongated)	3.45E-04		5.91E-04	2.95E-04	
<sup>129</sup> I	Duck	1.93E-05	1.61E-05		3.23E-06	
	Frog	1.90E-05	1.65E-05		3.30E-06	
	Salmonid egg	1.17E-05	2.37E-05			4.74E-06
	Rat					
	Earthworm (elongated)					
<sup>137m</sup> I	Duck	4.11E-05	9.87E-06		3.88E-06	
	Frog	4.07E-05	1.03E-05		5.94E-06	
	Salmonid egg	3.61E-05	1.48E-05			2.97E-06
	Rat	4.16E-05		9.22E-06	4.61E-06	
	Earthworm (elongated)	3.75E-05		1.35E-05	6.75E-06	
<sup>131</sup> I	Duck	1.32E-04	1.98E-04		9.64E-05	
	Frog	1.25E-04	2.05E-04		1.07E-04	
	Salmonid egg	8.79E-05	2.42E-04			4.85E-05
	Rat	1.45E-04		1.85E-04	9.25E-05	
	Earthworm (elongated)	1.07E-04		2.23E-04	1.12E-04	
<sup>210</sup> Po	Duck	3.06E-03	4.42E-09		8.86E-10	
	Frog	3.06E-03	4.60E-09		9.21E-10	
	Salmonid egg	3.06E-03	4.92E-09			9.86E-10
	Rat					
	Earthworm (elongated)					
<sup>226</sup> Ra	Duck	1.80E-02			6.76E-04	
	Frog	1.77E-02			7.67E-04	
	Salmonid egg					
	Rat	1.80E-02		1.36E-03	6.82E-04	
	Earthworm (elongated)	1.76E-02		1.74E-03	8.72E-04	

<sup>232</sup> Th	Duck	4.88E-04	3.48E-05		1.32E-05	
	Frog	4.82E-04	4.06E-05		4.29E-05	
	Salmonid egg	1.66E-04	3.56E-04			7.13E-05
	Rat	4.95E-04		2.75E-05	1.38E-05	
	Earthworm (elongated)	3.31E-04		1.92E-04	9.59E-05	
<sup>238</sup> Pu	Duck	2.97E-03	2.13E-07		5.54E-08	
	Frog	2.97E-03	1.77E-07		1.16E-07	
	Salmonid egg	2.97E-03	4.21E-07			8.44E-08
	Rat	2.97E-03		2.22E-07	1.11E-07	
	Earthworm (elongated)	2.97E-03		3.23E-07	1.61E-07	
<b>RADIONUCLIDES BELOW HERE WERE CONSIDERED IN EXERCISE 1</b>						
<sup>3</sup> H	Duck	3.28E-06	1.85E-10		3.56E-11	
	Frog	3.28E-06	2.84E-10		2.76E-10	
	Salmonid egg	3.28E-06	3.85E-09			7.70E-10
	Rat	3.28E-06		3.48E-11	3.19E-11	
	Earthworm (elongated)	3.28E-06		8.82E-10	8.08E-10	
<sup>14</sup> C	Duck	0.00E+00	3.02E-08		9.33E-09	
	Frog	0.00E+00	4.23E-08		6.45E-09	
	Salmonid egg	0.00E+00	9.19E-07			1.84E-07
	Rat	2.85E-05		1.00E-08	9.20E-09	
	Earthworm (elongated)	2.83E-05		2.17E-07	1.99E-07	
<sup>60</sup> Co	Duck	1.95E-04	1.31E-03		6.45E-04	
	Frog	1.42E-04	1.36E-03		7.03E-04	
	Salmonid egg	5.46E-05	1.45E-03			2.90E-04
	Rat	2.58E-04		1.24E-03	6.21E-04	
	Earthworm (elongated)	7.02E-05		1.43E-03	7.15E-04	
<sup>89</sup> Sr	Duck	6.22E-04	2.99E-05		9.66E-06	
	Frog	6.15E-04	3.71E-05		4.91E-05	
	Salmonid egg	2.19E-04	4.33E-04			8.68E-05
	Rat	6.31E-04		2.15E-05	1.08E-05	
	Earthworm (elongated)	4.18E-04		2.34E-04	1.17E-04	
<sup>137</sup> Cs	Duck	1.74E-04	2.95E-04		1.44E-04	
	Frog	1.62E-04	3.07E-04		1.61E-04	
	Salmonid egg	9.80E-05	3.71E-04			7.43E-05
	Rat	1.91E-04		2.78E-04	1.39E-04	
	Earthworm (elongated)	1.30E-04		3.39E-04	1.69E-04	
<sup>238</sup> U	Duck	5.66E-03	3.57E-05		1.34E-05	
	Frog	5.65E-03	4.14E-05		4.34E-05	
	Salmonid egg	5.34E-03	3.58E-04			7.17E-05
	Rat	5.67E-03		2.85E-05	1.42E-05	
	Earthworm (elongated)	5.50E-03		1.93E-04	9.63E-05	
<sup>241</sup> Am	Duck	3.19E-03	1.38E-05		5.83E-06	
	Frog	3.19E-03	1.38E-05		7.66E-06	
	Salmonid egg	3.19E-03	1.85E-05			3.71E-06
	Rat	3.20E-03		1.26E-05	6.31E-06	
	Earthworm (elongated)	3.19E-03		1.70E-05	8.52E-06	

Results without analogues – not many!

# Technical Report SP1a

- ⇒ Updated guidance for undertaking assessments using R&D128
- ⇒ Advice – when need to model radionuclides that are not in the R&D128 spreadsheets, use recommended analogues
  - ⇒ Internal EA report





# Exercise 3 – Analogue radionuclides

Analogue	Cs-137 (beta gamma > 10 d)	Co-60	I-131 (beta gamma 1-10 d)	P-32	Pu-239 (other alpha)	U-238 (uranium alpha)
Terrestrial & Freshwater	Cl-36, K-40, Ca-45, Cr-51, Mn-54, Fe-55, Co-57, Co-58, Ni-59, Ni-63, Zn-65, Se-75, Se-79, Sr-89, Zr-95, Nb-94, Nb-95, Ru-103, Cd-109, Sb-124, Sb-125, Te-129m, Cs-134, Cs-135, Cs-136, Ba-140, Ce-141, Ce-144, Eu-154, Eu-155, Ir-192, Pb-210, Ra-228, Pu-241	Ag-110m	Te-132, La-140, Eu-152, Th-231	P-33	Th-227, Th-228, Th-229, Th-230, Th-232, Pa-231, U-233, Np-237, Pu-238, Pu-240, Cm-242, Cm-243, Cm-244, Cf-252	U-234, U-235
Terrestrial	Tc-99, I-125				Po-210	
Freshwater	S-35				Ra-226	



## SP1a also notes

“Analogues, unless selected with great care, can give rise to misleading assessments. Analogues are often cautious because of the need to ensure a precautionary approach taking into account the uncertainties associated with their use.”

**Keep all this in mind when  
Nick presents the Exercise 3  
results!!**