A303 Amesbury to Berwick Down

Applicant's provision of technical reports supporting the Environmental Information Review

Public Health England Report - Phosphatic chalk risks at Parsonage Down

Document reference: Redetermination 2.20

Planning Act 2008

The Infrastructure Planning (Examination Procedure) Rules 2010

February 2022

Public Health England

Protecting and improving the nation's health

Radiological assessment of tunnel arisings from A303 Amesbury to Berwick Down Stonehenge bypass

Introduction

Highways England is proposing a road improvement scheme for the A303 between Amesbury and Berwick Down that includes a tunnel of approximately two miles in length (Highways England, 2018). Ground investigations have revealed that the land into which the tunnel would be bored contains phosphatic chalk, which contains naturally occurring radioactive material (NORM) (Mortimer et al, 2017).

Public Health England (PHE) were contracted by AECOM on behalf of Highways England to address concerns raised by the local population on the possible radiological risks posed by the deposition of the phosphatic chalk contained in the tunnel arisings at east of Parsonage Down. PHE analysed sample cores taken from boreholes made along the proposed route of the tunnel, and assessed potential future doses to those using the land onto which the material is deposited, based on the activity concentrations in those samples.

AECOM provided PHE with five sample cores of phosphatic chalk from the boreholes for analysis by gamma spectroscopy. The results of the analysis are shown in Table 1. The activity concentration of ^{238}U in chalk in the south of England typically ranges between 0.6 and 80 Bq kg^{-1} (Smedley et al, 2006), while levels in all soil types across the UK range from 2 to 330 Bq kg^{-1} depending on the underlying geology (Oatway et al, 2016).

Results of Analysis

The average expected values of activity concentrations measured in two samples (19-08001, 19-08005) are within the range or close to the maximum value of those found in similar substrates, while the activity concentrations in the remaining three samples (19-08002, 19-08003 and 19-08004) are significantly higher than the maximum value of those found in similar substrates but within the range found in the UK. The uncertainties given for each of the measured values are the least likely values and are not discussed further.

Table 1 Radionuclide activity concentrations in phosphatic chalk core samples from A303 Stonehenge bypass

PHE Sample number	AECOM Sample ID	Depth (m)	Wet/dry ratio	Activity concentration, dry mass (Bq kg^{-1})							
				^{235}U	^{238}U*	^{226}Ra	^{241}Bi†	^{210}Pb	^{228}Ac	^{212}Pb	^{40}K
19-08001	R607	19.8-19.9	1.24	3.4 ± 1.2‡	44 ± 38	39 ± 22	41 ± 5	37 ± 6	< 1.7	0.9 ± 0.3	8.3 ± 3.5
19-08002	R612	9.7-9.85	1.27	6.7 ± 1.8	160 ± 48	76 ± 32	80 ± 10	62 ± 9	2.6 ± 1.1	1.3 ± 0.5	12 ± 4.9
19-08003	R613	9.4-9.5	1.22	13 ± 2.9	190 ± 50	140 ± 50	160 ± 20	110 ± 20	1.9 ± 1.0	1.9 ± 0.6	9.2 ± 4.1
19-08004	R613	10.75-11.0	1.27	11 ± 2.2	220 ± 60	110 ± 40	130 ± 20	95 ± 13	3.9 ± 1.4	2.2 ± 0.5	15 ± 4.4
19-08005	R615	13.0-13.42	1.24	9.0 ± 2.2	82 ± 44	74 ± 37	105 ± 13	74 ± 11	3.0 ± 1.0	1.4 ± 0.6	12 ± 5.8

Version 1.2
6 March 2019
Alison Jones

Notes
* Based on measurements of ^{234m}Pa.
† No attempt to prevent ^{222}Rn loss from the samples was made and activity concentrations were not determined.
‡ The reported uncertainties are 2 standard deviations, which provide a level of confidence of approximately 95%.

Dose assessment

For the dose assessment the activity concentrations of members of the ^{238}U[1], ^{232}Th[2] and ^{235}U[3] radioactive decay chains were selected to be 200 Bq kg^{-1}, 3 Bq kg^{-1} and 10 Bq kg^{-1} respectively. In addition, a representative activity concentration for ^{40}K of 10 Bq kg^{-1} was assumed. These values are representative of the three highest activity concentration measurements shown in Table 1.

Gamma spectroscopy is capable of measuring the activity concentration of only some of the radionuclides present in the samples but the results obtained were sufficient to show that the radionuclides in the decay chains can generally be considered to be in secular equilibrium[4]. In this assessment the contribution from background radiation was not subtracted. The estimated doses are therefore the total dose that people would receive assuming that all the soil at the new location is made up of the phosphatic soil from the tunnelling and represents the worst case scenario.

The assessment made use of the methodology developed by the National Radiological Protection Board (a predecessor to Public Health England) to estimate doses to people from radioactively contaminated land which is described in report NRPB-W36 (Oatway and Mobbs, 2003). The assessment is based on cautious assumptions of the habits of people using the land onto which tunnel arisings have been placed.

Two scenarios were selected from the NRPB-W36 methodology: agriculture and recreational (Oatway and Mobbs, 2003). The agriculture scenario considers radiation doses to a farmer's family whilst the recreational scenario considers exposure of a family using the land for walking or playing. Doses were estimated to an adult, a 10 year old child and a 1 year old infant. The use of these age groups in a radiological assessment is in line with current recommendations from the International Commission on Radiological Protection (ICRP) (ICRP, 2006).

---

1 Members of the ^{238}U radioactive decay chain included in the assessment: ^{238}U, ^{234}Th, ^{234m}Pa, ^{234}Pa, ^{230}Th, ^{226}Ra, ^{218}Po, ^{214}Pb, ^{214}Bi, ^{214}Po, ^{210}Pb, ^{210}Bi, ^{210}Po

2 Members of the ^{232}Th radioactive decay chain included in the assessment: ^{232}Th, ^{228}Ra, ^{228}Ac, ^{228}Th, ^{224}Ra, ^{216}Po, ^{212}Pb, ^{212}Bi, ^{212}Po, ^{208}Tl

3 Members of the ^{235}U radioactive decay chain included in the assessment: ^{235}U, ^{231}Th, ^{231}Pa, ^{227}Ac, ^{227}Th, ^{223}Ra, ^{215}Po, ^{211}Pb, ^{211}Bi, ^{207}Tl

4 Secular equilibrium denotes a state within a radioactive decay chain where the activity of every radionuclide is the same.

For this assessment it was assumed that the excavated material covered an entire field used to produce food or within which people spend time on recreational activities. It was also assumed that radionuclides present in the soil were distributed evenly over the entire field and that the excavated material remained on the surface. No dilution of the radioactivity was assumed to occur after it had been placed on the land, for example through ploughing. Doses calculated for the agriculture scenario excluded doses from consumption of grain, fruit, root and green vegetables, as these foodstuffs are not normally grown on Salisbury Plain. Owing to the chalk substrate and current use of the land, it was assumed that the land was only used for producing beef, milk and sheep. This assumption was based on agricultural information compiled by the EDINA National Data Centre at Edinburgh University ([redacted]/). All parameter values used in the assessment, such as inadvertent ingestion rates and inhalation rates, were taken from report NRPB-W36 (Oatway and Mobbs, 2003). The doses calculated are given in Table 2. If arable crops were grown on the land with a minimum of 300 mm of clean topsoil added, doses would be expected to be negligible as the roots will not extend beyond the layer of clean topsoil.

Table 2 Estimated doses to different age groups for two distribution and land use scenarios

	Annual effective dose (mSv y^{-1})		
Scenario	**Adult**	**10 year old child**	**1 year old infant**
Agriculture scenario	0.04	0.03	0.06
Recreation scenario	0.06	0.06	0.06

To put the estimated doses in Table 2 into context, PHE has estimated that the average annual dose to the population of the UK from radioactivity of natural origin is about 2.3 mSv (Oatway et al, 2016) of which radon contributes about 57%.

It was estimated that the maximum annual dose that may be received by a farmer working the land and their family eating food produced on the land, or members of the public using the land for recreational purposes is about 0.06 mSv y^{-1}. This dose is very low and indicates that the material extracted during the tunnelling operation would pose little radiological risk to people living in the area where the material is disposed of. The most significant contribution to the dose is from ingestion of ^{210}Po and ^{210}Pb in milk and from external irradiation from ^{226}Ra and its progeny. It should be noted that exposure to radon gas was not included as an exposure pathway in our assessment because the scenarios considered only consist of outdoor activities and activity concentrations of radon outdoor are extremely low. The methodology in report NRPB-W36 is not able to estimate activity concentrations of radon in air indoors from a given activity concentration in soil.

Disposing of the excavated material onto the surface of the land is unlikely to result in additional levels of activity in the local aquifer since the phosphatic chalk already contributes to its radioactive content.

Environmental Permitting Regulations

It should be noted that the material extracted during the tunnelling operation does not fall under the definition of a NORM industrial activity and therefore would not be classed as radioactive material or waste and its disposal would be outside the scope of the Environmental Permitting Regulations (EPR) (UK Parliament, 2016). Additionally the activity concentrations in the phosphatic chalk are lower than the 1000 Bq kg^{-1} limit given in the EPR as the activity concentration for NORM to fall within the scope of the EPR and the estimated doses are significantly lower than the dose of 0.3 mSv y^{-1} adopted in the legislation as the criterion that the disposer must demonstrate doses do not exceed for the material to be considered out of scope.

References

Highways England (2018). A303 Amesbury to Berwick Down. Improving journeys, reuniting the Stonehenge landscape. H. England.

ICRP (2006). Assessing dose of the representative person for the purpose of radiation protection of the public and the optimisation of radiological protection. ICRP Publication 101. *Annals of the ICRP* **36**(3).

Mortimer RN, Gallagher LT, Gelder JT, Moore I, Brooks R and Farrant AR (2017). Stonehenge - a unique Last Cretaceous phosphatic chalk geology: implications for sea-level, climate and tectonics and impact on engineering and archaeology. *Proceedings of the Geologists' Association* **128**(4), 564-598.

Oatway WB, Jones AL, Holmes S, Watson SJ and Cabianca T (2016). *Ionising radiation exposure of the UK population: 2010 review.* CRCE, Chilton, PHE-CRCE-026.

Oatway WB and Mobbs SF (2003). *Methodology for Estimating the Doses to Members of the Public from the Future Use of Land Previously Contaminated with Radioactivity.* National Radiological Protection Board, Chilton, UK, NRPB-W36.

Smedley PL, Smith B, Abesser C and Lapworth D (2006). *Uranium occurrence and behaviour in British groundwater.* CR/06/050N.

UK Parliament (2016). *The Environmental Permitting (England and Wales) Regulations 2016*. TSO, United Kingdom (SI 2016)

This work was undertaken under the Radiation Assessments Department's Quality Management System, which has been approved by Lloyd's Register Quality Assurance to the Quality Management Standard ISO 9001:2015, Approval No: ISO 9001 – 00002655.

This document is also available on our website at www.nationalhighways.co.uk
For an accessible version of this publication please call 0300 123 5000 and we will help you.

If you have any enquiries about this publication email info@highwaysengland.co.uk
or call 0300 123 5000*. Please quote the National Highways publications code **PR48/22**
National Highways creative job number **BRS17_0027**

*Calls to 03 numbers cost no more than a national rate call to an 01 or 02 number and must count towards any inclusive minutes in the same way as 01 and 02 calls.
These rules apply to calls from any type of line including mobile, BT, other fixed line or payphone. Calls may be recorded or monitored.
Printed on paper from well-managed forests and other controlled sources when issued directly by National Highways.
Registered office Bridge House, 1 Walnut Tree Close, Guildford GU1 4LZ
National Highways Limited registered in England and Wales number 09346363