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Radiological Assessment Report on a Prospective Development Site: Land Rear of Diana Close, Spencers Wood, RG7 1HP

Contents

1. Introduction

1.1 As requested, I have examined the characteristics of the proposed development on land to the rear of Diana Close, Spencers Wood, RG7 1HP in respect of its location within the boundary of the REPPIR planning area (often known as the Detailed Emergency Planning Zone – DEPZ) for AWE Burghfield.

1.2 The proposed development comprises 24 residential dwellings. Taking a typical occupancy of 2.4 residents per unit, the total number of residents would be about 58. This sets a context for the potential change in the local population. Implications for the offsite emergency plan in relation to potential accidents occurring at AWE Burghfield are addressed below.

1.3 In this short report, Section 2 describes the activities undertaken at AWE Burghfield and the types of accident that might result in significant off-site releases of radioactive materials. Section 3 then uses this information to assess the radiological impacts of such releases on individuals located on the proposed development assuming it to be downwind of the site at the time of an accident. Section 4 considers how the potential radiological impacts of such accidents set a minimum size for the DEPZ and how other considerations have been used to increase the size of the DEPZ at AWE Burghfield such that the site of the proposed development now falls within it. Section 5 then addresses the implications of the site being located within the DEPZ in respect of effects on the emergency plan and on requirements for implementing mitigation measures to limit the radiological impacts of potential radiological accidents on residents. Conclusions from this analysis are presented in Section 6.

2. Activities at AWE Burghfield and Radiological Accidents that could occur

2.1 AWE Plc is the company that provides and maintains nuclear warheads for the UK continuous at sea deterrent Trident. AWE Aldermaston and AWE Burghfield are the company's two main sites. Burghfield operated as an ordnance factory until it entered the Atomic Weapons' Programme in 1954. Today, on-site operations include the entire cycle of warheads from concept and design, manufacturing, assembly, servicing, decommissioning and disposal [ONR, 2018].

2.2 Until recently, requirements relating to off-site emergency planning were defined under the Radiation (Emergency Preparedness and Public Information) Regulations 2001 [REPPIR, 2001]. However, these have now been replaced by REPPIR [2019]. Whereas under REPPIR [2001] the extent of the DEPZ was determined by the Office for Nuclear Regulation (ONR), under REPPIR [2019] it is determined by the lead Local Authority (LA), which, in this case is West Berkshire District Council (WBDC). The other main change of relevance here is that the accident conditions to be addressed in defining the DEPZ have changed. Previously, the DEPZ could be determined based on a 'reasonably foreseeable accident' and a dose contour of 5 mSv. However, under REPPIR [2019] the concept of a 'reasonably foreseeable accident' is no longer allowed. Instead there are several different requirements that must be considered:

- Age and other characteristics that would render specific members of the public especially vulnerable,
- Inclusion of all relevant pathways,
- Use of a representative range of source terms,
- Address a range of weather conditions to account for situations that are less likely but would have greater consequences.

2.3 In addition, the limiting dose contour is now 7.5 mSv rather than 5 mSv.

2.4 To define the location of the 7.5 mSv contour, AWE Burghfield produced a consequences report as required under REPPIR [2019]. This report [AWE, 2019] provides details of the environmental pathways of exposure that require consideration and the atmospheric stability conditions adopted in calculating the dispersal of radioactive materials beyond the site boundary. The information provided is summarised below.

2.5 The exposure pathways that require consideration include:

- First-pass inhalation of air in the plume of contamination.
- Short-term external irradiation during the passage of the plume (cloud-shine),
- Long-term inhalation after resuspension from ground contaminated by the plume,
- Long-term external irradiation from ground contaminated by the plume (ground-shine),
- Ingestion of food crops contaminated by the initial plume.

2.6 The most likely predicted accidents would spread material by explosive distribution, where the dominant material would be plutonium in an inhalable particulate form. However, for potentially more energetic events a range of fission products would be

produced. It is relevant to note that these fission products would arise from pre-existing material and not from an operating nuclear reactor, as there are no operating reactors present at AWE Burghfield.

2.7 For most fault sequences, the material released would be in the form of fine particulates of plutonium and the predominant pathway would be exposure by inhalation. Therefore, overall, the primary concern for early response decision making in emergencies involving possible accidents at AWE Burghfield only merits consideration of the first-pass inhalation dose and this means that sheltering is the recommended urgent protective action.

2.8 In respect of atmospheric dispersion, the REPPIR [2001] determination was based on a 5 mSv contour using 55% stability Category D conditions, i.e. the weather was taken to correspond to average conditions applicable in the UK. In contrast, the new REPPIR [2019] determination is based on a 7.5 mSv contour but on a weather category that is less likely, but which could provide significantly greater doses. Consideration of less likely weather categories, which occur around 12% of the time in the local geographical area, increases the 7.5 mSv dose contour to a distance of 3160 m from the centre of the Burghfield site [AWE, 2019].

2.9 Because there have been few changes in operations at the Burghfield site over the last few years, a further insight on the types of accident of interest can be obtained from ONR [2018]. This is based on the reference accident concept and states that AWE Plc identifies the reference accident at AWE Burghfield as a detonation within a cell (meaning a 'hot cell' for the manipulation of radioactive materials). Furthermore, ONR [2018] reports that the AWE Plc Report of Assessment (RoA) concludes from the reference accident that the area in which a member of the public might potentially receive a radiation dose of more than 5 mSv is bounded by a distance of 1.252 km (1252 m) from the centre of the licensed nuclear site.

2.10 ONR [2018] further comments that all accidents that could lead to a reasonably foreseeable radiation emergency result in the release of uranium and/or plutonium compounds. These materials emit alpha and weak gamma radiations. The AWE dose assessment includes internal contributions from plume inhalation over the year following the release. External irradiation from the passing plume or from deposited uranium/plutonium material was assessed as negligible due to the nature of these materials. The dose associated with the inhalation of re-suspended radioactive material was also assessed as being less than 1% of the dose uptake (see also the footnote in Section 5.2 of this report).

2.11 The exclusion of ingestion dose as adopted by AWE in its assessment was not accepted by ONR, as the definition of a radiation emergency according to REPPIR [2001] requires that the dose averted by urgent early health protection countermeasures initiated during the first 24 hours (such as food bans) should be disregarded when projecting the dose that members of the public are likely to receive. However, an assessment undertaken by the ONR found that the contribution to public dose from ingestion was negligible (i.e. approximately 1% compared to the total dose) compared with inhalation. This is because

ingested uranium and/or plutonium compounds pass through the body quickly in contrast to inhaled material which remains in the lungs. Therefore, ONR concluded that ingestion dose would not be significant.

2.12 The ONR [2018] further noted that high consequence, low frequency external events such as aircraft impacts were considered in the AWE safety case and no faults were identified that give rise to a significant off-site release of radiation. Also, the inadvertent detonation of a warhead was judged to be well beyond a reasonably foreseeable occurrence. A security review was also undertaken by AWE Plc and was assessed separately by the Defence Nuclear Safety Regulator, and ONR [2018] judged that it is not reasonably foreseeable for any security related event to lead to public dose consequences beyond the reference accident.

2.13 In summary, a large accident with potentially significant off-site radiological consequences that could arise at AWE Burghfield would be due to detonation in a hot cell with the release of plutonium (or enriched uranium) to the atmosphere. Under average weather conditions, such an accident could result in an individual effective dose of about 5 mSv at 1252 m downwind of the release, but under adverse weather conditions that occur for about 12% of the time, the individual effective dose could be as large as 7.5 mSv at 3160 m downwind of the release. In either case, the dose would be almost entirely due to inhalation of radioactive material from the plume by the individual while they were immersed in the plume.

3. Radiological Impacts on Residents of the Proposed Development

3.1 Using Google Earth Pro, the distance from the centre of the proposed development to the centre of the AWE Burghfield site was estimated as 3700 m, with the shortest distance to the site boundary being 3300 m. Thus, the proposed development is located outside the 3160 m contour, as discussed further in Section 4. Various studies have shown that the effective dose varies approximately as x^{-n}, where x (m) is the distance downwind from the release location and n is a numerical coefficient that typically takes a value of 1.5 [Electrowatt Engineering, 1997; Highton, 2008; Highton and Senior, 2008]. Thus, an effective dose of 5 mSv at 1252 m downwind would correspond to an effective dose of $5\times(1252/3700)^{1.5}$ = 1.0 mSv at 3700 m downwind. In contrast, 7.5 mSv at 3160 m corresponds to 7.5×(3160/3700) = 5.9 mSv at 3700 m downwind. Assuming that the characteristics of the accidents considered under REPPIR [2001] and REPPIR [2019] are similar, the adoption of less likely weather conditions under REPPIR [2019] has resulted in an increase in the assessed effective dose by a factor of approximately six. This is reasonable given the degree to which atmospheric dispersion varies between different atmospheric stability categories (see, e.g. Clarke [1979]).

3.2 In this context, it is appropriate to note that AWE adopted a definition of reasonably foreseeable to include all fault sequences for which the associated dose has a return frequency of at least one in one hundred thousand per annum [HSE, 2012]. Also, in general, the frequency of accidents decreases as their severity increases. Therefore, a reasonably foreseeable reference accident can be taken to exhibit a frequency of no more than about one in ten thousand per annum, i.e. corresponding to up to ten of the worst fault sequences considered.

3.3 Based on the above analysis, residents on the proposed development would incur an effective dose of about 1 mSv if an accident occurred under average weather conditions and about 6 mSv if it occurred under weather conditions that occur for only 12% of the time. Furthermore, these effective doses are conditional on the wind blowing toward the development at the time of the accident (a probability of about 10%) and take no account of sheltering, which is an effective measure in mitigating first-pass inhalation dose. Mitigation measures are discussed further in Section 5.

3.4 Thus, overall, in the event of the reference accident under typical weather conditions, an unprotected resident of the proposed development could incur an effective dose of about 1 mSv. This effective dose is relatively small, i.e. it is the same as the annual limit on effective dose for a member of the public [ICRP, 2007] and is within the range that the linear dose response with no threshold (LNT) model generally applied in radiological protection [ICRP, 2007]. That model assigns detriment-adjusted risk coefficients of $5.5\ 10^{-5}$ per mSv for cancer and $2.0\ 10^{-6}$ per mSv for heritable effects in the whole population (including infants, children and adults). Thus, the overall risk factor is $5.7\ 10^{-5}$ per mSv, which may be thought of as equivalent to the risk of death arising from the irradiation. Thus, for a reference accident giving rise to an effective dose of about 1 mSv, the risk conditional on that accident occurring is about $5.7\ 10^{-5}$. Furthermore, as the annual probability of such an accident occurring is thought to be less than one in ten

thousand, the annual risk of death from accidents up to and including the reference accident in size is no more than about 5.7 10^{-9} or one in one hundred and eighty million (accidents substantially smaller than the reference accident would not have significant off-site consequences).

3.5 The above risk makes no allowance for the probability that the wind is blowing towards the proposed development (about one in ten) or of mitigation of the effective dose through sheltering. Thus, overall, the annual probability of death for an individual on the proposed development due to an accident at AWE Aldermaston with significant off-site radiological consequences is assessed as less than one in one hundred and eighty million, and could be substantially less if the probability that the wind is blowing towards the proposed development (about one in ten) and/or mitigation of the effective dose through sheltering were taken into account.

3.6 For comparison, the HSE in its report Reducing Risks, Protecting People [HSE, 2001] has given annual risks of death from various causes. These include 1 in 16,800 from all forms of road accident, 1 in 29,000 from lung cancer caused by the radioactive gas radon in dwellings, 1 in 510,000 from a gas incident (fire, explosion or carbon monoxide poisoning) and 1 in 18,700,000 from lightning. From this comparison, the annual probability of death for an individual on the proposed development due to an accident at AWE Burghfield is about an order of magnitude less than the annual probability of being killed by being struck by lightning.

3.7 It is also relevant to note that, when assessing the significance of individual risk, the HSE [2001] comments that it 'believes that an individual risk of death of one in a million per annum for both workers and the public corresponds to a very low level of risk and should be used as a guideline for the boundary between the broadly acceptable and tolerable regions. As is very apparent from Tables 1-4 at Appendix 4 [of HSE, 2001], we live in an environment of appreciable risks of various kinds which contribute to a background level of risk - typically a risk of death of one in a hundred per year averaged over a lifetime. A residual risk of one in a million per year is extremely small when compared to this background level of risk. Indeed, many activities which people are prepared to accept in their daily lives for the benefits they bring, for example, using gas and electricity, or engaging in air travel, entail or exceed such levels of residual risk.'

3.8 The annual probability of death for an individual on the proposed development due to an accident at AWE Burghfield is more than two orders of magnitude below the boundary of the tolerable region, i.e. it is well within the region where the risk would be judged broadly acceptable.

3.9 Notwithstanding the low annual risks arising at the proposed development due to accidents at AWE Aldermaston, it is of interest to set the assessed effective dose in context. This effective dose is about 1 mSv for the reference accident and 6 mSv in adverse weather conditions. As the average annual effective dose in the UK, mainly from naturally occurring radioactivity, is around 2.7 mSv, the effective dose from the reference accident, if it occurs under adverse weather conditions, corresponds to just over two years of

background exposure. Comparisons can also be made with medical exposures. For example, a Computed Tomography (CT) scan of the chest typically delivers 6.6 mSv and a whole-body CT scan typically delivers 10 mSv. There are also considerable regional variations in natural background, with the average annual radon dose to the people of Cornwall being 7.8 mSv, compared with a UK-wide average value of 1.3 mSv[1].

3.10 Thus, the radiological impact of the reference accident, if it were to occur under adverse atmospheric stability conditions, on an individual located on the proposed development and who failed to shelter would be:

- About the same as the radiological impact due to exposure to background radiation for two years in a typical location in the UK,
- About the same as regional variations in the annual exposure to natural background in the UK,
- Similar in magnitude to the exposure incurred because of a medical CT examination.

3.11 This is not to argue that such exposures are of no importance. Indeed, substantial efforts are being made to reduce high regional exposures to radon and the use of CT scanning in medicine is subject to a requirement for justification and optimisation on a case-by-case basis. However, it does show that the radiation doses that would be likely to arise if a major accident occurred at the AWE Burghfield site are within the range commonly experienced by members of the public during their everyday life.

[1] All the cited values are from http://www.hpa.org.uk/Topics/Radiation/UnderstandingRadiation/, downloaded 10 February 2014.

4. Setting the Size of the Detailed Emergency Planning Zone

4.1 In this report the terminology Detailed Emergency Planning Zone (DEPZ) is used following historical and recent practice (see, e.g. Richardson and Anstey [2020]). This term is taken to refer to the Off-site Emergency Planning and Public Information Areas as used in ONR [2018].

4.2 REPPIR [2019] places a duty on the local authority to determine the DEPZ for installations within its area of responsibility based on the operator's recommendations and gives it the right to extend that area in consideration of:

- Local geographic, demographic and practical implementation issues,
- The need to avoid, where practicable, the bisection of local communities,
- The inclusion of vulnerable groups immediately adjacent to the area proposed by the operator.

4.3 The associated Approved Code of Practice (ACOP) also states that the DEPZ must be based on the minimum geographical extent proposed by the operator in the consequence report and should:

- Be of sufficient extent to enable an adequate response to a range of emergencies,
- Reflect the benefits and detriments of protective action by considering an appropriate balance between dose averted and the impact of implementing protective actions in a radiation emergency across too wide an area.

4.4 There is a further requirement that in defining the boundary of the DEPZ geographic features should be used for ease of use in implementing the off-site emergency plan. Thus, physical features such as roads, rivers, railways or footpaths should be considered as well as political and postcode boundaries.

4.5 ONR [2018] provides a map of the DEPZ as defined under REPPIR [2001]. This is shown in Figure 1.

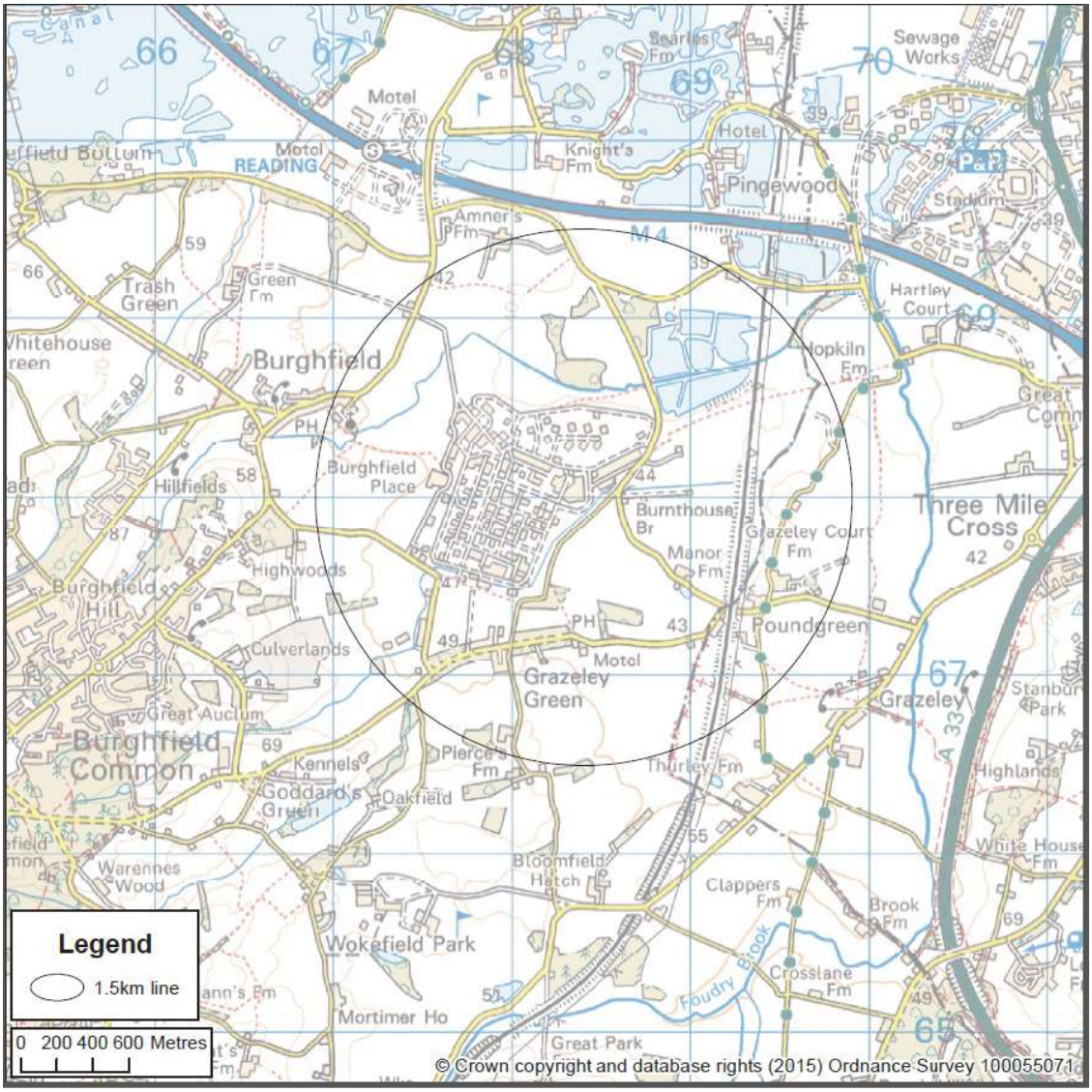

Figure 1: The DEPZ for AWE Burghfield as defined under REPPIR [2001].

4.6 The circle is set at 1.5 km, somewhat larger than required by the AWE assessment. Because of the limited size of the DEPZ and the rural nature of the surroundings, no major issues arise in respect of intersecting settlements. In contrast, the DEPZ, as defined under REPPIR [2019], is provided in Richardson and Anstey [2020] and is shown in Figure 2.

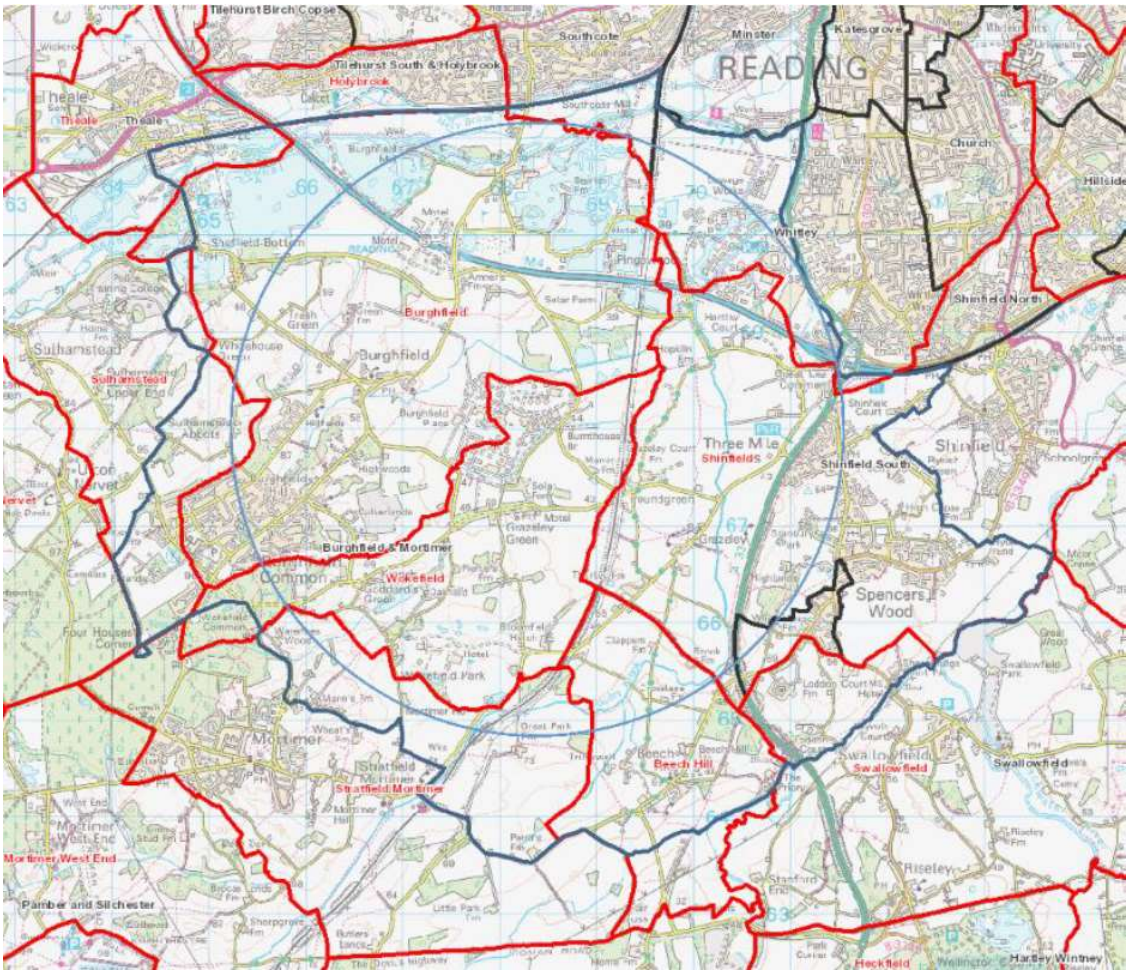

Figure 2: The DEPZ for AWE Burghfield as defined under REPPIR [2019]. Parish boundaries are shown in red.

4.7 The substantial expansion of the minimum size of the DEPZ (shown as the blue circle) means that it intersects various local communities and crosses various parish boundaries. Taking account of local considerations, WBDC, who are the lead local authority for off-site emergency planning relating to AWE Burghfield have expanded the DEPZ from its minimum size to the extent shown by the blue line in Figure 2. A substantial expansion has been made to encompass the whole of Spencers Wood, even though the whole of this community lies outside the blue circle. In contrast, just to the north of Spencers Wood, the boundary of the DEPZ lies approximately on the blue circle. This avoids including any part of the built-up area of Reading within the DEPZ.

4.8 Based on this figure, I sought clarification from Carolyn Richardson (WBDC) as to the basis for the expansion of the DEPZ around Spencers Wood. My query (dated 22 October 2020) is reproduced below.

> 'My apologies for troubling you, but I have just been reading your report (co-authored with Paul Anstey) on the AWE Detailed Emergency Planning Zone, which was considered by the Corporate Board on 12th March 2020. I have also been

reading the AWE Burghfield Consequences Report Issue 1, November 2019. That report sets out the basis for defining the minimum extent of the DEPZ (I continue to use this old terminology for conciseness) as being a radius of 3160 m from the Burghfield Site centre location. This corresponds to the blue circle in Appendix A: Map A of the Consequences Report. When I turn to Appendix A of your report, I find that the adopted DEPZ is properly always larger than this circle (since the circle specifies the minimum size of the DEPZ). However, as I understand it, a primary reason for increasing the size of the DEPZ is to avoid bisecting communities. Thus, to the north the DEPZ is limited at the boundary of the built-up area of Reading. However, the largest extension is to the east, where the DEPZ has been expanded to include the whole of Spencers Wood. However, if you had used a boundary located at the blue circle, as is done just to the north, then the whole of Spencers Wood would have lain outside the DEPZ and Three Mile Cross, which seems to be a distinct community would have lain just inside the DEPZ. I was wondering if there is any supplementary documentation as to why the decision was taken to include Spencers Wood within the DEPZ.'

4.9 I received a very prompt response from Carolyn Richardson on this matter (22 October 2020) and this is reproduced below.

'With respect to the DEPZ there is nothing else in particular I would suggest which would add value. What I may add however is that a huge number of visits have been to the site since what is shown on the map does not match what is on the ground, including a huge number of new homes being built. It was also consulted on by members of the AWE off-site planning group which included Wokingham Borough Council. Our aim throughout was being compliant and ideally keeping the area as small as possible within the limitations we had.'

4.10 Thus, the principal concern is identified as being new developments in this area.

4.11 A key consideration, as mentioned above, is whether Spencers Wood and Three Mile Cross should be treated as distinct settlements. If so, it would be reasonable for the boundary of the DEPZ to pass between them. In this context, in is relevant to consider the Shinfield Parish Neighbourhood Plan (Made Version, February 2017), because this shows the development areas within the relevant parish. The relevant map is reproduced as Figure 3.

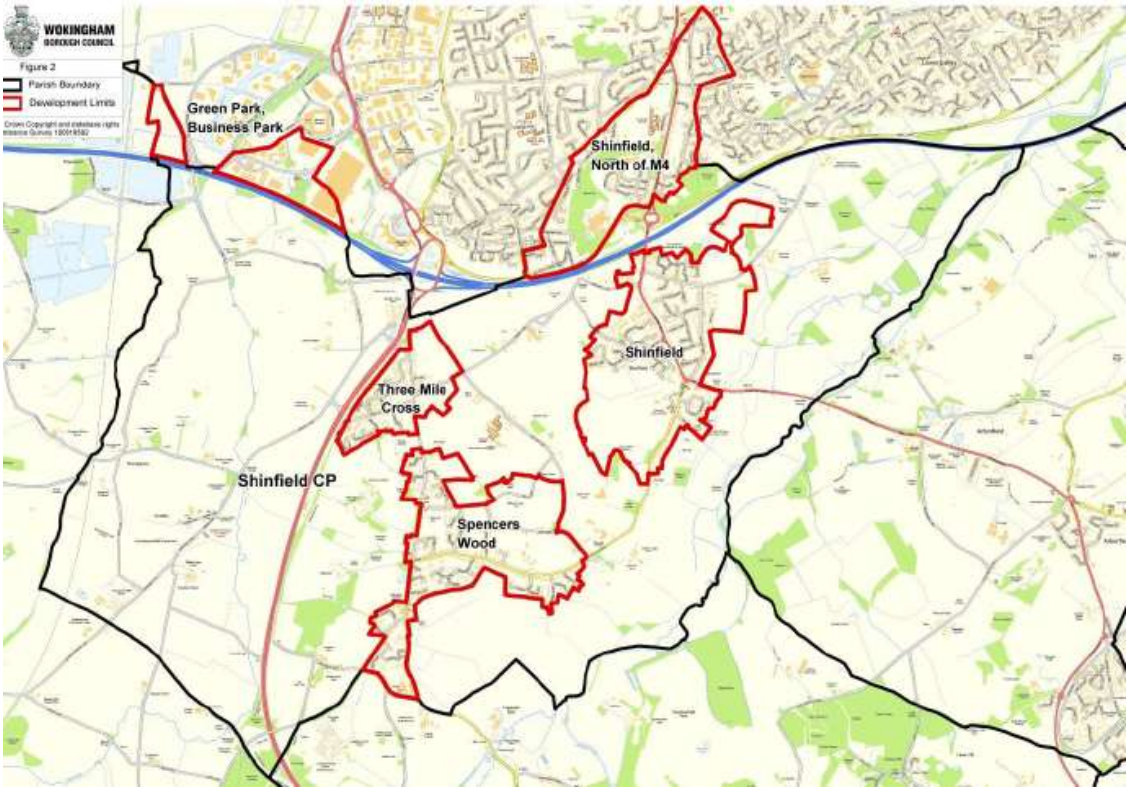

Figure 3: Development Limits within Shinfield Parish

4.12 Figure 3 shows Spencers Wood and Three Mile Cross as distinct communities. Furthermore, the Neighbourhood Plan states at paragraph 10.4:

> Wokingham's Core Strategy recognises the importance of the separate identity of the various settlements that form Shinfield Parish. Section A7.17 states: "The area to the south of the M4 is characterised by existing small settlements set within a rural context, which has thus far been retained through the formal allocation of green gaps. This sets it apart from the area to the north of the M4, which is perceived as being more closely aligned to Greater Reading. The character of the area is considered worthy of retention as it forms part of the identity of the Borough. New development must therefore seek to balance the demand for new housing with the prevailing settlement configuration and setting".

4.13 Thus, there is a substantial basis for considering that there is an intent that the pre-existing distinction between Spencers Wood and Three Mile Cross should be preserved. Figure 4, a Google Maps Pro image dated 23 June 2018 confirms the continued separation of the two communities. Therefore, there seems no reason, in principle, why the boundary of the DEPZ should not have been set to include Three Mile Cross and exclude Spencers Wood. This would closely match the boundary of the DEPZ to the blue circle, as is done on the outskirts of Reading to the north.

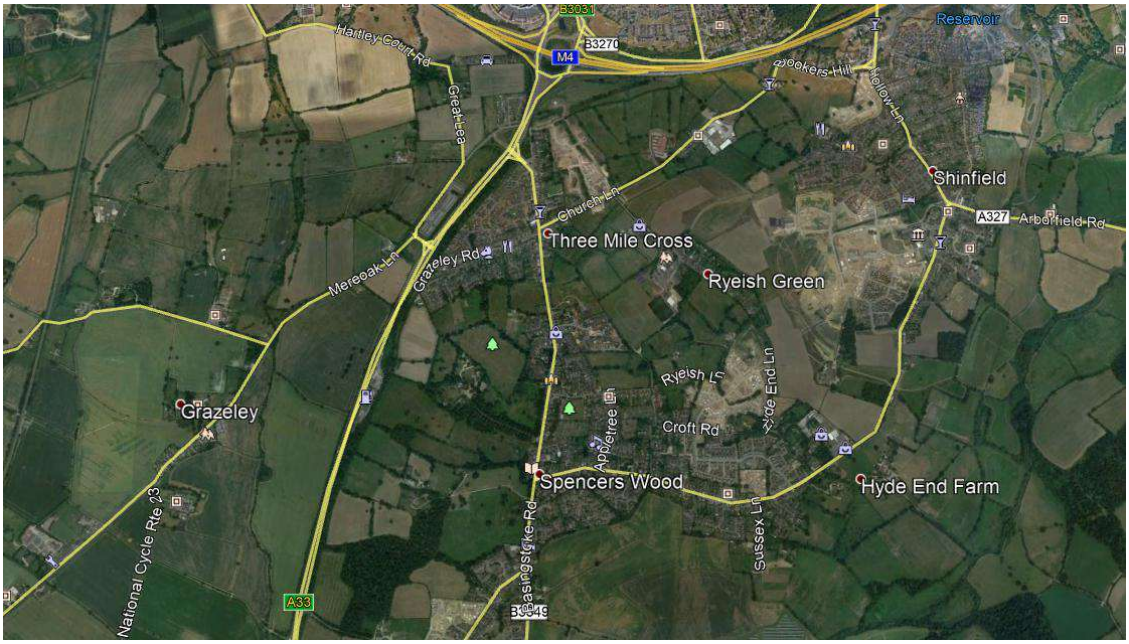

Figure 4: Image of Spencers Wood and Three Mile Cross as of 23 June 2018 (Google Maps Pro).

5. Implications of the Site being Located within the DEPZ

5.1 Overview of Issues addressed in the Off-site Emergency Plan

5.1 Because WBDC has decided to locate the site of the proposed development within the DEPZ, specific responsibilities lie with WBDC and other parties involved in specifying and executing (as necessary) the off-site emergency plan. Specifically, under REPPIR [2019], where a DEPZ has been specified and an off-site emergency plan has been prepared, the lead local authority (LA) must, in co-operation with the operator, ensure that the public are made aware of the relevant information and, where appropriate, are provided with it. In the event of an emergency, the LA has the responsibility to supply information about and advice on the facts of the emergency, of the steps to be taken and, as appropriate, of the protective action applicable.

5.2 These provisions are broadly like those under REPPIR [2001]. Therefore, off-site emergency plans made under the former regulations should be readily adapted to the new regulatory regime. In view of this, and in the absence of an updated off-site emergency plan, reference is made in this report to the most recent versions of the off-site emergency plan developed under REPPIR [2001]. However, it is helpful that, although a new off-site emergency plan has yet to be published, a REPPIR leaflet targeted at members of the public resident within the DEPZ that refers to and is in conformance with REPPIR [2019] has been published [West Berkshire Council, 2020].

5.3 In the event of an off-site emergency being declared, sheltering is the recommended countermeasure. When an incident had caused, or might cause, an offsite emergency, the following warning and informing actions would take place, as described in an earlier version of the off-site emergency plan [West Berkshire Council, 2017, Section 5.16.4].

- AWE would initiate the automatic telephone alerting system to households around the site. By this method, members of the public would be advised to go inside and stay inside the nearest suitable building and to tune into the radio and television to hear public service broadcasts.
- Information and warnings about the emergency would be regularly reported on TV, local and national radio, social media and websites, as appropriate.
- Other activities, such as loud hailers may be employed to ensure messages are going out. The emergency plan states that all means necessary will be employed to get the messages across.
- Emergency Media Briefing Centres and Emergency Help Lines may also be put in place.

5.4 Thus, as summarised in the most recent REPPIR leaflet [West Berkshire Council, 2020]:

> ‘Every household and business in the area will automatically receive a pre-recorded telephone message (landline only) from the AWE Alerting System. Local radio and TV stations will broadcast messages. Alongside this emergency service

responders will use news websites and social media to issue advice to the public. Please follow the advice IMMEDIATELY.'

5.5 Sheltering is the recommended countermeasure because the main potential radiological impact in the initial phase of an accident arises from inhalation of radionuclides from the plume of radioactive material as it disperses downwind of the accident. This advice is set out in some detail in West Berkshire Council [2020]:

- **Go indoors immediately and stay there.** Contamination levels are likely to be higher outside buildings than inside. Staying inside is the most important advice because the fabric of the building will provide a layer of protection against any ionising radiation and will reduce exposure to any radioactive particles. If you are not at home, go into the nearest permanent building.
- **Keep your pets inside** if they were not outside at the time of the emergency; those that have been outside could be kept in a separate room or building.
- **Close all windows and doors** to stop radioactive particles from entering buildings.
- **Turn off boilers and air conditioning units and put out fires and wood-burners.** Fans, heating systems, boilers, gas fires and air conditioning all draw in air from outside so these should be shut down to minimise radioactive particles entering buildings.

5.6 West Berkshire Council [2020] notes that, as a precautionary measure, the advice on sheltering may be sent to the entire DEPZ in the initial response stages of a radiation emergency. Extensive monitoring will then be used to confirm where sheltering needs to remain for longer and to identify those areas where it is no longer required. Because the advice will be updated during an incident West Berkshire Council [2020] emphasises the following.

- **Listen to local TV and radio for instructions and updates.** During a radiation emergency, advice will be broadcast regularly. This will include updates about the care of children at school, food and water supplies and care of farm animals and pets.
- **Do not make phone calls by landline or mobile.** This is important because the phone system could be overloaded, preventing the emergency services and other responders from receiving or making calls, or from contacting you.

5.7 Also, members of the public are strongly counselled against self-evacuation from the affected area (see Section 5.9.2 of West Berkshire Council [2017] and Section 5.10.2 of Joint Emergency Planning Unit [2019]). On this point, West Berkshire Council [2020] states 'Stay where you are. You will be safer to stay where you are rather than travelling around outside, vehicles provide less protection against ionising radiation than houses and other solid buildings. If you try and leave the area, roads could quickly become gridlocked and prevent access for emergency services. You could also end up in an area with more radioactive contamination unknowingly or by accident. It is very unlikely that an evacuation would be necessary but if that does happen, details of what to do will be given on local radio, TV and social media.'

5.8 In the longer-term, countermeasures other than sheltering might be initiated. These are set out in Section 5.7.4 of the 2017 issue of the Off-site Emergency Plan [West Berkshire Council, 2017] and in Section 5.8.4 of the 2019 version [Joint Emergency Planning Unit, 2019] developed under REPPIR [2001]. Specifically, there may be situations in which an urgent evacuation or subsequent evacuation may be necessary. The potential requirements for evacuation are set out in Sections 5.8 and 5.10 of Joint Emergency Planning Unit [2019].

- Immediate or urgent evacuation, at the direction of the emergency services at the scene, may be required for non-radiological scenarios, e.g. releases of asphyxiating gases, or for persons close to the site boundary in some radiological scenarios, e.g. in respect of very severe accidents or those involving the on-site transport of radioactive materials.
- Subsequent evacuation, on a timescale of days to weeks, of people taking cover in buildings such as factories, offices and other work places, or other buildings that may not be suitable in terms of providing support for the people there for any length of period due to lack of facilities, food and bedding. Such evacuation may also be required as part of the post-accident recovery process, e.g. while decontamination activities are undertaken.

5.9 Priority in evacuation will be given to care homes, schools and caravan sites, with specific consideration of vulnerable clients, who may require extra support.

5.10 Section 5.10 of Joint Emergency Planning Unit [2019] proposes that immediate evacuation may be required up to 150 m from the AWE Burghfield site boundary. Urgent evacuation may be required out to 600 m from the site boundary, but this will depend on the level of projected contamination and of the vulnerability of the community in the area.

5.11 If evacuation were to be recommended, the Police and other emergency services would be responsible for advising residents in the affected area that they were to be evacuated and for directing them to assembly points or rest centres or alternative accommodation. Inside the contaminated area, transportation would be arranged by the Police Service with support in sourcing the vehicles by the Local Authorities, whereas outside the contaminated area transport would be arranged by the Local Authorities. Reception Centres outside the sheltering zone would act as the central information point for persons excluded from their homes as well as being the locations to which any persons who had been evacuated would be sent initially [West Berkshire Council, 2017, Section 5.9, Joint Emergency Planning Unit, 2019, Section 5.10]. Decontamination processes would normally be set up at the edge of the contaminated area. People would then be moved onward to a clean area and rest centre or radiation monitoring unit [West Berkshire Council, 2017, Section 5.12].

5.12 A relevant consideration is whether, in the event of an off-site emergency, traffic movements to and from the proposed development could adversely affect access to the AWE Burghfield site, e.g. for the emergency services. In this context, it is relevant to note that access routes for emergency services to AWE Burghfield will be determined, in part, by meteorological conditions at the time of the accident, because there is a requirement to

approach from upwind, where possible [Joint Emergency Planning Unit, 2019, Section 5.2].

5.13 During and following an accident that resulted in off-site contamination, there would be requirements for monitoring and decontamination. These requirements are likely to relate to contamination of people, animals, pets and property, including gardens, homes and businesses [Joint Emergency Planning Unit, 2019, Section 5.13].

5.14 Decontamination of people will require their movement from their initial place of safety. This will be advised both through the media and door-to-door visits and may require individuals to take off their own clothes and wear modesty suits. Post-decontamination, they will need to be provided with clothing, medical care as necessary, money, keys to access homes outside the area (as appropriate), mobile phones and access to the internet [[Joint Emergency Planning Unit, 2019, Section 5.13.5].

5.15 The remediation process following an accident resulting in significant off-site contamination would involve several phases. The early phase, with a duration of a few days, would involve prompt tie-down of contamination and the recovery of items. The intermediate phase would involve treatment of the heaviest or most significant contamination over a few weeks, whereas the late phase would last at least several months and would involve reduction of environmental contamination to acceptable levels [Joint Emergency Planning Unit, 2019, Section 5.19.7].

5.16 The approach adopted to remediation would be strongly determined by the extent and nature of the contamination present after a specific accident. However, some options that would be suitable for the type of contamination likely to result from a uranium or plutonium release from AWE Burghfield are given in Section 5.19.9 of [Joint Emergency Planning Unit, 2019]. These are:

- Tie-down agents, such as water, bitumen emulsion and strippable paints, may be applied to reduce the spread of contamination and limit risks arising from resuspension of the deposited activity.
- Non-aggressive decontamination techniques, e.g. vacuum brushing or hosing, which are relatively cheap may be applicable where contamination is low level and loosely bound to surfaces.
- Aggressive techniques, such as high-pressure water or grit blasting, may be required in areas where contamination is at a higher level and fixed to surfaces. Such techniques are much slower and more expensive than the non-aggressive techniques and can generate large volumes of waste.

5.2 Relevance of Issues to the Proposed Development

5.17 As discussed in Section 4, the proposed development lies in an area that could potentially have been excluded from the DEPZ. Furthermore, it is sufficiently far from AWE Burghfield that the effective dose from a reference accident as defined under REPPIR [2001] is about 1 mSv in typical weather conditions and 6 mSv in adverse weather conditions. As the average annual effective dose in the UK, mainly from naturally

occurring radioactivity, is around 2.7 mSv, the effective dose from the reference accident, if it occurs under adverse weather conditions, corresponds to just over two years of background exposure.

5.18 Were an off-site incident to be declared at AWE Burghfield, residents of the proposed development would be notified by the automatic telephone system and would be able to shelter promptly in their own houses. In view of the small dose that would be incurred even if a resident failed to shelter (typically similar to the principal limit on annual effective dose for a member of the public of 1 mSv), it would not be appropriate to use responders to visit the development and confirm that residents were sheltering. Thus, the process of warning and informing residents would place no additional burden on the off-site emergency plan. It is recognised that the increase in size of the AWE DEPZ has already increased the numbers of properties, people and businesses within this hazard zone and that, whilst an emergency is extremely unlikely, this increase places pressure on emergency plans and responding agencies (Paragraph 4.5 of AWE [2020]). However, this is a general consideration and has no direct relevance to the acceptability of the proposed development. Compared with a radioactive plume blown directly towards the proposed development, one blown in a somewhat more northly direction and impacting on the outskirts of Reading, which are at a similar distance from AWE Burghfield but outside the DEPZ, would have the potential to place a substantially larger load on the off-site emergency plan.

5.19 Because the proposed development is located more than 3 km from AWE Burghfield, it is well beyond the range at which immediate or urgent evacuation would be required, even for the largest accidents considered and under adverse weather conditions. This means also that there would be no issues with entering this part of the DEPZ if there was a need to attend to a medical emergency or provide support to a vulnerable individual present on the proposed development. In practice, the types of hot cell accident envisaged at AWE Burghfield would typically result in atmospheric releases of no more than a few hours duration. Therefore, all but urgent medical interventions could be deferred until the radioactive plume had dispersed, further decreasing any dose incurred by responders.

5.20 Again, because of the types of accident envisaged, sheltering would be required typically for a few hours and certainly for no more than two days. This is stated explicitly in Part 2, Paragraph 1c of AWE [2019] 'This 'sheltering' action may be necessary for a period of up to two days, or at least until the initial contaminated plume has passed and monitoring of ground contamination has been undertaken to determine the level of groundshine'. Residential properties would be ideal for sheltering for periods of this duration and residents plus visitors should be able to shelter for up to two days without placing any significant requirements on responders.

5.21 If individuals were located outside during the passage of the radioactive plume, there might be a requirement for individual monitoring. However, in view of the relatively small potential radiological impact of an accident, it seems likely that this monitoring would be precautionary and for reassurance of individuals as to their health status. It would not be expected to lead to any requirement for decorporation procedures beyond removing and washing contaminated clothing and washing or showering by the individual.

Furthermore, there would be no need to prioritise such monitoring, except in so far as to reduce anxiety in the exposed individual. Most individuals would be able to shelter and for them such reassurance monitoring should not be required.

5,22 In the longer-term, the presence of ground contamination might lead to a requirement for relocation. However, the contamination present would be likely to be oxide particles of uranium and/or plutonium. These emit only small amounts of photon radiation (x-rays and gamma rays), are poorly absorbed from the gastrointestinal tract and are taken up by plants from soil to only a limited degree. Thus, the main potential route of exposure would be resuspension of this material and its inhalation. However, the concentration of resuspended material in air would be orders of magnitude smaller than the concentration in air present during the passage of the original plume. Thus, potential doses incurred from this resuspension pathway would be much less than 1 mSv.[2] This strongly suggests that long-term relocation of residents from the proposed development would be inappropriate, recognising that some might remain fearful of any residual contamination and wish to relocate irrespective of the tiny risk associated with the residual contamination. If decontamination of the proposed development were to be required, it seems likely that non-aggressive processes, such as the washing down of hard surfaces, would be appropriate. In this context, it is relevant to note that whereas radioactive isotopes of caesium (which were important after the Chernobyl and Fukushima accidents) bind strongly to urban surfaces, oxide particles of uranium and plutonium would be expected to be only loosely attached.

5.23 Finally, it is noted that because the proposed development is remote from the AWE Burghfield site, any traffic movements to and from the proposed development during an off-site emergency should have no effect on the ability of the emergency services to access the AWE Burghfield site. Furthermore, the requirement to shelter during such an off-site emergency will tend to decrease traffic movements (though it is recognised that some individuals may leave or return to the proposed development despite official guidance to the contrary).

[2] This is readily shown. If it is assumed that the original plume gives an air concentration of 1 Bq m^{-3} that persists for 3 hours, then an individual breathing 1.2 m^3 h^{-1} of air (which is typical for light exercise [ICRP, 1994]) will inhale 3.6 Bq. For insoluble Pu-239, the committed effective dose per unit intake by inhalation for an adult member of the public is 1.6 10^{-5} Sv Bq^{-1} [ICRP, 2012]. Therefore, an intake of 3.6 Bq corresponds to a committed effective dose of 5.8 10^{-5} Sv. However, a typical deposition velocity for an aerosol is 1 10^{-3} to 1 10^{-2} m s^{-1} [Coughtrey and Thorne, 1983]. Therefore, a concentration of 1 Bq m^{-3} will give a deposition rate of 1 10^{-3} to 1 10^{-2} Bq m^{-2} s^{-1}. Over 3 hours (10,800 s), the cumulative deposition will be 10.8 to 108.0 Bq m^{-2}. Following deposition, typical, long-term resuspension rates are 1 10^{-7} m^{-1} or less [Coughtrey and Thorne, 1983]. Thus, the long-term maintained air concentration in the open air could be up to 1.08 10^{-6} to 1.08 10^{-5} Bq m^{-3}. Breathing outdoor air for 8 hours per day, 365 days per year at 1.2 m^3 h^{-1}, would give an annual intake 3.8 10^{-3} to 3.8 10^{-2} Bq, corresponding to a committed annual effective dose of 6.1 10^{-8} to 6.1 10^{-7} Sv, i.e. about 0.1 to 1.0% of the first-pass plume inhalation dose. Thus, for a first-pass effective dose by inhalation of 1 mSv, the long-term annual committed effective dose due to resuspension would be no more than about 10 μSv.

6. Conclusions

6.1 A relatively small-scale development is proposed on land to the rear of Diana Close, Spencers Wood, RG7 1HP. This would comprise 24 residences with a likely residential population of about 58 individuals. Until 2019, the proposed development would have been located about 2 km outside the boundary of the DEPZ for AWE Burghfield. However, under REPPIR [2019] a new basis for defining the extent of the DEPZ has been adopted. Based solely on the consequence analysis performed by AWE [2019] on this new basis, the proposed development would still have lain outside the DEPZ. However, local considerations led to an expansion in size of the DEPZ to give an irregular outline encompassing the whole of Spencers Wood and hence the site of the proposed development. It is debatable whether this expansion of the DEPZ was justified. A reasonable alternative would have placed the boundary between the separate communities of Spencers Wood and Three Mile Cross. This would have left the proposed development lying outside the DEPZ.

6.2 Because the proposed development lies further from AWE Burghfield than the limit of the DEPZ determined in the consequence analysis [AWE, 2019], the effective dose that might be received by a resident due to an accident at AWE Burghfield is estimated at about 1 mSv (which is also the limit on annual effective dose to a member of the public from planned exposures and less than the annual effective dose received from natural background) or 6 mSv under adverse weather conditions. Effective doses of this magnitude are of only limited radiological significance and would not justify disruptive mitigation activities. Sheltering alone should be sufficient to decrease the effective dose received to less than 1 mSv even under adverse weather conditions.

6.3 In view of these considerations, it is appropriate to examine the grounds for refusal set out in Section 4 of AWE [2020].

6.4 Paragraph 4.5 claims that even minor planning applications for small numbers of properties in the DEPZ have an impact on the emergency plan. However, the discussion in Section 5 of this report shows that because the proposed development is located close to the outer boundary of a DEPZ that has been expanded beyond what is required by the consequence analysis, there is no impact on responders under the emergency plan and no adverse impact on the access of emergency services to the AWE Burghfield site.

6.5 Paragraph 4.6 claims that if residents are in receipt of care packages then carers would be unable to visit. However, in most accident scenarios sheltering would be required for between a few hours and two days. Therefore, even if visits were banned during the sheltering phase, this would be only a short hiatus. Furthermore, the assessed effective doses are so low that visiting during the period of sheltering should be acceptable if it was considered necessary for the well-being of the resident.

6.6 Paragraph 4.7 claims that vulnerable residents could not be suitably supported. Here the arguments are the same as those pertaining to residents in support of care

packages, i.e. at worst the hiatus in support would be short and, as required, support could be provided during the period of sheltering.

6.7 Paragraphs 4.8 and 4.9 raise concerns about the capacity for onward care of evacuees. This is not relevant because immediate or urgent evacuation would not be required and longer-term relocation, if required, could be planned to avoid overloading local resources.

6.8 Paragraph 4.10 proposes that long-term resident relocation requirements would overwhelm the Council's capacity. However, with non-urgent, staged relocation there is no reason why this should be the case. Relocation would primarily be to dispel anxiety and facilitate clean-up operations. Relocation would not primarily be to avert effective dose, so its timing is not critical. Furthermore, relocation would properly be focused on properties closer to AWE Burghfield and not those at the periphery of the DEPZ.

6.9 Overall, although the location of the proposed development within the DEPZ of AWE Burghfield is a material planning consideration, the arguments presented in this paper show that it is a consideration of limited importance. Hence it should be given little weight when determining the overall planning balance in respect of the proposed development.

6.10 Finally, it is appropriate to consider the proposed development in the light of the local Development Plan Policy. At TB04: Development in vicinity of Atomic Weapons Establishment (AWE), Burghfield this states that:

> Development will only be permitted where the applicant demonstrates, that the increase in the number of people living, working, shopping and/or visiting the proposal (including at different times of the day) can be safely accommodated having regard to the needs of "Blue Light" services, and the emergency off-site plan for the Atomic Weapons Establishment site at Burghfield.

6.11 However, the applicant only needs to provide this information where the proposal exceeds the scale of development detailed for the consultation zone as defined on the Policies Map. For a development more than 3 km from the AWE Burghfield site, this requirement relates to all residential or non-residential applications where 500 or more additional people may live. work, shop and/or visit. The proposed development is much smaller than this and is only slightly larger than the limit of 50 or more additional individuals applicable to proposed developments at between 1.5 and 3.0 km from AWE Burghfield.

6.12 Thus, the proposed development is too small and too far distant from AWE Burghfield to be subject to the requirements of TB04. Furthermore, as this report demonstrates, even if it were subject to those requirements, it could be safely accommodated having regard to the needs of "Blue Light" services, and the emergency off-site plan for the Atomic Weapons Establishment site at Burghfield.

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