

<p>1 Tuesday, 21 June 2016 2 (10.00 am) 3 MR RICHARD HALLARD (continued) 4 MR TER HAAR: My Lord, before Dr Busby's cross-examination 5 of Mr Hallard continues, could I raise a question? 6 On the first day of this hearing the Tribunal, 7 through you, my Lord, indicated that you might be helped 8 by a document you described as a Scott Schedule. I'm 9 afraid, having thought about it, I'm not entirely sure, 10 speaking for my appellants, I'm entirely sure what it is 11 would be of most assistance to the Tribunal. 12 I wonder if it's possible at some point to give 13 a little bit more clarification of what you have in 14 mind. 15 MR JUSTICE BLAKE: It's possible. 16 MR TER HAAR: I'll just leave it there for the moment. 17 MR JUSTICE BLAKE: Yes. 18 A. My Lord, I've produced an expanded version of the 19 aircraft survey of the Shackleton which I think is 20 rather more legible than the original version which was 21 in my report. 22 MR JUSTICE BLAKE: Yes. Thank you. That's your figure 6, 23 isn't it? 24 A. My figure 6. I've actually referred to this as 25 figure 3, unfortunately, because that's the figure from</p> <p style="text-align: center;">Page 1</p>	<p>1 SVs? 2 A. Yes. Sieverts and grays have only been introduced in 3 the past 15 to 20 years, from memory. I can't remember 4 exactly when they came in. Prior to that there were 5 three units that were used, all of which unfortunately 6 began with R -- a roentgen, a rem and a rad. There is 7 no modern equivalent to roentgen but it's approximately 8 equivalent -- 100 roentgen would be approximately 9 equivalent to a sievert. 10 1 rad is the equivalent unit to a gray, where again 11 100 rad is 1 gray. 12 And a rem is the equivalent unit to a sievert, where 13 100 rem is equivalent to 1 sievert. 14 In the original AWE references most of the units 15 that they would use -- most of them, not all -- would 16 refer to R. 17 MR JUSTICE BLAKE: All right, thank you very much. Yes. 18 Cross-examination by DR BUSBY (continued) 19 DR BUSBY: Good morning. 20 A. Good morning. 21 Q. Well, as I recall, we had just finished off yesterday 22 looking at the CERRIE report and what I was going to go 23 on to, just briefly, was to ask you -- I asked you about 24 the dose from -- whether it was meaningful to, or how 25 meaningful it might be to consider a dose from</p> <p style="text-align: center;">Page 3</p>
<p>1 the original reference. 2 MR JUSTICE BLAKE: Right. 3 A. Which is how I tend to think of it. So I've called it 4 figure 3, but you're right, it's my figure 6. 5 MR JUSTICE BLAKE: Thank you very much. 6 A. Shall I pass them up? 7 MR JUSTICE BLAKE: If you could. (Handed) 8 A. I have also indicated -- 9 MR JUSTICE BLAKE: Do you have one of these? 10 DR BUSBY: No, we haven't. (Handed) 11 MR JUSTICE BLAKE: Right, can we just have a few moments 12 just to have a look at this to see. Right, it's also 13 a little clearer as to the trajectory of the aircraft 14 which I was trying to improve with your evidence. 15 A. Yes, I should have put this in the original report, 16 my Lord, or something like it. 17 MR JUSTICE BLAKE: Yes, it's useful to have. Right. 18 (Pause) 19 A. I've also -- I think I may have said the units were 20 milliR. The units are actually microR, as I've 21 indicated in the key at the top, and I've also given 22 an approximate conversion that 100 microR is 23 approximately equivalent to 1 microsievert in the modern 24 units. 25 MR JUSTICE BLAKE: Right. They were using Rs rather than</p> <p style="text-align: center;">Page 2</p>	<p>1 a particle to local tissue and compare it with the ICRP 2 way of diluting it into kilograms of tissue. 3 Now I'm going to ask you if you think -- whether 4 an internal radionuclide which binds to DNA might be 5 considered to represent a similar problem for dosimetry. 6 A. Right. I need to stress, of course there was quite 7 a lot of discussion about the issue of nuclides binding 8 to the DNA last week and I need to stress that I have no 9 expertise in that area. 10 Q. It's just the dosimetry. I'm not asking about the 11 biological plausibility or anything to do with 12 chemistry, just if the DNA is a target, first of all. 13 Do you accept that the DNA is a target? 14 A. The DNA is the principal target. 15 Q. The principal target? 16 A. There will be other targets -- 17 Q. Of course. 18 A. -- similar to that. 19 Q. Of course. 20 A. The DNA will be the principal target. 21 Q. So my question just to sort of simplify it then is that 22 the effect of a nuclide that decays bound to the DNA 23 would not be the same or would be very much greater than 24 the effect of a nuclide that was not bound to the DNA, 25 that was just in the cytoplasm somewhere else far away</p> <p style="text-align: center;">Page 4</p>

<p>1 from the DNA?</p> <p>2 A. I would think that would be true.</p> <p>3 Q. Thank you.</p> <p>4 A. As I said, I don't have that detailed expertise in</p> <p>5 internal dosimetry modelling but I would think that</p> <p>6 would be true.</p> <p>7 Q. So you haven't included -- I mean the ICRP doesn't</p> <p>8 include any way in which doses from nuclides that bind</p> <p>9 to DNA, for example strontium 90, would be distinguished</p> <p>10 from nuclides that don't, for internal radionuclide</p> <p>11 dosimetry?</p> <p>12 A. That's true, I don't believe ICRP do that. I did read</p> <p>13 two papers, one by I think Tanner and Harrison and</p> <p>14 another by Eakins, both from Public Health England, who</p> <p>15 looked at the issue of what I think you referred as to</p> <p>16 the photoelectric amplification --</p> <p>17 Q. We'll come to that. That's a different matter. I'm</p> <p>18 just talking about binding to DNA now.</p> <p>19 A. Okay, right.</p> <p>20 Q. Now, in your report you use the ICRP risk model -- we</p> <p>21 have already said that -- and you've used the ICRP dose</p> <p>22 co-efficients in order to get from the internal dose,</p> <p>23 which you derived through various steps, to the overall</p> <p>24 doses, the internal doses which you produced in your</p> <p>25 report.</p> <p style="text-align: center;">Page 5</p>	<p>1 rules for experts and for expert reports that they</p> <p>2 should review alternative approaches to what it is that</p> <p>3 they're being asked to do and explain why it is they</p> <p>4 didn't use them. You're explaining that now, of course,</p> <p>5 but you didn't seem to do this in your report.</p> <p>6 A. Okay. I think two points perhaps to make on that. The</p> <p>7 judgment that I made was not a technical judgment.</p> <p>8 I don't believe that I have the appropriate internal</p> <p>9 dosimetry expertise in order to make a technical</p> <p>10 judgment. The judgment that I made was based on what is</p> <p>11 the international standard.</p> <p>12 I was not --</p> <p>13 MR JUSTICE BLAKE: Sorry to interrupt you, but are you aware</p> <p>14 of any other safety dosimetry exercise which uses the</p> <p>15 European Committee's model opposed to the ICRP model?</p> <p>16 A. I'm not, my Lord.</p> <p>17 But I have to say, to answer your question fully,</p> <p>18 that I was not aware of the ECR/210 model at the time</p> <p>19 that I wrote my report. I have read it now but I read</p> <p>20 that rather later in the process.</p> <p>21 DR BUSBY: Could I take you to SB10/163. If we go to</p> <p>22 page 244.</p> <p>23 A. This is the ECR/210?</p> <p>24 Q. That's right, yes.</p> <p>25 A. And page what, I'm sorry?</p> <p style="text-align: center;">Page 7</p>
<p>1 Now my question is: why did you use the ICRP dose</p> <p>2 co-efficients? Why did you not consider dose</p> <p>3 co-efficients from the European Committee on Radiation</p> <p>4 Risk? It's not the only model around at the moment, is</p> <p>5 my point.</p> <p>6 A. No. But I think as I said last night, the ICRP model is</p> <p>7 the international standard, it's the international</p> <p>8 benchmark, it's the one that is used almost universally</p> <p>9 to my knowledge. If you look at the International</p> <p>10 Atomic Energy Agency's basic safety standards -- I think</p> <p>11 I said some of this last night -- that document which</p> <p>12 was issued, I think only about two to three years ago,</p> <p>13 actually contains the current ICRP inhalation and</p> <p>14 ingestion dose co-efficients in a table.</p> <p>15 The European Union Basic Safety Standards</p> <p>16 Directive --</p> <p>17 Q. Could I just stop you? I'm sure all of that is true.</p> <p>18 It's not really my point. My point is that --</p> <p>19 MR JUSTICE BLAKE: It may be relevant to the answer to the</p> <p>20 question that you posed, so that's why we've got it in.</p> <p>21 DR BUSBY: Well, if you wish -- I don't want to stop you but</p> <p>22 I just want to point out that that wasn't really where</p> <p>23 I am going with this.</p> <p>24 A. Okay.</p> <p>25 Q. What I wanted to ask you is if you were aware of the</p> <p style="text-align: center;">Page 6</p>	<p>1 Q. Page 244.</p> <p>2 A. Okay.</p> <p>3 Q. Well, you have looked at the ECRR report.</p> <p>4 A. I have.</p> <p>5 Q. So you will know that the ECRR -- the committee attempts</p> <p>6 to resolve this problem of particles and also the</p> <p>7 problem of binding that I just put to you.</p> <p>8 You can see here there's a list of risk</p> <p>9 co-efficients that you might have used, if you had</p> <p>10 decided to just write down that there was an alternative</p> <p>11 approach.</p> <p>12 Is that correct? You could have used these to</p> <p>13 produce a different set of doses?</p> <p>14 MR JUSTICE BLAKE: You weren't aware of these at the time</p> <p>15 you wrote your report?</p> <p>16 A. I wasn't aware of these at the time I wrote my report,</p> <p>17 my Lord. I read this document rather later.</p> <p>18 MR JUSTICE BLAKE: Okay, so you have given that answer. You</p> <p>19 have explained why the ICRP is the international model</p> <p>20 that you used.</p> <p>21 Now you have had a look at these, do you have any</p> <p>22 comment to make upon them as an alternative dose</p> <p>23 co-efficient?</p> <p>24 A. If I recall from the document it uses a modification of</p> <p>25 the ICRP risk model in that it introduces two additional</p> <p style="text-align: center;">Page 8</p>

<p>1 weighting factors and I assume that they've been used in 2 this table. 3 DR BUSBY: This is just a list -- that's right, it's a list 4 of the ones that have come out of using those weighting 5 factors which are described in the text but we don't 6 need to go there. 7 A. Not all of the isotopes which I've used would be listed 8 here. The list of isotopes came from the Carter report. 9 Quite a number of them are here, but not all. 10 Q. No, but some are. 11 A. But some are, so from that point of view -- 12 Q. My question is that if you had used these, I think, 13 would you agree that your doses would have been higher? 14 A. Yes. They would -- 15 Q. Right. So now my final question in this area is -- 16 well, not quite final -- is it possible -- do you think 17 it's possible -- because the argument in this Tribunal 18 is about reasonable doubt. 19 A. Yes. 20 Q. So my question is, is it possible that the ECRR model is 21 closer, and possible now, not that it is or it might, 22 but might it be that the ECRR approach would give you 23 a better dose in the sense of the way in which you would 24 relate dose to illness ultimately? Is that possible? 25 A. I don't have the expertise to be able to make a judgment</p> <p style="text-align: center;">Page 9</p>	<p>1 MR JUSTICE BLAKE: But can you help us? What kind of 2 expertise and what kind of people who have addressed 3 this issue would have the relevant competent skills and 4 expertise to -- 5 A. They would need to be a specialist in internal 6 dosimetry, my Lord, and there were such specialists, two 7 or three, I think, without naming anyone, who were on 8 the original CERRIE Committee. 9 MR JUSTICE BLAKE: On the CERRIE Committee. 10 A. Yes, my Lord. 11 DR BUSBY: Can I take you to page 247 of the same tab 12 number. This a statement that was made by a number of 13 very eminent radiation biologists and other experts. 14 I was included there but I don't say that I am one of 15 those. There were some very eminent people there. 16 It says at item 2 on page 247: 17 "Assert that employing the ICRP risk model to 18 predict the health effects of radiation leads to errors 19 which are at minimum 10 fold while we are aware of 20 studies relating to certain types of exposure that 21 suggest that the error is even greater." 22 At 5 they: 23 "Urge the responsible authorities and all those 24 responsible for causing exposures to adopt a 25 precautionary approach, and in the absence of another</p> <p style="text-align: center;">Page 11</p>
<p>1 on that. The only comment I would make -- I think I'm 2 repeating a statement I made last night -- is that the 3 COMARE response to the CERRIE document, because 4 obviously the approach which you've described was 5 considered I think at some length in the CERRIE 6 Committee -- 7 Q. No, it wasn't -- 8 A. Okay, well, it's referred to in the CERRIE Committee -- 9 perhaps I could put it like that -- 10 Q. Yes. 11 A. -- that the COMARE response to that committee said -- 12 I do actually have a page reference if that would help. 13 MR JUSTICE BLAKE: Just give us your answer and then -- 14 A. The COMARE response said that it did not consider that 15 the members of the CERRIE Committee who had suggested 16 that the risk from internal emitters was between 100 and 17 500 times greater than the ICRP risk estimates, that 18 the -- that COMARE did not consider that they had 19 justified their views. And it then went on to discuss 20 where ICRP currently -- or the years that ICRP have been 21 working on its current values. 22 MR JUSTICE BLAKE: Now you've given us that answer. You've 23 explained that you don't think your expertise is at the 24 field of whether ICRP is to be replaced by ECRR. 25 A. Yes, my Lord.</p> <p style="text-align: center;">Page 10</p>	<p>1 workable and sufficiently precautionary risk model, to 2 apply without undue delay the provisional ECRR 2003 risk 3 model which more accurately bounds the risks reflected 4 by current observations." 5 Do you have any comment on that? 6 MR JUSTICE BLAKE: Were you aware of this? 7 A. The Lesvos Declaration, yes, I have seen it. I think 8 it's quoted in -- I think it's actually in the ECRR/210 9 document, if I remember correctly. Sorry, that's what 10 this is. 11 DR BUSBY: Yes. 12 A. So, yes, I'm aware of it. 13 MR JUSTICE BLAKE: Were you aware of it at the time you were 14 writing your report last year? 15 A. I don't think I'd actually read the Lesvos Declaration 16 at the time. I don't think I had. 17 MR JUSTICE BLAKE: It may be that you've already answered 18 this question. Are you aware of any responsible 19 authority who had adopted these measures? 20 A. I'm not, my Lord. It might help to expand on that 21 answer slightly, unless you would rather I didn't. 22 MR JUSTICE BLAKE: Well, if you're not aware of a 23 responsible authority adopting it, that may be 24 sufficient. 25 A. Okay.</p> <p style="text-align: center;">Page 12</p>

<p>1 MR JUSTICE BLAKE: If someone else wants to ask you 2 questions about it, we can go there. 3 Right. 4 DR BUSBY: Thank you, that's all I need to talk about on 5 that item. 6 I'd like now to ask you about Mr Ken Johnston who 7 you rely upon in your report to some extent. 8 A. I use some of his expert evidence, that's correct. 9 Q. You consider him authoritative and dependable as 10 a source of information then? 11 A. I believe so. He has expertise which was valuable which 12 I don't have, particularly in nuclear explosions. 13 Q. Such expertise to the extent that you relied upon it 14 is -- I won't say critical, but fairly pivotal to the 15 decisions that you made, the assumptions that you made 16 in making your calculations? 17 A. Some of them, I think, yes. 18 Q. Yes. Can I take you to SB13/24. 19 A. I'm sorry, which tab? 20 Q. SB13/24. 21 A. 24. 22 Q. This is one of the first, if not the first -- 23 A. Yes. 24 Q. -- report by Mr Johnston. I just want to take you to 25 the subscript, the little note which has a (i) next to</p> <p style="text-align: center;">Page 13</p>	<p>1 from coral. I honestly don't know whether it's all of 2 the -- 3 MR JUSTICE BLAKE: I know the Maldives, for example, are 4 entirely made up of coral, aren't they? 5 A. That could well be the case here as well. 6 MR JUSTICE BLAKE: I just don't know whether there's any 7 topography or volcanic activity or anything else -- 8 A. I don't know. It could well be that it's entirely from 9 coral. 10 MR JUSTICE BLAKE: Right. Anyway -- 11 A. Certainly it is surrounded by coral in the sea. 12 MR JUSTICE BLAKE: You are just answering Dr Busby's 13 question by reference to what you've read -- 14 A. Yes. 15 MR JUSTICE BLAKE: -- that other surveys found some natural 16 uranium in Christmas Island? 17 A. Yes, my Lord. 18 MR JUSTICE BLAKE: Whether that's from coral, which is 19 a possibility, or otherwise, you can't say? 20 A. No, I can't. But they found it. 21 DR BUSBY: But these surveys were carried out after the 22 testing? 23 A. Yes, they were. In the 1970s, 1980s and 1990s. 24 Q. So if Mr Johnston is right and that there's no uranium 25 in coral, then we surely conclude that the uranium that</p> <p style="text-align: center;">Page 15</p>
<p>1 it at the bottom of page 3. 2 A. Right. 3 Q. In which he says, and I read: 4 "For example, uranium is present in most soils at 5 a hu(?) ppm level and also in coal deposits. Fallout, 6 particulate and fly ash from coal-fired plants therefore 7 contains uranium and its daughter products. It is, 8 however, absent from coral." 9 Would you agree with that? 10 A. The environmental survey, or one of the environmental 11 surveys -- I think it was the New Zealand environmental 12 survey, the NRL survey, but it might have been the 13 Washington survey, one of those two -- does refer to 14 levels of natural uranium on the Island. It doesn't 15 quantify that. I think it refers to two natural 16 isotopes. So from that point of view I'm aware of the 17 survey which makes a qualitative statement that there is 18 natural uranium on the Island which presumably means in 19 coral. 20 Q. But this survey was done after the -- 21 MR JUSTICE BLAKE: Are they coral islands? 22 A. They are, I believe, coral islands, my Lord. 23 MR JUSTICE BLAKE: Entirely coral? 24 A. I couldn't answer that, to be honest, but I believe it's 25 a coral atoll, so some of the soil on it will be made</p> <p style="text-align: center;">Page 14</p>	<p>1 was found -- I am going to go there too -- in the McEwan 2 report, the New Zealand report, arrived there 3 afterwards? 4 A. Well, I would assume that there's two possibilities. 5 (1) that Mr Johnston may have been incorrect in what he 6 says, or the other, if he was correct, then I suppose 7 that would be a reasonable assertion but I don't know if 8 there's any others. Again, you are going outside my 9 expertise. 10 MR HEPPINSTALL: My Lord, I rise because this is something 11 of a fantasy discussion. Dr Busby is well aware from 12 his involvement in the Upper Tribunal that Mr Johnston 13 conceded Dr Busby's point that there was uranium in 14 coral -- 15 MR JUSTICE BLAKE: So we are going down a wrong turning. 16 MR HEPPINSTALL: Yes, and Dr Busby is fully aware of that 17 from the proceedings before Mr Justice Charles. 18 MR JUSTICE BLAKE: Thank you. 19 DR BUSBY: I'm not sure the extent to which it's fair for 20 Mr Heppinstall to jump up in the middle of my line of 21 questioning -- 22 MR JUSTICE BLAKE: It is if you are going to be going off 23 and putting questions on a false hypothesis. 24 DR BUSBY: He doesn't know where I am going with this, 25 my Lord.</p> <p style="text-align: center;">Page 16</p>

<p>1 MR JUSTICE BLAKE: Wherever you are going, you can't make 2 a question asking a witness to comment on something 3 where, if you have the information, you know that may 4 not be a secure foundation. 5 DR BUSBY: But Mr Johnston never conceded -- 6 MR JUSTICE BLAKE: No, Dr Busby, you've got to manage your 7 time -- by the way, I'm giving you whatever you need to 8 do, but you've got to manage this process so you can 9 extract the points where you disagree with this witness, 10 where you can put a positive case to this witness that 11 you rely upon, and if you are asking a question based 12 upon something which is contained elsewhere in this mass 13 of papers, try to make sure it reflects at least the 14 consensus or the legitimate differences of opinion, if 15 it's opinion-based. Yes? 16 Okay, let's go on. 17 DR BUSBY: Right, we are still on uranium. 18 There are two papers that are relevant. One is the 19 one that you've already mentioned. There was another 20 report that was made from a survey by the University of 21 Washington in Seattle which we've put in which we'll 22 talk about later. 23 A. Which was the other one I referred to. 24 Q. Before we go there, you were informed on 18 May that you 25 might be asked some questions during this hearing.</p> <p style="text-align: center;">Page 17</p>	<p>1 particularly uranium and plutonium. 2 MR JUSTICE BLAKE: Yes, as I understand it, you mention in 3 your report because of the classification issues they 4 have given a gist of a conservative or an upper 5 estimate. 6 A. That's correct, my Lord. 7 MR JUSTICE BLAKE: You've taken that upper estimate? 8 A. Yes. It's up to a factor of 10 greater. 9 MR JUSTICE BLAKE: So this may not necessarily be what was 10 actually there? 11 A. No. 12 MR JUSTICE BLAKE: But if the upper estimate is to be taken 13 at face value then you can do a calculation to tell us 14 what that means in weight? 15 A. Yes, my Lord, and that's what I've done. 16 MR JUSTICE BLAKE: And the answer was 3.3? 17 A. Yes, from memory Grapple Y was 3.3. 18 I have notes, my Lord, which I'll try not to refer 19 to, but if I do need to refer to the notes would that be 20 in order? 21 MR JUSTICE BLAKE: Yes, as an expert you are not meant to 22 keep everything in your head. 23 A. Thank you, my Lord. 24 MR JUSTICE BLAKE: You are entitled to refer to your notes, 25 particularly if you've been asked to do a calculation to</p> <p style="text-align: center;">Page 19</p>
<p>1 There was a list of questions sent to you, wasn't there? 2 A. Yes. 3 Q. You got those. Right. 4 Since much of our concern is in our statement of 5 case and in this discussion generally, we flagged up 6 that we would ask you to tell us how much uranium is in 7 the bombs by mass rather than by activity. I mean of 8 course I can do that but I'm not allowed to be an expert 9 and you are an expert, and it's a fairly simple 10 calculation. So perhaps -- and you did in response to 11 a question about the total activity calculate that. If 12 you could just convert that into mass for us in the 13 Grapple Y I would be very grateful. 14 A. Oh, just Grapple Y? 15 Q. Well, all of them would be nice but I think we can more 16 or less approximate -- if we know what Grapple Y was, in 17 terms of the amount of UT-38 in terms of kilograms, 18 tonnes, whatever, then I think we can assume that we can 19 get an overall amount of uranium as a sort of rough -- 20 A. I've got an overall breakdown but the total mass of 21 uranium from Grapple Y from memory was about 3.3 tonnes 22 based on what is called the -- or what I've referred to 23 as the AWE gist document. It's known as "the Bevis 24 Parker gist". That's a one-page document which quotes 25 extreme upper limits of a number of nuclides of</p> <p style="text-align: center;">Page 18</p>	<p>1 assist us. 2 Is Grapple Y sufficient for your purposes? 3 DR BUSBY: It probably is but since he has done the sums 4 I thought we may as well hear what the answers are for 5 the other ones. 6 A. The total mass, these are the three alpha emitting 7 nuclides. They were all obviously beta emitting 8 nuclides as well and I have actually done a calculation 9 for those but the half lives are so short it's not 10 relevant. 11 Q. All I want is the total mass of uranium 238 that came 12 from all of the bombs, because one of our appellants is 13 Mr Smith, who was there much later, and we are trying to 14 get to some idea of the amount of uranium that was 15 exploded over the islands in total. 16 MR JUSTICE BLAKE: Pause there. It is total mass of uranium 17 238. 18 A. The total mass of uranium 238 for all of the weapons 19 that I calculated was approximately 8,000 kilograms, 20 that's 8 tonnes. 21 DR BUSBY: 8 tonnes. Right. That's very helpful. Very 22 helpful. 23 Now -- 24 A. That was uranium 238. 25 Q. Yes, yes.</p> <p style="text-align: center;">Page 20</p>

5 (Pages 17 to 20)

<p>1 MR JUSTICE BLAKE: And this is Christmas Island?</p> <p>2 A. This is Christmas Island, yes.</p> <p>3 DR BUSBY: So we have 8 tonnes of uranium 238 turned into</p> <p>4 particles over Christmas Island.</p> <p>5 Do you know what the density of uranium oxide is?</p> <p>6 A. Oh, is it something like 11 grams per millilitre or what</p> <p>7 would that be?</p> <p>8 Q. 11.</p> <p>9 A. So uranium oxide did you say?</p> <p>10 Q. 11 is right, roughly right. I'm not allowed to say</p> <p>11 that. I would agree with you if you were to say --</p> <p>12 MR JUSTICE BLAKE: Come on, just ask the question. Keep out</p> <p>13 the comments, please.</p> <p>14 DR BUSBY: 11?</p> <p>15 A. 11, I believe, yes.</p> <p>16 Q. So it's a very heavy particle then?</p> <p>17 A. It would be a heavy particle.</p> <p>18 Q. We have 8 tonnes of heavy particles micronised into</p> <p>19 nanoparticles over Christmas Island over a period of</p> <p>20 time.</p> <p>21 A. Yes, they would be vaporised in the detonation, of</p> <p>22 course, and then they would condense out in the cloud.</p> <p>23 Q. So do you think it's possible that this material would</p> <p>24 have contaminated Christmas Island to some extent?</p> <p>25 A. To some extent. I mean clearly, as I was saying in my</p> <p style="text-align: center;">Page 21</p>	<p>1 A. Well, I have done that calculation but there is</p> <p>2 a difficulty with that too, in that if all of the</p> <p>3 uranium were to fall on the Island, which clearly is</p> <p>4 a huge assumption, all of the fission products which</p> <p>5 would be associated with that would also fall on the</p> <p>6 Island. Everything would have to fall at that time.</p> <p>7 I would say first of all that I don't believe</p> <p>8 there's any evidence to support that assertion but we</p> <p>9 can perhaps come back to that.</p> <p>10 But if all the fission products fell on the Island,</p> <p>11 just for Grapple Y I calculated that the external dose</p> <p>12 alone will be several tens of sieverts which would be</p> <p>13 a fatal exposure.</p> <p>14 Q. But that wasn't my question.</p> <p>15 MR JUSTICE BLAKE: Sorry, what was the question?</p> <p>16 DR BUSBY: The question was: what would be the concentration</p> <p>17 of uranium on the Island, not fission products?</p> <p>18 A. Yes, but what I'm saying is that the two would be</p> <p>19 associated and therefore you would need to look at the</p> <p>20 whole situation and what I'm saying is that the fission</p> <p>21 product component of that question would result in fatal</p> <p>22 exposures for everyone on the Island by some margin, and</p> <p>23 therefore, taking it one step further, I don't believe</p> <p>24 that it's reasonable to assume that all of the uranium</p> <p>25 or all of the fission products fell because it would</p> <p style="text-align: center;">Page 23</p>
<p>1 evidence yesterday, I have assumed quite a significant</p> <p>2 level, quite a high level, of fission product</p> <p>3 contamination, widespread contamination over the Island</p> <p>4 and a proportion of that would be from uranium. From</p> <p>5 the calculations which I did, the becquerel proportion</p> <p>6 is very low from that.</p> <p>7 Q. Yes. Well, do you know what the surface area of</p> <p>8 Christmas Island is, roughly?</p> <p>9 A. Well, you quoted it in the questions at 388 square</p> <p>10 kilometres, and then asked if I could estimate the</p> <p>11 activity falling over that area. I do have a difficulty</p> <p>12 with that calculation. Because for the cloud, the</p> <p>13 nuclear cloud, to span from the surface zero where the</p> <p>14 weapon exploded to the populated areas, the radius of</p> <p>15 that cloud would have to be about 40 kilometres in which</p> <p>16 case the area of the cloud would be about 5,000 square</p> <p>17 kilometres so approximately one order of magnitude</p> <p>18 greater than the area of the Island.</p> <p>19 So I felt it would be misleading to assume that all</p> <p>20 of the activity fell just on 388 square metres. So I've</p> <p>21 done the calculation for 5,000 square kilometres which</p> <p>22 would be the area of the cloud.</p> <p>23 Q. Well, we'll come to this later, but if you've done the</p> <p>24 calculation for 5,000 square kilometres, which is what</p> <p>25 you assume it will fall on, what was the answer?</p> <p style="text-align: center;">Page 22</p>	<p>1 create a situation which clearly did not happen.</p> <p>2 Q. Okay. Fair enough. I won't take that any further.</p> <p>3 But you say that it fell over a larger area and</p> <p>4 presumably then into the sea?</p> <p>5 A. Yes.</p> <p>6 Q. Right.</p> <p>7 A. Some of it would have fallen on the Island, given the</p> <p>8 scenario you've asked me to look at, and the rest would</p> <p>9 have fallen in the sea.</p> <p>10 Q. Okay. If there was rain -- and I think we are going to</p> <p>11 bring in a number of witness statements to say there was</p> <p>12 rain -- and entrainment of seawater too, which</p> <p>13 produced -- we will argue, then precipitation out of the</p> <p>14 cloud or through the cloud is much more quantitative, is</p> <p>15 it not? I mean it brings down all the stuff that's up</p> <p>16 there, or how much would you say it brings down?</p> <p>17 A. Well, I don't believe I can answer that question.</p> <p>18 I haven't got the relevant expertise, but we did</p> <p>19 discuss, or we did touch on this yesterday as well,</p> <p>20 particularly the witness statements of Dr Nicholson and</p> <p>21 Mr Stretch and the transcript of Dr Nicholson's</p> <p>22 evidence. I think the conclusion from that was -- if</p> <p>23 I can paraphrase, and again stressing that I've no</p> <p>24 expertise -- that even Dr Nicholson with his expertise</p> <p>25 felt that it was probable but not definite that there</p> <p style="text-align: center;">Page 24</p>

6 (Pages 21 to 24)

<p>1 may have been some scavenging of activity from the cloud 2 by rainwater.</p> <p>3 I am certainly not in a position to be able to 4 quantify that, which is why I've not tried to do that. 5 I've tried to remain within my expertise, and that is 6 why I remain -- that I looked at the evidence for 7 contamination on the Island and took what I believed was 8 an upper limit of the levels of widespread contamination 9 on the Island. That was what I based my report on.</p> <p>10 Q. Yes. But if rain occurs, do you agree that it would 11 bring down a significant amount, much more of the 12 material, than if it were just coming down on the basis 13 of gravity?</p> <p>14 A. Than dry deposition?</p> <p>15 Q. Yes.</p> <p>16 A. Yes, I do.</p> <p>17 Q. Yes.</p> <p>18 A. Indeed, in my report I'd assumed that the 19 contamination -- I had taken it that the level of 20 contamination which I'd assumed, which is significant, 21 was likely to have arisen from some scavenging due to 22 rain rather than dry deposition.</p> <p>23 Q. Is it possible, do you think -- is it possible now -- 24 that the levels -- I mean the levels that you used for 25 your calculation were the highest levels found on</p> <p style="text-align: center;">Page 25</p>	<p>1 people using contamination monitoring instruments in 2 certainly the southern part of the Island, that's around 3 Vaskess Bay -- the south western part of the Island 4 I should say -- in Port London, on the ship, and I also 5 said I think that my deduction would be that if there 6 was that kind of monitoring going on in Port London 7 because of rainfall there would have similarly been 8 monitoring going on in Main Camp which was also the main 9 inhabited area, which was only anyway a few kilometres 10 from Port London.</p> <p>11 Q. But these are Geiger-Muller counters?</p> <p>12 A. Yes.</p> <p>13 Q. Yes, and they are not responsive to alpha emissions.</p> <p>14 A. Those particular ones wouldn't be. Some modern Geigers 15 are actually very responsive to alpha. It depends on 16 the thickness of the window.</p> <p>17 MR JUSTICE BLAKE: What were they using at the time?</p> <p>18 A. What they were using at the time, no, would not have 19 responded to alpha, my Lord.</p> <p>20 MR JUSTICE BLAKE: So this line of questioning, as 21 I understand it, is that you draw attention to and rely 22 upon the Geiger-Muller monitoring on the Island?</p> <p>23 A. Yes, my Lord.</p> <p>24 MR JUSTICE BLAKE: Dr Busby has put to you but that doesn't 25 pick up -- is it all alphas?</p> <p style="text-align: center;">Page 27</p>
<p>1 various sticky filters?</p> <p>2 A. They were more than that actually.</p> <p>3 Q. But not a lot more?</p> <p>4 A. No, they were about 50 per cent more than the very 5 highest and I could go through my reasoning if that 6 would help.</p> <p>7 Q. But in fact we have heard already -- I don't need to 8 bring the memorandum, but there was a memorandum that 9 says that the sticky filters were to be taken in -- or 10 if they were left out they wouldn't work because the 11 rain would wash it all off.</p> <p>12 So my question is: is it possible that the levels of 13 contamination were significantly higher in places, not 14 everywhere, not over the whole Island, but in places 15 where there was heavy rain, that there might have been 16 very much higher contamination than you assume in your 17 analysis?</p> <p>18 A. We did discuss this yesterday and I did discuss that in 19 my evidence yesterday, that it's possible that you could 20 get localised areas due to rainfall which could have 21 been higher, but I believe that the most reliable form 22 of direct contamination monitoring would have been to 23 use instruments held by people, monitors, and we 24 discussed yesterday the evidence which I have seen which 25 indicates that there were certainly surveys done by</p> <p style="text-align: center;">Page 26</p>	<p>1 A. It wouldn't pick up any alphas, my Lord, because the 2 tube is simply too thick.</p> <p>3 MR JUSTICE BLAKE: Right. So logically I would imagine the 4 next question is, well, then can you draw any 5 information from the use of the Geiger-Muller counter as 6 to alpha radiation?</p> <p>7 A. I believe you can, my Lord. There was quite a lot of 8 discussion in the previous First Tier Tribunal, 9 particularly between Mr Johnston and Professor Regan 10 about the appropriateness of using beta and gamma 11 measurements to calculate alpha.</p> <p>12 The reasoning is -- and I think it was accepted at 13 the end of this discussion -- the reasoning is that when 14 the activity is condensing in the cloud, the nuclear 15 cloud from the detonation, that you will get a mixture 16 of what are called refractory materials and fission 17 products together in a fairly uniform mix, along with 18 the materials from the bomb which would have been 19 originally aluminium which effectively would dissolve 20 some of the other materials within it.</p> <p>21 MR JUSTICE BLAKE: So you are referring to the evidence in 22 the previous hearing?</p> <p>23 A. I'm referring to the evidence in the previous hearing.</p> <p>24 MR JUSTICE BLAKE: In a sense, it's probably not a useful 25 use of your time to summarise that all but you've</p> <p style="text-align: center;">Page 28</p>

<p>1 identified it and I think you have referred to it. You 2 agree with that? Or what's your position? 3 A. I have no expertise in that, my Lord, I'm afraid. 4 MR JUSTICE BLAKE: So you simply note that. 5 A. But I've noted it and I have accepted particularly 6 because -- if my recollection serves me correctly -- 7 I think it was broadly accepted in the end by both that 8 there was likely to be -- that use of beta and gamma 9 measurements as an indicator of the presence of 10 plutonium was a reasonable thing to do, until the 11 fission products had decayed to such a point that they 12 would no longer be detectable. 13 MR JUSTICE BLAKE: I suspect that Dr Busby is interested in 14 the uranium. 15 A. The same would be true of uranium. 16 MR JUSTICE BLAKE: And although this is not an area of 17 expertise of yours, you don't have any adverse comment 18 upon that? 19 A. No, just applying -- 20 MR JUSTICE BLAKE: The debate or the reasoning or the 21 conclusion or whatever it is? 22 A. No. Just applying logic, it appeared to be reasonable 23 from what I could understand. 24 MR JUSTICE BLAKE: Yes. 25 DR BUSBY: So if we take a situation where there was</p> <p style="text-align: center;">Page 29</p>	<p>1 nuclides. But of that order. But that would be in 2 a pool. If it was simply a wet surface -- 3 MR JUSTICE BLAKE: Sorry, I don't understand your answer. 4 A. Ah. 5 MR JUSTICE BLAKE: Can a Geiger counter pick up beta 6 radiation in a pool of water? 7 A. In a pool, if the pool was deep enough then it probably 8 wouldn't but if it was simply a wet surface from rain, 9 then it would. So if it was a thin layer from rain, say 10 a millimetre, 2 millimetres thick, then it would be able 11 to detect the beta and the gamma. 12 MR JUSTICE BLAKE: At what point of thickness or depth of 13 water do you think that the beta radiation would not be 14 detected? 15 A. I would have to calculate it, my Lord, to be sure, but 16 I would say of the order of about 1 to 2 centimetres, 17 perhaps. Say 2 centimetres. 18 DR BUSBY: So that's a partial "no", is it, do we say? Is 19 that -- 20 MR JUSTICE BLAKE: He said -- I've recorded the answer as 21 the Geiger counters cannot pick up beta radiation in 22 a pool of water deeper than 1 to 2 centimetres. 23 DR BUSBY: Yes, that's fine. 24 A. But on a wet surface they would pick it up. 25 MR JUSTICE BLAKE: But contrast with a wet surface as</p> <p style="text-align: center;">Page 31</p>
<p>1 torrential rain and someone was there with 2 a Geiger-Muller counter, and presumably they were 3 because they would have been quite nervous and I think 4 in our witness statements we see there were a lot of 5 people with radiation suits running around with 6 Geiger-Muller counters. 7 A. I've never actually seen a witness statement. 8 Q. We are going to go to one. Where was I? Oh yes, the 9 beta emissions from these materials in the water would 10 not make it out of the water, would they, because of the 11 stopping power of the water? If there was a pool of 12 water, very little beta activity would emerge from the 13 water because betas don't have the energy to penetrate 14 more than half an inch of water? 15 MR JUSTICE BLAKE: Let's try and ask a question. Do 16 I understand the question rightly that the Geiger 17 counters would not pick up beta radiation in the water? 18 Is that the question? 19 DR BUSBY: That is, yes. 20 MR JUSTICE BLAKE: Okay. Well, that's the question. 21 A. In a pool of water that might be 1 or, say, particularly 22 2 centimetres deep, the range -- I can't remember the 23 exact range of beta in water, I would have to work it 24 out, but it's probably going to be of the order of about 25 2 centimetres, depending on the energy, depending on the</p> <p style="text-align: center;">Page 30</p>	<p>1 opposed to a pool of water. 2 A. Yes, so simply a wet surface on a pavement or something 3 they would pick up the beta without any trouble at all. 4 DR BUSBY: So the attenuation of the beta radiation by water 5 would affect any conclusions that could be drawn about 6 the nature of the material emitting -- you were saying 7 earlier that there was some discussion about. But what 8 I'm saying is if it was a wet surface or if it was 9 a pool of water those considerations would be invalid? 10 A. If it was a deep puddle of several centimetres then, no, 11 I don't think the betas -- or there would have been very 12 limited beta, obviously from the very surface, but from 13 a normal wet surface, which most of it I think would 14 have been, then yes, they would detect the beta. They 15 would certainly detect the beta on the people and of 16 course they were monitoring people as well. 17 Q. I would like to now go to your report. I have down here 18 it's SB2/2.17. But I'm not sure. 19 A. I've got 2.14. Is this my original report? 20 Q. No, it is the 2.17 one on uncertainties. (Pause) 21 MR JUSTICE BLAKE: I think you are being asked to look at 22 tab 2.17, page 130 of 151, table 4.1, "Comparison of 23 uncertainty factors for dose co-efficients used to 24 protect adult members of the public." 25 Is that what you want?</p> <p style="text-align: center;">Page 32</p>

1 DR BUSBY: Yes.
 2 MR JUSTICE BLAKE: Right. Page 130.
 3 **A. Page 130, yes, I have that.**
 4 **DR BUSBY: We don't seem to have it in our bundle my Lord.**
 5 MR JUSTICE BLAKE: That, I'm afraid, I can't help you with.
 6 DR BUSBY: That's it. Mr ter Haar has given it to me here.
 7 Right. Now, in this table you've written down
 8 "A comparison of uncertain effects for dose
 9 co-efficients ..." blah, blah, blah. And for uranium
 10 238, ingestion and various other ones, there are three
 11 columns.
 12 You write:
 13 "This study."
 14 And you've written -- well, between 3 and 4. That
 15 says 3, 3, 3, 2, 4. Yes?
 16 **A. Sorry, we are on page 130?**
 17 Q. We are on page 130.
 18 **A. This is the page headed "Table 4.1"?**
 19 Q. Yes. Okay?
 20 MR JUSTICE BLAKE: What's the question?
 21 DR BUSBY: The question is: why didn't you use the higher
 22 uncertainty factor from the US Environmental Protection
 23 Agency?
 24 **A. The final one?**
 25 Q. It's bigger than the other one. I mean --

Page 33

1 MR JUSTICE BLAKE: Let's get the answer.
 2 DR BUSBY: Yes.
 3 **A. Well, I've quoted both. I haven't actually used the**
 4 **results. The papers that this came from, there was**
 5 **effectively two similar papers, one by Harrison and**
 6 **Puncher, I think, and the other by Puncher. This was**
 7 **a table that was effectively used in both papers. It**
 8 **made reference to the USEPA values which you refer to in**
 9 **the final column, but if my memory of the two papers**
 10 **serves me correctly, and the paper which was co-written**
 11 **by Harrison was the longer of the two, more detailed, he**
 12 **actually made a comment in that paper that they believed**
 13 **that the results in the USEPA were too high for a number**
 14 **of reasons which he quoted in the paper, I think**
 15 **including they'd used an older model or something like**
 16 **that.**
 17 **But I'm afraid all of that is outside my expertise.**
 18 **What I have tried to do with this -- you've probably**
 19 **realised that I tend to be a cautious individual,**
 20 **I think that's common amongst health physicists, and so**
 21 **this paper was looking at uncertainties to members of**
 22 **the public from environmental releases of activity and**
 23 **I read the paper and I concluded that I felt that the**
 24 **table, allowing for the fact that I had no expertise in**
 25 **that area, that the table was relevant. But I didn't**

Page 34

1 **believe --**
 2 MR JUSTICE BLAKE: Pause, pause, pause.
 3 **A. Sorry.**
 4 MR JUSTICE BLAKE: The question was: why did you not use the
 5 USEPA?
 6 To the casual observer you clearly have mentioned
 7 three columns of uncertainty factors and put in the last
 8 one the USEPA. Did you use any of the three columns?
 9 **A. No, my Lord.**
 10 MR JUSTICE BLAKE: Right, so the answer is: "I didn't".
 11 **A. No, I didn't. Okay, right.**
 12 MR JUSTICE BLAKE: Right.
 13 **A. But this table was taken straight out of the Harrison**
 14 **and Puncher paper.**
 15 **DR BUSBY: How shall I put it? You have just said that you**
 16 **are a very cautious individual, and all health**
 17 **physicists are, but should not caution be aimed at**
 18 **taking the highest value rather than no value at all?**
 19 **A. The reason I didn't use a value was because, rightly or**
 20 **wrongly, I didn't believe that I had sufficient**
 21 **expertise to be able to understand sufficient of what**
 22 **was behind these number to be sure that I was using the**
 23 **numbers in the way that they were intended. I could**
 24 **take the numbers. To be honest it would have been very**
 25 **straightforward simply to have multiplied some of my**

Page 35

1 **internal dose estimates by these values and some of the**
 2 **others by a factor of 10. But it is simply the fact**
 3 **that I didn't feel that I had sufficient expertise to be**
 4 **confident that what I was doing was a reasonable**
 5 **approach.**
 6 **The CERRIE report itself, I think in its**
 7 **conclusions -- in the conclusions of the CERRIE report**
 8 **I think it says that the ICRP dose co-efficients should**
 9 **be used as they stand without applying additional**
 10 **factors of pessimism or optimism because they didn't**
 11 **feel that was appropriate.**
 12 **I think if I had had more confidence that**
 13 **I understood sufficient to be -- sufficient of the**
 14 **internal dosimetry to feel that I knew what I was doing**
 15 **I wouldn't have been constrained by that statement, but**
 16 **in the absence of specific expertise -- that's what I'm**
 17 **referring to particularly in terms of my caution -- it**
 18 **was the caution in terms of: do you know enough to know**
 19 **what you are doing with these numbers?**
 20 Q. Mr Hallard, I'm a bit confused here because, as
 21 I understood it, your job was to inform the Tribunal to
 22 the best of your ability and using all of the
 23 information available to you of the doses that you
 24 believe, on the basis of your subjective judgments in
 25 all sorts of areas, were likely to be the highest doses

Page 36

1 that anybody received. I think you've said that, that
 2 you have chosen to contaminate the whole of
 3 Christmas Island at some high level, you have made all
 4 sorts of other subjective choices which tend to make us
 5 think that you are looking to make these doses as high
 6 as possible and yet we find that you've ignored the
 7 CERRIE report which says they could be out by a factor
 8 of 10 for some radionuclides and you've ignored the
 9 Lesvos Declaration which says the same, but possibly
 10 even higher, and now we have the Environmental
 11 Protection Agency here, which you yourself quote as
 12 saying that there could be an uncertainty of almost 10
 13 times, and even this study you write "three times".
 14 But you now tell us that you haven't used any of
 15 those numbers and that in fact if you had, the answers
 16 you would have given the Tribunal -- and if nobody had
 17 asked this question about uncertainties those would be
 18 the numbers everybody would believe were the correct
 19 numbers. I am at a bit of a loss to know why, you know,
 20 you made this subjective decision not to include these
 21 uncertainty values.
 22 **A. The reason was because I don't believe that that area is**
 23 **within my expertise. I have said that several times.**
 24 **I've said it in this report and in others.**
 25 MR JUSTICE BLAKE: So when you did your report, you used

Page 37

1 what uncertainty values?
 2 **A. I didn't use the uncertainty -- I didn't use any**
 3 **uncertainty value for those dose co-efficients, my Lord.**
 4 MR JUSTICE BLAKE: Any uncertainty values?
 5 **A. Not for the dose co-efficients, my Lord, no.**
 6 MR JUSTICE BLAKE: Because?
 7 **A. Because ICRP themselves say that the dose co-efficients**
 8 **are intended to be used as point values, i.e. as they**
 9 **are.**
 10 MR JUSTICE BLAKE: And you had confidence in that?
 11 **A. I used that -- I relied on that statement. I may have**
 12 **been in error, but that's the judgment that I took.**
 13 MR JUSTICE BLAKE: Yes.
 14 DR BUSBY: So, Mr Hallard, we received a first paper from
 15 you, a very large, 250 pages paper, which gave answers
 16 for each of these individuals from all sorts of
 17 exposures that you decided that every exposure they
 18 could have received from different routes. That gave
 19 an answer, you know: A, B, C, D, dose, dose, dose, dose.
 20 Now if nobody asked any questions, if we here on
 21 this Battersby/Smith team hadn't said "Can you answer
 22 this question about uncertainties?" those numbers would
 23 have remained, nobody would have questioned them, they
 24 would have been used as the basis for the argument by
 25 Dr Haylock and Professor Thomas that the doses were too

Page 38

1 low to cause the cancers.
 2 That's the case, isn't it, if nobody had asked any
 3 more questions, if we'd just left it at that?
 4 **A. Yes, I think that's probably true.**
 5 Q. But we did ask questions and as a result of that you
 6 said, "Yes, there are some uncertainties" and you'd
 7 missed out a few dose routes as I recall it, and
 8 produced another very large paper, 185 pages, in which
 9 all of the doses had changed. Is that right?
 10 **A. Actually I think the final dose estimates for most of**
 11 **them didn't change. The only one that changed**
 12 **significantly, from memory, was the dose estimate for**
 13 **Mr Battersby. That did change significantly by about**
 14 **30 per cent. But I think the -- I would have to go back**
 15 **and look through the dose estimates.**
 16 Q. I'm not arguing about the actual doses, which we don't
 17 accept anyway. That's not the point. The point is that
 18 we now learn that if we had asked -- and we didn't know
 19 that you hadn't. It's not clear here that you hadn't
 20 used any of these uncertainties. It actually says in
 21 column 1:
 22 "This study. 3, 3, 3, 3."
 23 But now you tell us you didn't use the 3, 3, 2 and
 24 whatever it is. The uncertainty factor.
 25 **A. I think I've made it -- well, certainly I sought to make**

Page 39

1 **it clear. You're talking about the replies that I sent**
 2 **to you?**
 3 Q. No. No.
 4 MR JUSTICE BLAKE: What does this study mean at page 130,
 5 table 4.1?
 6 **A. I'm sorry, my Lord, I can't find the statement.**
 7 MR JUSTICE BLAKE: "Uncertainty factor", the last column.
 8 **A. Yes.**
 9 MR JUSTICE BLAKE: Subheading: "This study".
 10 **A. Right.**
 11 MR JUSTICE BLAKE: What does "This study" mean?
 12 **A. "This study" refers to the paper that this table was**
 13 **taken from. So "This study" refers to the paper by**
 14 **Harrison and Puncher.**
 15 MR JUSTICE BLAKE: Right, as footnote 3 explains?
 16 **A. Yes.**
 17 MR JUSTICE BLAKE: Right. It's not the study that you have
 18 performed for us?
 19 **A. No, I've simply extracted this paper and I've tried to**
 20 **explain that on the previous page.**
 21 MR JUSTICE BLAKE: Okay.
 22 DR BUSBY: Right. So if we were to let's say approximate,
 23 we could argue that you had used the uncertainty factor
 24 of the USEPA your doses would have been multiplied by
 25 a factor of about 10. Is that correct?

Page 40

<p>1 A. Yes. The figures in that final column I think are used 2 in a slightly different way to the way that Harrison and 3 Puncher used them. Again I looked at them and tried to 4 convert one to the other and I wasn't sure I could. But 5 either, yes, you would use a factor of 2 to 3 if you 6 took the Harrison and Puncher figures or the others for 7 nuclides which have got a good body of evidence. 8 Q. So quite apart from any considerations of the CERRIE 9 Committee or the Lesvos Declaration or the ECRR risk 10 factors co-efficients that we looked at, quite apart 11 from any of those, if we just take the United States 12 Environmental Protection Agency, do you consider that to 13 be an authoritative body, firstly? 14 A. It's -- it's an authoritative body. As I say, the paper 15 felt that the Harrison and Puncher paper which this 16 table came from, felt that their estimates were better 17 because they used more up-to-date data and there were 18 a number of other reasons why they felt their estimates 19 were better. 20 Q. Harrison and Puncher are, if I could put it like this, 21 the National Radiological Protection Board? 22 A. Or Public Health Protection Agency, I think they were at 23 the time. 24 Q. But the United States Environmental Protection Agency is 25 not a radiological committee, it's a committee that has</p> <p style="text-align: center;">Page 41</p>	<p>1 close to the centre of the range than at the outside. 2 The uncertainties will be plus or minus. Particularly 3 taken over a range of nuclides there would therefore 4 have been some balancing of those so that the final 5 number over a range of nuclides would not be likely to 6 be as great as that. 7 But at the extreme, then yes, the numbers could have 8 been higher by that value. 9 Q. The decision of this Tribunal will be based on 10 an interpretation of the law which involves reasonable 11 doubt, and so would you agree that it would be fair to 12 use the highest figure possible that one could obtain 13 taking all the uncertainties into consideration, 14 especially uncertainties published by an agency as 15 authoritative as the US Environmental Protection Agency? 16 It would be better to use that high figure if we were 17 talking about doubt? 18 A. Well, again, I'll not go back to comment -- 19 (Overspeaking) 20 MR JUSTICE BLAKE: Let him answer the question, please. You 21 posed the question. 22 DR BUSBY: Sorry. 23 MR JUSTICE BLAKE: What's your answer? 24 A. Again, it comes back to my feeling that I simply don't 25 have the expertise to be able to understand the</p> <p style="text-align: center;">Page 43</p>
<p>1 to do with a wide range of concerns relating to 2 environmental protection; is that correct? 3 A. I don't know. 4 Q. No. Anyway, to get to the point here, had you used this 5 factor of 10 -- we can say that just as yardstick, 6 a factor of 10 -- Mr Battersby's dose which you produced 7 of, as I recall, almost 40 millisieverts -- 8 A. Yes. 9 Q. -- let's say, it was a bit less, but let's say 10 40 millisieverts, would become 400 millisieverts, is 11 that right? 12 A. If you used a factor of 10 it would. If you used 13 a factor of 3, obviously it would have been lower. 14 Q. If you used a factor of 3 it would be 120 millisieverts? 15 A. Yes. 16 Q. These are significant doses, aren't they? 17 A. Yes. 18 Q. So if your report had used these, our appellant, 19 Mr Battersby, would have received a dose which nobody 20 would say was insignificant. 21 A. No, I think that's true, but again I would be using 22 numbers in a way that they were not intended to be used 23 from my reading of ICRP, from my reading of CERRIE and 24 others. COMARE also comment that they believe that the 25 true value of the dose coefficient is more likely to be</p> <p style="text-align: center;">Page 42</p>	<p>1 uncertainties adequately. 2 MR JUSTICE BLAKE: My understanding that the context for 3 this sub-question is the wounds; is that right? 4 A. Particularly for Mr Battersby it would have been 5 a wound, yes. 6 MR JUSTICE BLAKE: I mean all this comes in response to 7 question 2.2: 8 "ICRP 72 is ...(Reading to the words)... dose 9 co-efficients." 10 Et cetera. 11 A. Yes. 12 MR JUSTICE BLAKE: I understand from your answers that you 13 have used ICRP figures because COMARE and others 14 indicate that that's the most reliable. 15 A. Yes. 16 MR JUSTICE BLAKE: When you were asked these questions you 17 provided other information about others with greater 18 error margins and that information is put in table 4.1. 19 A. Yes. 20 MR JUSTICE BLAKE: You did not use any of those uncertainty 21 factors in your reports because you had confidence in 22 ICRP because others were telling you about that? 23 A. Effectively, yes, my Lord. 24 MR JUSTICE BLAKE: And the question is now being put that if 25 you had used the range of uncertainty factors between</p> <p style="text-align: center;">Page 44</p>

<p>1 those two columns, "This study", which refers to Puncher 2 and Harrison and USEPA, then for example in 3 Mr Battersby's case the millisievert exposure would go 4 up from 40 to 120 to 400?</p> <p>5 A. In essence, my Lord. There is a slight qualification 6 I would make, that the wound dose co-efficients which I 7 calculated were based on themselves a very pessimistic 8 model for calculating the wound dose. So there would 9 have been some factor effectively built in for that. 10 But --</p> <p>11 MR JUSTICE BLAKE: Well, I am trying to work out the 12 relationship between the factors that you did use in 13 your original report --</p> <p>14 A. Yes.</p> <p>15 MR JUSTICE BLAKE: -- and the uncertainty factors that you 16 told us about in answer to a question.</p> <p>17 A. I think I can't really quantify the uncertainties in the 18 method that I've used. So I think I would have to say 19 in answer to your question that, yes, you would apply 20 this uncertainty perhaps of a factor of 3 if you used 21 the Health Protection Agency values, a slightly higher 22 value if you use the USEPA values.</p> <p>23 MR JUSTICE BLAKE: And do you think that is a reasonable 24 approach to dosimetry in Mr Battersby's case?</p> <p>25 A. You mean to use the factors or not use them?</p> <p style="text-align: center;">Page 45</p>	<p>1 I can.</p> <p>2 MR JUSTICE BLAKE: That's all we are asking of you, but 3 since the topic has arisen I would just like to know 4 where you end up on the question.</p> <p>5 A. I have used them as point values because that's what 6 ICRP recommend, it's what the CERRIE Committee says 7 should be done.</p> <p>8 MR JUSTICE BLAKE: Has anybody, ICRP or CERRIE or other 9 agencies that you consider authoritative, responded to 10 the risk factor, uncertainty factor?</p> <p>11 A. You mean have they multiplied any of the values by these 12 factors?</p> <p>13 MR JUSTICE BLAKE: Have they responded saying that that's 14 asking the wrong questions or "We disagree with it" or 15 "We agree with it" or is it just ships sailing through 16 the night not communicating with each other?</p> <p>17 A. Dr Harrison is actually a member of ICRP so obviously 18 there is a communication link there.</p> <p>19 MR JUSTICE BLAKE: Well, maybe, but I mean --</p> <p>20 A. But I'm not aware of any response to this particular 21 paper. I don't think the paper was written for that 22 purpose. Or it may indeed feed into the calculations of 23 the revised dose co-efficients which is currently going 24 on at the moment.</p> <p>25 MR JUSTICE BLAKE: Right. Yes.</p> <p style="text-align: center;">Page 47</p>
<p>1 MR JUSTICE BLAKE: To have used the risk factors which seem 2 to increase the dose estimates?</p> <p>3 A. So to apply a factor of 3 or 10 or whatever?</p> <p>4 MR JUSTICE BLAKE: Between 3 and whatever it is, yes. We 5 have the things in the table. I don't know which one 6 you want to have a look at. But I mean if we're 7 interested in 238 uranium it's 3 and then 5 to 6, 8 whichever one.</p> <p>9 A. Yes.</p> <p>10 MR JUSTICE BLAKE: Do you understand the question?</p> <p>11 A. I do understand the question.</p> <p>12 MR JUSTICE BLAKE: Well, is that a reasonable approach to 13 this form of dosimetry assessment?</p> <p>14 A. It would not normally be done.</p> <p>15 MR JUSTICE BLAKE: Because?</p> <p>16 A. Because ICRP themselves say it's -- the CERRIE Committee 17 also says that the way that it would -- that the way you 18 should use the dose co-efficients is to use them as 19 point values as they say, simply to use the value. 20 In the context of whether I should use them, whether 21 I should have used them in this calculation in order to 22 remain beyond reasonable doubt, it's still a difficult 23 judgment. I think perhaps the answer is yes. But 24 again -- sorry, I'm not trying to be evasive or awkward. 25 I am just trying to give you as honest an answer as</p> <p style="text-align: center;">Page 46</p>	<p>1 DR BUSBY: Just one final point on this issue. I would just 2 like you to confirm that these are uncertainty factors 3 over the ICRP risk co-efficients. That is to say the 4 USEPA doesn't have their own risk model. They all use 5 the ICRP model and what they are saying here is that it 6 might be out by a factor of whatever it says in this 7 column, 5, 2, 8 or 3 or whatever?</p> <p>8 A. That's my understanding of it, yes.</p> <p>9 Q. So there's no alternative risk model in this table. 10 It's not about any other risk model --</p> <p>11 A. No, both papers were about estimating the uncertainties.</p> <p>12 DR BUSBY: Good, thank you.</p> <p>13 Well, my Lord, I don't know whether you want to -- 14 I mean my next line of questioning might take some time. 15 I could start it now and continue. But I just mention 16 that if --</p> <p>17 MR JUSTICE BLAKE: Well, we've got to have a break in the 18 next 15 minutes. If you would prefer to take a break 19 now ...</p> <p>20 DR BUSBY: It might be better to take a break now and then 21 I can take the next line of questioning through 22 continuously. Of course it's your --</p> <p>23 MR JUSTICE BLAKE: Well, no, you probably have an idea of 24 what you are going to go to next. Right, we'll take 25 a break.</p> <p style="text-align: center;">Page 48</p>

<p>1 25 past. We'll continue then. 2 (11.12 am) 3 (A short break) 4 (11.25 am) 5 MR JUSTICE BLAKE: Yes. 6 DR BUSBY: Right. Well, we are going to look at 7 re-suspension factors. Before we do so, though, if 8 I could just finish off -- I have a little extra bit to 9 finish off on the uncertainties. 10 Could I take you to table 4.1 on page 130 of your 11 second report, the 2.17 report, the one we've been 12 looking at. 13 A. So we are looking at this table from the Harrison and 14 Puncher. 15 Q. Yes, we were. 16 MR JUSTICE BLAKE: You cut and pasted from that? 17 DR BUSBY: In the same tab. 18 A. Yes. 19 MR JUSTICE BLAKE: Yes, the question? 20 DR BUSBY: In the same tab there's a table 3 on page 106. 21 A. Yes. 22 Q. Right. Now, if we go down the first -- this 23 says: "Source of dose", "Co-efficient", "Estimated 24 potential uncertainty"? 25 A. Yes.</p> <p style="text-align: center;">Page 49</p>	<p>1 numbers in a less conservative way than I did, perhaps 2 a more realistic way, if you like, a balance of 3 probabilities-type way, and had you done the calculation 4 that way you would have got a number which could have 5 been up to a factor of 20 less. 6 Q. I see, good. That's all, thank you. I was a bit 7 confused by this table. I wondered what it was it was 8 saying. 9 MR JUSTICE BLAKE: Thank you for drawing it into the 10 discussion. I had asked you a question before the 11 adjournment, and I don't know whether the reference to 12 that table 3 helps at all, as to what is the 13 relationship between table 3 and table 4. Do your 14 uncertainty estimates incorporate any of those at table 15 4.1 or is it a different approach to the same issue? Is 16 there double counting if one takes yours and then 17 multiplies by 3 or 5? 18 A. It's a different approach to the same thing. What I've 19 done in table 3 is just quote factors, but on their own 20 that isn't terribly helpful because they could be 21 misleading, so what I've done is then converted those 22 into what the equivalent uncertainty would be in 23 millisieverts in dose. 24 So again it's the same approach that the far column, 25 so the column to the far right, is showing the --</p> <p style="text-align: center;">Page 51</p>
<p>1 Q. It goes down here: 2 "Overestimate to estimated dose, per cent." 3 If we go down to number 4 here, where it says: 4 "Activity of cloud in inhabited areas of the 5 Island." 6 I see it says "factor of 20". 7 A. Yes. 8 Q. What I don't understand is did you use that factor of 20 9 or are you pointing out that that factor of 20 might be 10 possible to be used? 11 A. These are the ranges of uncertainties that I believe 12 exist in the calculations. 13 MR JUSTICE BLAKE: In your calculations? 14 A. My calculations, my Lord. 15 MR JUSTICE BLAKE: Yes. 16 A. So what I'm saying with that is that I believe that the 17 calculation which I've done is an upper level, which is 18 the final column, but that that could overestimate the 19 dose by up to a factor of 20. 20 DR BUSBY: So you did use the factor of 20 in that -- you 21 are saying that that factor of 20 was incorporated into 22 your -- 23 A. No, what I'm saying is that the calculation I did 24 I believe was an upper estimate using the numbers which 25 I used in the report. But you could interpret the</p> <p style="text-align: center;">Page 50</p>	<p>1 MR JUSTICE BLAKE: Of table -- 2 A. Of table 4. 3 MR JUSTICE BLAKE: Table 4, yes. 4 A. Yes, is showing the potential underestimate. So that if 5 there were uncertainties which had not been fully 6 included in the calculation they would be shown in that 7 final column as an underestimate and you'll see that 8 most of the values shown there are described as "upper 9 levels", that is I believe that they are upper levels, 10 upper limit values, based on very conservative 11 assumptions. 12 MR JUSTICE BLAKE: Sorry "upper levels" we get from table 3, 13 page 106, final column; yes? 14 A. Yes, it's the same description here. 15 MR JUSTICE BLAKE: And toggling between, as I am trying to 16 do, 106 and 130, just describe to us the relationship 17 between the two tables. 18 A. Between 106 and 130, my Lord? 19 MR JUSTICE BLAKE: Yes. 20 A. The only relationship between those two tables is 21 that -- if I can just find 130 again -- the only 22 relationship between that is that if you look on -- so 23 if we're on table 4 again, if you look under item 7 24 there, so this is on page 117 -- 25 MR JUSTICE BLAKE: 117.</p> <p style="text-align: center;">Page 52</p>

<p>1 A. This is on table 4, my Lord. Sorry, I thought this was 2 the table you were referring to. 3 MR JUSTICE BLAKE: No, I was referring to your table at 4 page 130, table 4.1. But never mind. 5 A. Right. 6 MR JUSTICE BLAKE: You have introduced table 4 as well, yes? 7 A. I'm sorry, my Lord, I thought that's the one you were 8 referring to. 9 MR JUSTICE BLAKE: Right. 10 I am going to make one final attempt at this. 11 A. Right. 12 MR JUSTICE BLAKE: Is there any connection between your 13 uncertainties for each dose co-efficient in table 3 and 14 the table you put in table 4.1? 15 A. The only relationship, my Lord, if you look on item 7 -- 16 that's effective dose -- an example would be item 13. 17 MR JUSTICE BLAKE: At table 4 you are now on? 18 A. No, I've gone back to table 3. So this is page 109. 19 MR JUSTICE BLAKE: 109. 20 A. So item 13, which it says at the end of the row: 21 "Estimation of the uncertainty of the ICRP dose 22 models is beyond my expertise." 23 And it's discussed in my response to question 2.2 on 24 pages 129 to 132. 25 MR JUSTICE BLAKE: So the estimates you've made in table 3,</p> <p style="text-align: center;">Page 53</p>	<p>1 Mr Johnston's reports for some of the bases of your 2 calculations? 3 A. Some of them. 4 Q. And that you see him as a dependable authority, although 5 recently perhaps not in the case of uranium. 6 A. I think particularly in terms of the nuclear weapons 7 expertise that I've relied on his nuclear weapons 8 expertise, yes. 9 Q. Right. In your report, the first report on page 81, 10 SB2/2.12, can we just have a look at that? 11 MR JUSTICE BLAKE: This witness' first report? 12 DR BUSBY: Yes. 13 A. Do you mean 2.12 or 2.14? 14 DR BUSBY: I have 2.12. 15 MR JUSTICE BLAKE: His first report, page 80? 16 DR BUSBY: Page 81. 17 MR JUSTICE BLAKE: 81. 81 of 285. That's 2.14. Yes. 18 DR BUSBY: Yes, "Re-suspension factor," here we are. 19 A. Right. 20 Q. You actually ended up using a re-suspension factor under 21 (h). This is page 82, not page 81, I see here. So at 22 (h) you say here: 23 "Hence a re-suspension factor of 10 to the minus 24 4..." 25 So 10 to the minus 4 is what you use?</p> <p style="text-align: center;">Page 55</p>
<p>1 if one was to -- applying a precautionary approach, 2 would one then modify the calculations by the table 4.1 3 uncertainties? That's what I'm trying to get at. 4 A. Right. I can make a judgment here, my Lord, and I hope 5 this helps. 6 It would not normally be done for the reasons that 7 I said, that ICRP themselves say that it should be used 8 as a point value and there are other documents which 9 we've seen which make a similar comment. 10 If you wanted to estimate the highest possible 11 inhalation dose, taking account of the uncertainties, so 12 right at the extreme end of perhaps a 95 per cent 13 probability or something like that, then it is possible 14 that you would use those uncertainty values. 15 MR JUSTICE BLAKE: Right. 16 A. But that is not the way they're intended to be used, 17 my Lord. 18 MR JUSTICE BLAKE: Yes. We're moving on. 19 DR BUSBY: Well, we can leave that now. 20 So you have made a number of subjective judgments 21 about all kinds of questions coming to the results that 22 you came to for the doses, is that correct? 23 A. I've made judgments and assumptions. I hope I've 24 explained the basis for them in the report. 25 Q. I think you've already said that you rely upon</p> <p style="text-align: center;">Page 54</p>	<p>1 A. Yes. 2 Q. Right. So having accepted that now, can we please go to 3 Mr Johnston's report, which is SB13/36. 4 Now, in this report on page 11 -- where does he say 5 that now? He uses -- I can't quite find it, but he uses 6 a re-suspension factor of 10 to the minus 3, Mr Johnston 7 says? 8 A. Yes. 9 Q. You agree that that was his assumption? 10 A. That's what he's used here. In a later report he 11 corrected that and used a value of 10 to the minus 5. 12 Q. But he did use it here, 10 to the minus 3? 13 A. He used 10 to the minus 3 here and then changed it 14 later. 15 Q. I think Mr ter Haar asked you about this before but is 16 there not a report from the National Radiological 17 Protection Board where they calculate dose constraints, 18 collective effective limits for isotopes of uranium, 19 plutonium, radium and so forth, where they use the 20 factor of 10 to the minus 3 for dusty conditions due to 21 ploughing fields? 22 A. I haven't seen that report. If that's the one I was 23 looking for I have sought to find it and I looked on the 24 relevant websites including I sought it from the archive 25 and I could not -- there were actually two reports that</p> <p style="text-align: center;">Page 56</p>

1 are referred to. I simply couldn't find them, so in the
 2 end I relied on the information which I think included
 3 those because they were referenced in the Carter report
 4 and in the end I used the information in the Carter
 5 report.
 6 Q. But had you used the factor of 10 to the minus 3 which
 7 I think you agree might -- well, has been cited by many
 8 people as being in these reports which you couldn't
 9 find, the doses would have gone up significantly?
 10 A. Any inhalation dose based on deposition would have gone
 11 up significantly, yes.
 12 Q. 10 times?
 13 A. It would have gone up 10 times, but there was a lot of
 14 discussion in the Carter report about re-suspension
 15 factors which we discussed yesterday. Carter used
 16 a re-suspension factor of 10 to the minus 5, which he
 17 considered to be conservative, based on experiments
 18 which have been done in Maralinga. So he used 10 to the
 19 minus 5 which he considered to be very conservative. He
 20 said the range effectively was from occasional values at
 21 10 to the minus 4 up to about 10 to the minus 6 or
 22 above. So I used 10 to the minus 4 on the basis that
 23 that was the highest level which had been seen in their
 24 measurements and therefore I considered that to be
 25 highly conservative actually.

Page 57

1 Q. Do you concede that the NRPB actually gave a figure of
 2 10 to the minus 3 for dusty conditions?
 3 A. I've not seen that.
 4 Q. So you say it didn't happen?
 5 A. No, I mean I haven't seen that report. I haven't seen
 6 that value used.
 7 Q. We have the report but not here unfortunately. So
 8 I guess that's as far as I can go with that.
 9 MR JUSTICE BLAKE: Do you know when they did?
 10 DR BUSBY: Yes, it was in --
 11 A. I'm sorry, my Lord?
 12 DR BUSBY: Oh sorry, the witness. Yes.
 13 MR JUSTICE BLAKE: I was asking do you know when the NRPB,
 14 in the report that you haven't been able to track down,
 15 used 10 to the minus 3?
 16 A. No, my Lord, I've not seen that report.
 17 MR JUSTICE BLAKE: I appreciate you haven't seen it. I just
 18 wondered whether you knew what era the report was from.
 19 A. I see, what the date was? I could probably find out
 20 from the Carter report.
 21 MR JUSTICE BLAKE: The citation?
 22 A. If my memory -- yes, there was a citation. I'm pretty
 23 sure there was.
 24 MR JUSTICE BLAKE: If it's NRPB, it's before they became
 25 Public Health England.

Page 58

1 A. Before they became Health Protection Agency and then
 2 Public Health England. It's quite an old report.
 3 MR JUSTICE BLAKE: Yes.
 4 DR BUSBY: Could I suggest to you that it was about 2002?
 5 Would that seem reasonable?
 6 A. I can't remember. I don't know. I was disappointed not
 7 to be able to find them and I did try very hard to find
 8 them but in the end I concluded that since the Carter
 9 report had cited them, that therefore the information in
 10 the Carter report would be based on that, and would have
 11 taken account of that and therefore it would be
 12 reasonable.
 13 Q. There are various kinds of dust, do you agree? So the
 14 concept which I think was raised earlier in these
 15 discussions about intolerable levels of dust would have
 16 much to do with the particle size, would it not?
 17 A. It's a subjective statement. Perhaps it might have some
 18 relation to particle size. I wouldn't have thought it
 19 would be dependent on particle size. It's simply
 20 dependent on the fact it was a very dusty and therefore
 21 highly unpleasant environment.
 22 Q. But the ultra-fine particles, if you like the
 23 nanoparticles that generally are conceded are the
 24 consequence of the condensation of the plasma from the
 25 explosion, those particles are essentially an aerosol,

Page 59

1 are they not?
 2 A. Well, the very fine particles, particularly if they were
 3 taken down to earth in rainfall, which is what I assume
 4 because if they were that fine actually it's very
 5 unlikely that they would be deposited on the ground by
 6 dry deposition and pretty much the only way that small
 7 particles like that -- from my reading of Dr Nicholson's
 8 report particularly and Mr Stretch's report, the main
 9 way for very small particles to be deposited on the
 10 ground would be if they were taken down in rain and
 11 that's what I've assumed in my report. Therefore, they
 12 would be distributed on the ground.
 13 Q. I think my question is about this question of the
 14 tolerability of very dusty circumstances.
 15 So what I am trying to ask you is would you consider
 16 that if the dust particles were so small that they were
 17 almost an aerosol they could be present in the
 18 atmosphere at very high concentrations but not
 19 considered to be intolerable because they were not
 20 clearly sticking to things and covering surfaces and
 21 generally kind of making people cough?
 22 A. Well, we're perhaps going beyond my expertise. As
 23 a comment, I would had said that it would depend on the
 24 mass in the air rather than the particle size. But if
 25 there was a certain mass as grams per metres cubed or

Page 60

1 **whatever in the atmosphere that that mass -- and that**
 2 **was considered intolerable at one particle size I would**
 3 **have thought as a judgment -- although I don't have**
 4 **expertise in this area -- as a simple judgment I would**
 5 **have thought that would be intolerable for any particle**
 6 **size, within reason.**
 7 Q. We are going back to uranium. Can I take you back to
 8 the Washington report which is SB6/79.
 9 MR JUSTICE BLAKE: So we've finished with SB13, have we?
 10 DR BUSBY: Yes, we have, yes.
 11 **A. Which tab?**
 12 **DR BUSBY: SB6/79.**
 13 **This is a paper which we obtained from the archives**
 14 **of the University of Washington. It's a survey of**
 15 **Christmas Island and various other places.**
 16 **A. Yes, I've seen this.**
 17 Q. I want to take you to the Christmas Island table which
 18 is one of these. Page 7 is Christmas Island.
 19 MR JUSTICE BLAKE: ??
 20 DR BUSBY: And page 8. Yes, so page 7 talks about
 21 Christmas Island and it says the sites where the
 22 analysis was done in 1975.
 23 Over the page we have table 3. Now where is the
 24 uranium stuff? (Pause)
 25 MR JUSTICE BLAKE: Yes.

Page 61

1 DR BUSBY: I think maybe this is a different paper, my Lord.
 2 In this report there is a report in which they say
 3 concentrations of uranium found --
 4 MR JUSTICE BLAKE: You had better put the right document --
 5 DR BUSBY: -- on Christmas Island, but this doesn't seem to
 6 be the one. Unless I haven't got the right table.
 7 MR JUSTICE BLAKE: Mr Heppinstall is giving you a prompt.
 8 MR HEPPINSTALL: That one? So that's in 77.
 9 DR BUSBY: 77, sorry, I gave you the wrong --
 10 MR JUSTICE BLAKE: Leave 79.
 11 DR BUSBY: SB6/77, not 79.
 12 MR JUSTICE BLAKE: Delete 79, put in 77. Right.
 13 DR BUSBY: Right, here we are.
 14 So this is table 1 in that report on SB6/77.
 15 **A. Which page is that on?**
 16 Q. It's quite a short report --
 17 MR JUSTICE BLAKE: Page number?
 18 DR BUSBY: It doesn't have a page number, my Lord. It's
 19 sort of --
 20 MR JUSTICE BLAKE: If you go in --
 21 DR BUSBY: It's the eighth page into the --
 22 MR JUSTICE BLAKE: Into the tab.
 23 DR BUSBY: -- tab. It's called:
 24 "Table 1. Radioactivity of the three most abundant
 25 gamma-emitting radionuclides in selected samples from

Page 62

1 Christmas Island."
 2 MR JUSTICE BLAKE: Have you got it there?
 3 **A. Yes, I have.**
 4 MR JUSTICE BLAKE: Right, well done. We have the table.
 5 DR BUSBY: This is one of the few reports that we have which
 6 actually lists concentrations of uranium. As you said,
 7 the McEwan report mentions it but doesn't give any
 8 numbers.
 9 So if you look on the right-hand side, the third
 10 column of this is uranium 238. It gives the
 11 concentrations in picocuries per gram?
 12 **A. Yes.**
 13 Q. Can you say whether these are significant quantities of
 14 uranium 238? Whether you would expect to find them on
 15 a coral island, given Mr Johnston's remarks about
 16 concentrations of uranium on coral islands?
 17 **A. Well, this is outside my expertise in terms of**
 18 **environmental concentrations of uranium on the Island.**
 19 **I have looked at this.**
 20 MR JUSTICE BLAKE: You've looked at this report before, have
 21 you?
 22 **A. I have looked at the report before, yes.**
 23 MR JUSTICE BLAKE: So it's not something you are having to
 24 deal with fresh.
 25 **A. No, and --**

Page 63

1 MR JUSTICE BLAKE: What was the question again?
 2 DR BUSBY: Would you consider these to be normal levels of
 3 uranium in the environment on a coral island?
 4 **A. Okay, I'm going from memory.**
 5 MR JUSTICE BLAKE: Can you comment upon that?
 6 **A. Yes, I can from memory, my Lord.**
 7 MR JUSTICE BLAKE: Right. Okay.
 8 **A. So I may need to confirm this data and come back to you.**
 9 **It was a little while ago that I did this, but I looked**
 10 **at -- ah yes, I looked at typical levels of uranium just**
 11 **from doing a Google search and found some papers which**
 12 **appeared to be authoritative, from good sources. If my**
 13 **memory serves me correctly, these levels were -- and**
 14 **I will need to confirm this, so please understand that**
 15 **these are based on memory -- that these levels, that the**
 16 **level in soil, and we see that there are not many values**
 17 **for soil, there's only two or three values for soil,**
 18 **everything else is from animals, but that these were**
 19 **actually fairly consistent with typical levels of**
 20 **uranium in Britain, and in the United States and**
 21 **particularly in Canada the levels tended to be rather**
 22 **higher.**
 23 **DR BUSBY: That's very helpful, thank you, yes.**
 24 **If we look at this table on the right-hand side of**
 25 **238-uranium, the highest levels are in fish, would you**

Page 64

<p>1 say that? Is that correct?</p> <p>2 A. Goatfish, mullet -- yes, they appear to be.</p> <p>3 Q. We have three fish here, Milkfish, mullet and goatfish</p> <p>4 and I know there are hardly any -- it's a very, very --</p> <p>5 you know, but it's all we have. It's all we have.</p> <p>6 A. (Nodded assent).</p> <p>7 Q. So there does seem to be more uranium in the fish than</p> <p>8 there is on the Island?</p> <p>9 A. Yes.</p> <p>10 MR JUSTICE BLAKE: In the soil.</p> <p>11 DR BUSBY: Thank you.</p> <p>12 A. But then there's uranium in seawater.</p> <p>13 DR BUSBY: Of course, of course. But then the seawater also</p> <p>14 lands on the land, doesn't it? I mean it's a coral</p> <p>15 island.</p> <p>16 A. I mean, I say there's uranium in seawater because I know</p> <p>17 there's uranium in seawater. I could not make any</p> <p>18 quantitative association between what appears in the</p> <p>19 fish and what's in the uranium. I simply don't know.</p> <p>20 MR JUSTICE BLAKE: When you say uranium in seawater do you</p> <p>21 mean as a naturally occurring --</p> <p>22 A. Yes, my Lord. You get natural uranium in seawater in</p> <p>23 the same way as you get natural uranium in soil.</p> <p>24 DR BUSBY: There is no way we can tell from this table if</p> <p>25 this is natural uranium, is there?</p> <p style="text-align: center;">Page 65</p>	<p>1 MR JUSTICE BLAKE: What's the question? Because let's see</p> <p>2 whether this witness can help upon this topic at all.</p> <p>3 If he hasn't read the paper I rather doubt it but what's</p> <p>4 the question?</p> <p>5 DR BUSBY: The question is: do you agree that the rain would</p> <p>6 have contained -- that the rain at Hiroshima, the black</p> <p>7 rain at Hiroshima contained uranium?</p> <p>8 A. I can't comment. I really can't.</p> <p>9 Q. We'll leave it in that case. It's not really your area</p> <p>10 of expertise.</p> <p>11 So we'll leave that altogether now. It was just to</p> <p>12 draw attention to the presence of uranium on</p> <p>13 Christmas Island from the Washington report.</p> <p>14 MR JUSTICE BLAKE: Right. So we aren't going to pursue that</p> <p>15 one.</p> <p>16 DR BUSBY: We can now go to SB7/96.</p> <p>17 A. SB7 again.</p> <p>18 Q. Yes.</p> <p>19 A. And which tab?</p> <p>20 MR JUSTICE BLAKE: 96.</p> <p>21 DR BUSBY: 96. Yes.</p> <p>22 Have you seen this paper before?</p> <p>23 A. I have. I've looked at it briefly. I haven't studied</p> <p>24 it in detail. I only received it quite recently, so</p> <p>25 I just did some preliminary calculations on it and</p> <p style="text-align: center;">Page 67</p>
<p>1 A. It's uranium 238, which is the principal constituent of</p> <p>2 natural uranium. Apart from that, no. It's simply</p> <p>3 a statement of how much uranium was measured.</p> <p>4 Q. We would need to have other uranium isotope measurements</p> <p>5 in order to see whether it was from the nuclear</p> <p>6 explosions or whether it was from the -- yes, thank you.</p> <p>7 A. Yes.</p> <p>8 Q. Can we just go now to SB7/110.</p> <p>9 Have you read this paper before? Have you seen this</p> <p>10 paper?</p> <p>11 A. I don't recognise it. I have read papers from</p> <p>12 Professor Sawada on black rain and I've read one of his</p> <p>13 references but I'm not sure this is the one I've read.</p> <p>14 Q. This is a different Sawada, this one.</p> <p>15 A. Oh, is it? In that case I won't have read it.</p> <p>16 Q. But it was cited by Professor Sawada. Essentially you</p> <p>17 can see if you can just have look at the abstract</p> <p>18 I guess -- and I'll just let you look at that. (Pause)</p> <p>19 A. Okay.</p> <p>20 Q. These people then, would you agree that these people</p> <p>21 were measuring uranium in the black rain at the areas</p> <p>22 where the black rain fell after the Hiroshima --</p> <p>23 A. As far as I can tell. I mean I've only read the</p> <p>24 abstract and of course, as we discussed the other day,</p> <p>25 that could be misleading.</p> <p style="text-align: center;">Page 66</p>	<p>1 that's all.</p> <p>2 Q. You are a health physicist?</p> <p>3 A. Yes, I am.</p> <p>4 Q. Are you aware of the studies that have been carried out</p> <p>5 of doses at the Marshall Islands by the Health Physics</p> <p>6 Society, a very large paper by SL Simon and various</p> <p>7 other people?</p> <p>8 A. I'm not aware of that particular paper. I mean I know</p> <p>9 a lot of work has gone on in the Marshall Islands but</p> <p>10 I'm not aware of that particular paper.</p> <p>11 Q. Earlier on you said that you used the dose -- that the</p> <p>12 distribution of radionuclides in your calculation and</p> <p>13 you took -- which would have occurred after a bomb test,</p> <p>14 and you took that from the Carter report.</p> <p>15 A. Yes, subsequently modified in my supplementary report.</p> <p>16 In the supplementary report I discovered that the</p> <p>17 information in the -- well, perhaps we'll go into that</p> <p>18 later but with that qualification then yes, I used the</p> <p>19 Carter report.</p> <p>20 Q. Now, when a bomb explodes and produces all sorts of</p> <p>21 fission products and activation products and residues</p> <p>22 from the bomb casing and whatnot, the actual</p> <p>23 concentrations, the immediate concentrations or the</p> <p>24 concentrations after one hour or whatever, 10 hours,</p> <p>25 15 hours, days and so forth, they depend greatly on the</p> <p style="text-align: center;">Page 68</p>

<p>1 spectrum of radionuclides that are there; is that 2 correct?</p> <p>3 A. Well, the rate of decay of the mix of nuclides for both 4 fission weapons, that's atomic weapons, and 5 thermonuclear weapons, there is an approximate 6 relationship and that same relationship is being used 7 for both types of weapon. It's the so-called -- the 8 relationship is T, which is time, to the power of minus 9 1.2. Now it's an approximate relationship but it's 10 quoted in Carter, it was quoted in quite a few of the 11 papers from Christmas Island, it's quoted in "The effect 12 on nuclear weapons", the book called "The effect on 13 nuclear weapons" by Glasstone.</p> <p>14 So the indication from that is that regardless of 15 the precise mix of the nuclides, that the approximate 16 rate of decay -- of the mix, not the individual 17 isotopes, of the mix -- is roughly the same.</p> <p>18 Q. Yes, but to calculate the actual internal doses you rely 19 upon the concentrations of the specific nuclides because 20 then you have to go to the ICRP risk co-efficients for 21 those nuclides, is that correct?</p> <p>22 A. Yes, and largely I've used the mix and the internal dose 23 co-efficients that were in the Carter report.</p> <p>24 Q. The internal dose co-efficients are not so important as 25 the actual concentrations of the substances which are in</p> <p style="text-align: center;">Page 69</p>	<p>1 Q. Yes.</p> <p>2 A. From the gist document, the Bevis Parker document.</p> <p>3 Q. But you could have gone to this -- this is the standard 4 work on the distribution of radionuclides from fission 5 fallout and from thermonuclear fallout?</p> <p>6 A. Okay.</p> <p>7 MR JUSTICE BLAKE: Is that a question?</p> <p>8 DR BUSBY: Why didn't you?</p> <p>9 A. Well, because I wasn't familiar with this paper. I've 10 only seen it relatively recently -- very recently in 11 fact -- and prior to that I wasn't aware of the 12 document.</p> <p>13 Q. But, Mr Hallard, you hold yourself out to be an expert 14 in this area.</p> <p>15 A. My expertise is in health physics, rather than nuclear 16 weapons and the precise mix, which is why I've used the 17 data from Carter because it was authoritative. I can 18 also explain why I think there were certain --</p> <p>19 Q. So is it fair to say that your expertise is not in the 20 health physics relating to the assessment of risk from 21 nuclear weapon fallout?</p> <p>22 A. Not specifically. It's general expertise in health 23 physics.</p> <p>24 Q. So your report is written by somebody who you now tell 25 us does not have expertise in the analysis of fallout</p> <p style="text-align: center;">Page 71</p>
<p>1 the people for which those co-efficients are applied -- 2 to which those dose co-efficients are applied.</p> <p>3 MR JUSTICE BLAKE: Is that a statement or a question? I've 4 lost this. What questions do you want to pose about 5 this document?</p> <p>6 DR BUSBY: I am saying that the --</p> <p>7 MR JUSTICE BLAKE: Ask him a question.</p> <p>8 MR TER HAAR: I thought I did, my Lord. But the results of 9 the internal dose calculations for different spectra of 10 radionuclides would be different, is that correct?</p> <p>11 A. Yes. Yes. There would be some isotopes which would 12 tend to dominate but yes, it would vary depending upon 13 the precise mix.</p> <p>14 Q. There are different isotopes in a fusion, in 15 a thermonuclear bomb to the ones that are produced by 16 a fission bomb, is that correct?</p> <p>17 A. Yes, and I discussed that at some length in my report.</p> <p>18 Q. In fact, principally you used the data from Carter which 19 was for a fission bomb; is that correct?</p> <p>20 A. Yes, but I then modified it in my supplementary report 21 to take account of three additional nuclides, which was 22 uranium-240, neptunium-240 and plutonium-240.</p> <p>23 Q. Where did you get the information for the concentrations 24 of those?</p> <p>25 A. Of those three nuclides?</p> <p style="text-align: center;">Page 70</p>	<p>1 from nuclear weapons; is that correct?</p> <p>2 A. Er --</p> <p>3 Q. Or not fully, perhaps? I mean perhaps I am being too 4 cruel here.</p> <p>5 A. I'm not an expert in nuclear weapons, no, and I've said 6 that before, I think. And I did discuss in some depth, 7 I think, the data that I was using from the Carter 8 report and why I concluded in the end that it was 9 reasonable to do so.</p> <p>10 Q. I think what I am asking you to agree is that the inputs 11 to your calculation in terms of the -- yes, the inputs 12 into your calculations were not inputs that would have 13 been used by someone who was an expert, like 14 Professor Simon, in the doses from nuclear weapon tests.</p> <p>15 A. I think the Carter data is generally taken, certainly 16 from the information that I have, as being good data and 17 amongst the best data available which is not classified.</p> <p>18 Q. But -- yes.</p> <p>19 MR JUSTICE BLAKE: If you want to make a point about this 20 document you'd better make it because we've had it open 21 for some time and we haven't gone beyond the title page 22 and we're going to have to put it into a question or 23 abandon it.</p> <p>24 DR BUSBY: Well, I have made all my points about this, 25 my Lord.</p> <p style="text-align: center;">Page 72</p>

<p>1 MR JUSTICE BLAKE: If you are asking questions of this 2 witness, Dr Busby, I want you to ask a question. 3 DR BUSBY: The Carter data then you agree was the best data 4 available for fission bombs, but your report is about 5 exposure to fallout from thermonuclear bombs which is 6 not the same. If you look in this report you can see 7 data for both fission bombs and thermonuclear bombs, 8 which are different, is that correct? 9 A. I've not studied the report in that much detail. There 10 will be variations between individual weapons. The 11 data, I mean I -- 12 MR JUSTICE BLAKE: Look, I'm sorry, I'm going to cut across 13 this. This is just getting nowhere. 14 You have explained in your report how you have used 15 Carter. 16 A. Yes, my Lord. 17 MR JUSTICE BLAKE: And you have modified it for the nuclear 18 devices. 19 A. Yes, my Lord. 20 MR JUSTICE BLAKE: And because of different radionuclides an 21 you made calculations. 22 You are familiar with this document? 23 A. I have seen it, my Lord, recently, but I've not had time 24 to study it in significant detail. 25 MR JUSTICE BLAKE: From what you have read is there anything</p> <p style="text-align: center;">Page 73</p>	<p>1 proportion of plutonium and that in itself will lead to 2 a degree of pessimism. 3 In terms of the other short-lived isotopes I simply 4 haven't done enough or I haven't looked at that in that 5 depth in this report. 6 MR JUSTICE BLAKE: Okay. Pause there. Now if there is 7 anything you want to develop in that answer or challenge 8 or point anything else out, now is your chance, 9 Dr Busby. 10 DR BUSBY: Do you consider you are expert enough to have 11 made the modifications that you made to the Carter 12 fission spectrum? 13 A. In the supplementary report? 14 DR BUSBY: Yes. 15 MR JUSTICE BLAKE: The modifications you made. 16 DR BUSBY: The modifications you just told us you made? 17 A. In the supplementary report, I believe so. 18 Q. I take it that's a "yes"? yes? 19 A. Yes, I had a short conversation or a conversation with 20 somebody in Aldermaston to confirm that my 21 interpretation of that gist report was the correct 22 interpretation of it and he confirmed that it was. 23 Q. You've just told us a minute ago that you had a look at 24 a couple of things here and you said "less than a factor 25 of 2", so in other words, it wasn't the same, was it?</p> <p style="text-align: center;">Page 75</p>
<p>1 in this report which suggests that what you were doing 2 in modifying Carter was wrong or inappropriate? 3 A. I've looked at the decay rate in this report, my Lord, 4 and I was finding similar decay rates. 5 MR JUSTICE BLAKE: Yes. 6 A. I've looked at the gamma levels, this is the gamma 7 levels at 1 metre height from the deposit of the 8 radionuclides contained in this, and the numbers were 9 similar. I think these numbers were coming out to be 10 slightly higher, less than a factor of 2. So the Carter 11 report data was within a factor of 2 for gamma of the 12 data here. I've done no other analysis of this. 13 MR JUSTICE BLAKE: Are you still comfortable about your 14 modification of Carter to get the results that you 15 produced to us in the light of this report or do you 16 think anything you have read would require you to 17 recalculate? 18 A. I haven't studied the specific nuclide mix in this, 19 my Lord. The data that I've used was the best data that 20 I had available, frankly, and I still believe is 21 reasonable and actually pessimistic because the use of 22 data from a fission weapon -- fission weapons actually 23 have a higher proportion of plutonium in them than the 24 fusion weapons because there is residue from the core of 25 the fission weapon so therefore you get a higher</p> <p style="text-align: center;">Page 74</p>	<p>1 A. In terms of the gamma levels. No, but there will be 2 variations -- I mean there will be variations between 3 individual weapons, let alone between different reports. 4 Q. Of course. So if you had used this authoritative data 5 from Lawrence Livermore, you would have got a different 6 result, would you not? 7 A. The external result might have been slightly higher. 8 I haven't done that. I mean I would need to do the full 9 integrations, et cetera, to be able to compare them. 10 But I think they broadly would be at least within 11 a factor of 2. 12 Q. Right. So that's another factor that we have to 13 consider in terms of increasing the dose, apart from the 14 EPA factor of uncertainty and all the other stuff, is 15 that correct? 16 A. A small factor, difference between them, but I would 17 need to look at the -- 18 Q. Of course. 19 A. I would need to do the calculations to be sure. 20 Q. Of course. 21 A. But a small factor. As I say, there will be variations 22 between individual weapons. It depends on the design of 23 the weapon in terms of -- well, the weapon design. 24 MR JUSTICE BLAKE: At the end of the day we're looking at 25 specific issues about specific weapons.</p> <p style="text-align: center;">Page 76</p>

1 **A. Yes.**
 2 MR JUSTICE BLAKE: As between Carter that you modified and
 3 whatever is dealt with in this document, which do you
 4 think was the most useful starting point for your task
 5 to assist us? What weapons are being discussed in this
 6 document, do you know?
 7 **A. This does include thermonuclear weapons.**
 8 MR JUSTICE BLAKE: Of the sort we are concerned with?
 9 **A. Yes, so this does include 1 megaton weapons. So**
 10 **particularly in terms of the gamma dose rates,**
 11 **et cetera, this could be more accurate than the levels**
 12 **that I've used.**
 13 MR JUSTICE BLAKE: Right.
 14 DR BUSBY: I think that's all we need to go to on this
 15 issue.
 16 Now, I want to go to a paper which has been rather
 17 elusive -- it has gone into the bundle and disappeared
 18 and come back and so on -- which I call the Morgan
 19 memorandum but this is AB61275, now. It has been put
 20 back in again.
 21 MR JUSTICE BLAKE: Is this the document which emerged last
 22 night?
 23 DR BUSBY: Yes.
 24 MR JUSTICE BLAKE: I think it's now SB22, tab 11.
 25 DR BUSBY: SB22, tab 11.

Page 77

1 MR HEPPINSTALL: AB6 would be the reference before
 2 Mr Justice Foskett.
 3 DR BUSBY: Right.
 4 **A. Tab 11?**
 5 Q. Well, it's a document that emerged last night so it now
 6 has SB22, tab 11.
 7 **A. My tab 11 is empty.**
 8 MR JUSTICE BLAKE: Yes. Well, I tell you what --
 9 MS BUSBY: We have spare copies. (Handed)
 10 MR JUSTICE BLAKE: Have you seen this document before?
 11 **A. I have, my Lord.**
 12 MR JUSTICE BLAKE: All right.
 13 **A. I looked at it on a website.**
 14 MR JUSTICE BLAKE: Lucky you. Right.
 15 DR BUSBY: Well, these are minutes of a meeting held at the
 16 Atomic Energy Research Establishment, Harwell, in 1953.
 17 Present at the top you see here Dr Karl Z Morgan,
 18 Oakridge, Tennessee.
 19 You are a health physicist; have you heard of
 20 Dr Morgan?
 21 **A. I have.**
 22 Q. A very famous man, the father of health physics?
 23 **A. Yes, I have heard that. I don't know a great deal about**
 24 **him, but I certainly have heard about him and I know he**
 25 **is a great man.**

Page 78

1 Q. Okay. Well, if we go down to --
 2 MR JUSTICE BLAKE: The third paragraph, is it?
 3 DR BUSBY: The bottom of this.
 4 MR JUSTICE BLAKE: "Other subjects"?
 5 DR BUSBY: "Other subjects ..."
 6 MR JUSTICE BLAKE: Do you have that, the last paragraph?
 7 **A. Yes.**
 8 **DR BUSBY: "Other subjects were touched upon and Dr Morgan**
 9 **promised to send details [blah, blah] in reply to a**
 10 **question from Dr Butterworth he said that the hazard**
 11 **from enriched uranium would be a radioactive hazard**
 12 **rather than a toxic one and related to the presence of**
 13 **U-234."**
 14 **Do you agree with that?**
 15 **A. Yes, that's likely to be the case. It would depend upon**
 16 **the precise proportions of U-234. Enriched uranium --**
 17 **and I assume from the date, 1953, that when they are**
 18 **talking about enriched uranium they are probably talking**
 19 **about nuclear weapons-type enriched uranium, in which**
 20 **case --**
 21 Q. This was a meeting about nuclear weapons.
 22 **A. Yes, in which case when they are talking about enriched**
 23 **uranium they would be talking about uranium which**
 24 **contains a very, very high proportion of U-235 and that**
 25 **U-234 would effectively be seen as a contaminant within**

Page 79

1 **that material.**
 2 **But the comment here, I think particularly relates**
 3 **to the fact that the specific activity, that is the**
 4 **activity per unit mass, so if you like the becquerel per**
 5 **kilogram of U-234 is about 3,000 times higher than the**
 6 **becquerels per kilogram of U-235, and I think that's**
 7 **probably what he's referring to here, that even if the**
 8 **proportion of U-234 was quite low, because the becquerel**
 9 **per kilogram of U-234 is so much higher than U-235 it**
 10 **would probably still be more important in terms of**
 11 **becquerels.**
 12 Q. Right, well there's more than that. It's not just that,
 13 it's about the quantity, as you said, the quantity of
 14 U-234 present.
 15 Now, when they extract U-235 from natural uranium
 16 they do it by mass, is that not correct? They separate
 17 it on the basis of its mass?
 18 **A. Yes.**
 19 Q. So when they separate the U-235 from the U-238 mix they
 20 would also get something that was even lighter than 235?
 21 **A. Yes.**
 22 Q. They would get all the U-234?
 23 **A. Yes.**
 24 Q. Do you know how much more -- what the ratio of U-234 to
 25 U-235 is?

Page 80

<p>1 A. I don't.</p> <p>2 Q. So would you disagree if I were to say it was about 20</p> <p>3 times U-234 to U-235?</p> <p>4 A. I would take your word for that if you tell me that</p> <p>5 that's correct.</p> <p>6 Q. All right. So it's possible that what Dr Morgan was</p> <p>7 talking about here was the fact that not only was it</p> <p>8 more radioactive but there was a lot more of it in the</p> <p>9 enriched uranium.</p> <p>10 In fact, if you look at the Bevis Parker, you've</p> <p>11 analysed the Bevis Parker gist and you find that there</p> <p>12 is a -- I mean, did you find that there was a lot of</p> <p>13 U-234 in the weapons' residues, that it represented</p> <p>14 quite a significant proportion in terms of its activity?</p> <p>15 A. Yes. There was significantly more in terms of total</p> <p>16 kilograms. So I'll just read out the figures which</p> <p>17 I think is probably the simplest way of answering your</p> <p>18 question.</p> <p>19 Q. That would be helpful.</p> <p>20 A. So this is total kilograms for all weapons based on the</p> <p>21 Bevis Parker data, which of course was an upper limit.</p> <p>22 So for uranium-238 it was approximately</p> <p>23 8,000 kilograms; for uranium-235 it was approximately --</p> <p>24 well, about 400 kilograms; and for uranium-234 it was</p> <p>25 approximately 10 kilograms.</p> <p style="text-align: center;">Page 81</p>	<p>1 A. I won't.</p> <p>2 MR JUSTICE BLAKE: Yes, can we move on to another topic?</p> <p>3 DR BUSBY: Yes, we can.</p> <p>4 There's one thing I want to go to which is the</p> <p>5 various routes that there were for exposure.</p> <p>6 MR JUSTICE BLAKE: You've finished with this document now,</p> <p>7 have you?</p> <p>8 DR BUSBY: Yes, I have, yes.</p> <p>9 MR JUSTICE BLAKE: We can close that one up. Pathways to</p> <p>10 exposure?</p> <p>11 DR BUSBY: Pathways to exposure, yes.</p> <p>12 MR JUSTICE BLAKE: Right.</p> <p>13 DR BUSBY: I don't intend to take you to any documents on</p> <p>14 this one. But I just want to go to some missing</p> <p>15 exposures and in particular one missing exposure.</p> <p>16 MR JUSTICE BLAKE: Right. So your report deals with</p> <p>17 pathways, I think, from page 16 -- well, you are dealing</p> <p>18 with various sources of information, aren't you?</p> <p>19 A. I am, and I discussed the various pathways which I've</p> <p>20 used in the report.</p> <p>21 MR JUSTICE BLAKE: Yes, right. Well, with that in mind</p> <p>22 I think it's going to be suggested that there's</p> <p>23 a pathway that was missing.</p> <p>24 A. Okay.</p> <p>25 MR JUSTICE BLAKE: Right. Which is that?</p> <p style="text-align: center;">Page 83</p>
<p>1 Q. Could you just tell us what that is in activity? Is</p> <p>2 that possible?</p> <p>3 A. In terms of total activity?</p> <p>4 Q. Well, if we could do the same for one bomb, I mean it</p> <p>5 would give us the same --</p> <p>6 A. I've got it in various units, kilogram per metre squared</p> <p>7 and things like that.</p> <p>8 Q. Becquerels is what we want.</p> <p>9 A. In terms of total becquerels the simplest thing might be</p> <p>10 if I just do that calculation.</p> <p>11 MR JUSTICE BLAKE: Well, if you haven't done it, don't do it</p> <p>12 now. You may have to do it at a later time.</p> <p>13 DR BUSBY: It would be unfair to ask you to do it now.</p> <p>14 MR JUSTICE BLAKE: I am not going to do it in the witness</p> <p>15 box.</p> <p>16 Do you really want that calculation, the total</p> <p>17 becquerel activity?</p> <p>18 DR BUSBY: Yes, we would like the total becquerel --</p> <p>19 MR JUSTICE BLAKE: Is that a calculation that you can</p> <p>20 perform for us if you are asked to do it?</p> <p>21 A. I can, my Lord.</p> <p>22 MR JUSTICE BLAKE: Can you do it over the short adjournment</p> <p>23 or something like that? Is that possible?</p> <p>24 A. It wouldn't take very long. I have all the data I need.</p> <p>25 MR JUSTICE BLAKE: Don't try and do it now.</p> <p style="text-align: center;">Page 82</p>	<p>1 DR BUSBY: Right. We were talking earlier about where all</p> <p>2 this stuff fell, and there's a lot of speculation about</p> <p>3 how much of it fell on the Island and how much of it</p> <p>4 fell in the sea and so on. But would you agree that</p> <p>5 a significant amount of it fell in the sea?</p> <p>6 A. That seems likely from various mechanisms, yes.</p> <p>7 Q. In fact, it's the Secretary of State's position that</p> <p>8 most of it fell in the sea.</p> <p>9 Now, you work at Sellafield and you've been involved</p> <p>10 in health physics at Sellafield. There have been a lot</p> <p>11 of papers and a lot of concerns about what's called</p> <p>12 sea-to-land transfer; is that right? Have you been</p> <p>13 involved in that at all?</p> <p>14 A. I've never been -- no, I've never been involved in that.</p> <p>15 Q. But do you agree that there is such a phenomenon and</p> <p>16 it's well characterised, well described?</p> <p>17 A. Yes. I mean I'm assuming what you mean is a combination</p> <p>18 of silt coming back or perhaps activity dissolved or</p> <p>19 suspended in seawater being what is called blown off the</p> <p>20 surface in terms of air activity, that kind of thing.</p> <p>21 Is that the sort of thing?</p> <p>22 Q. Yes, it's quite a specific phenomenon called sea-to-land</p> <p>23 transfer.</p> <p>24 MR JUSTICE BLAKE: Have you heard of this phenomenon called</p> <p>25 sea-to-land transfer?</p> <p style="text-align: center;">Page 84</p>

1 A. Yes, my Lord, in a general term, a general sense.
 2 DR BUSBY: Are you aware there have been many measurements
 3 made of plutonium, for example, along the coast of the
 4 Irish Sea in Cumbria?
 5 A. Yes, I am.
 6 Q. By distance from the sea?
 7 A. Yes.
 8 Q. Have you seen any of these? There's a paper by Eakins
 9 and Lally, a very famous one.
 10 A. If I have I can't remember, it would have been too long
 11 ago.
 12 Q. Yes, but you would agree that the phenomenon exists
 13 whereby radionuclides which are in the sea are brought
 14 ashore and are available for inhalation for people who
 15 live close to the sea within about 1 kilometres,
 16 2 kilometres, that sort of thing?
 17 A. Potentially, yes.
 18 Q. It would seem quite reasonable, anyway, quite plausible
 19 that such a thing would happen with small particles --
 20 MR JUSTICE BLAKE: There's a tendency to make statements
 21 rather than asking questions. I need to break it down
 22 so I have the answer.
 23 I think you just agreed -- do you agree with the
 24 proposition that you can get radionuclides in the sea
 25 transferred to land which can then result in inhalation

Page 85

1 or some other form of contact by humans when transferred
 2 to land?
 3 A. Yes, I do, my Lord, and yes, as a pathway as
 4 a principle.
 5 MR JUSTICE BLAKE: You agree with that pathway?
 6 A. Yes.
 7 MR JUSTICE BLAKE: Right.
 8 DR BUSBY: You were aware of this before you wrote this
 9 report?
 10 A. Yes, in general terms yes.
 11 Q. But you haven't included any of that in the report?
 12 A. No. I don't believe that it will be a significant
 13 pathway in comparison to the others. I didn't look at
 14 it specifically, no.
 15 MR JUSTICE BLAKE: Why was that then?
 16 A. Why didn't I look at it, my Lord? Because to be honest
 17 I didn't think about it. I didn't think about it
 18 specifically.
 19 MR JUSTICE BLAKE: Right.
 20 A. I am trying to consider now what the potential for that
 21 might be. It's difficult for me to make some sort of
 22 quantitative assessment in the witness box.
 23 My overall thought would be that the dilution of any
 24 activity falling into the sea would be considerable, it
 25 will be considerable and very rapid. The sea is a huge

Page 86

1 body of water and there's a lot of turbulence within
 2 that body of water, obviously, from wind, storms, that
 3 kind of thing, and currents, et cetera.
 4 Therefore my first reaction to that question would
 5 be that the activity would be dispersed within the
 6 seawater very quickly and particularly of course the
 7 fission products are also decaying very rapidly, by
 8 orders of magnitude within periods of days and weeks,
 9 and therefore the decay rate would also be very rapid.
 10 So the activity would have to come back to land quite
 11 quickly in order for it to be significant.
 12 My thoughts are that the dilution would probably be
 13 too great for that. But I haven't looked at it
 14 specifically and tried to quantify that. But it would
 15 also have to be greater than the level of contamination
 16 which I've assumed for the Island and, as I say, the
 17 level of contamination which I'd assumed across the
 18 whole Island at 16 megabecquerels per metre squared is
 19 a very high level and therefore again I would have
 20 thought that given the decay, given the dilution within
 21 that mass of seawater I would be surprised if it was
 22 a significant component.
 23 DR BUSBY: Do you agree that the sea-to-land transfer
 24 process is one in which materials in the sea are
 25 re-suspended, that is to say that they are brought

Page 87

1 ashore in the air? They are available for inhalation.
 2 So it's not a question of contamination of the ground
 3 and re-suspension co-efficients, it specifically
 4 produces a re-suspension. That is the process?
 5 A. I believe that is the case. Again you are moving beyond
 6 my expertise here in terms of the environmental
 7 expertise but I'm familiar with the concept of blow-off
 8 which I think is what you are referring to.
 9 Q. No, it's not quite that. But anyway, sea-to-land
 10 transfer, we can leave it at that. We don't need to go
 11 into the mechanisms.
 12 MR JUSTICE BLAKE: Do you know what you are just agreeing
 13 to?
 14 A. I'm not sure I do, my Lord.
 15 MR JUSTICE BLAKE: Sea-to-land transfer takes the form of
 16 suspended material that when it reaches land then
 17 becomes capable of inhalation. You just agreed with
 18 that.
 19 A. I think as a general statement I would, but now what I'm
 20 wondering is whether you're referring to some specific
 21 mechanism within that.
 22 DR BUSBY: No.
 23 A. It's just a general statement?
 24 Q. Yes.
 25 A. As a general statement, yes, I agree.

Page 88

<p>1 Q. Just a general statement, yes.</p> <p>2 Your response was not an expert response, you would</p> <p>3 agree, it was just your opinion?</p> <p>4 A. Yes, it's an opinion.</p> <p>5 Q. Right.</p> <p>6 A. And it's an opinion made in the witness box in the space</p> <p>7 of a few minutes.</p> <p>8 Q. And your opinion is also that this enormous amount of</p> <p>9 radioactivity from the explosions, including 8 tonnes or</p> <p>10 up to 8 tonnes of uranium as particles that would fall</p> <p>11 in the sea, they would just be dissipated and diluted</p> <p>12 and generally of no importance with regard to exposure</p> <p>13 at Christmas Island? That's your thought, your opinion?</p> <p>14 A. That's my first reaction. I mean, the activity from the</p> <p>15 detonations would clearly go -- from any large</p> <p>16 detonation, thermonuclear detonation, a lot of that</p> <p>17 activity is transferred into the stratosphere or into</p> <p>18 the high troposphere. These are layers in the</p> <p>19 atmosphere. From there they are dispersed over very</p> <p>20 large parts of the globe -- over the whole globe, in</p> <p>21 fact, and I'm sure that you are familiar with that</p> <p>22 principle.</p> <p>23 Some of that activity would presume -- well, it</p> <p>24 would have fallen in the sea, because of course we know</p> <p>25 from the experience with the Shackleton aircraft that</p> <p style="text-align: center;">Page 89</p>	<p>1 Christmas Island? Is that a possibility?</p> <p>2 MR HEPPINSTALL: I am not going to let Mr Hallard answer</p> <p>3 that question.</p> <p>4 MR JUSTICE BLAKE: Yes. You are being asked to speculate</p> <p>5 upon an unknown premise.</p> <p>6 A. I just don't know would be the answer.</p> <p>7 MR JUSTICE BLAKE: Right.</p> <p>8 DR BUSBY: Have we got the --? No, in that case we'll leave</p> <p>9 that.</p> <p>10 MR JUSTICE BLAKE: Yes.</p> <p>11 DR BUSBY: But you do -- well, we can leave this with what</p> <p>12 you've said so far which is that that was just</p> <p>13 a pathway --</p> <p>14 MR JUSTICE BLAKE: We have what he said, so if you want to</p> <p>15 move on to another topic that he can help you with.</p> <p>16 DR BUSBY: So that pathway wasn't one that you considered.</p> <p>17 Yes, there was one point about that before I leave</p> <p>18 it.</p> <p>19 Do you agree that that pathway has been suggested as</p> <p>20 a cause of the increase in childhood leukaemia near</p> <p>21 Sellafield? Do you remember that as a possible cause?</p> <p>22 MR JUSTICE BLAKE: Do you know about that?</p> <p>23 A. I think I couldn't comment on that, my Lord. I don't</p> <p>24 think I know enough about it. It would be well beyond</p> <p>25 my expertise. Any information I have on that would be</p> <p style="text-align: center;">Page 91</p>
<p>1 that aircraft flew through activity which was falling in</p> <p>2 light rain. But the distance, that was already many</p> <p>3 tens, over 100 kilometres I think from the Island, and</p> <p>4 therefore again we're talking about significant</p> <p>5 distances and huge bodies of water.</p> <p>6 That's what I have in mind when say that I wouldn't</p> <p>7 have thought as an initial reaction that it would be</p> <p>8 a significant pathway.</p> <p>9 Q. Would you agree that the Pacific Ocean has currents?</p> <p>10 A. Yes. I don't know anything about the currents but</p> <p>11 I would agree it's got currents.</p> <p>12 Q. A current means the water moves either to the west or</p> <p>13 the east or somewhere?</p> <p>14 A. Yes.</p> <p>15 Q. And if the material falls in the sea then the current</p> <p>16 will take it towards the land?</p> <p>17 A. I don't know enough about the currents in the Pacific.</p> <p>18 MR JUSTICE BLAKE: Depending which way the current is</p> <p>19 blowing, I would have thought. That's somewhat</p> <p>20 abstract, I'm afraid.</p> <p>21 DR BUSBY: We can --</p> <p>22 MR JUSTICE BLAKE: Well, no, if you have a particular</p> <p>23 question to put, put it.</p> <p>24 DR BUSBY: Is it possible that a current would have brought</p> <p>25 that material that fell in the sea ashore on</p> <p style="text-align: center;">Page 90</p>	<p>1 general and it would be based on memories from years</p> <p>2 ago. I think it would be --</p> <p>3 MR JUSTICE BLAKE: We don't want to do that.</p> <p>4 DR BUSBY: Fair enough, okay.</p> <p>5 Now, there was another pathway that was used by the</p> <p>6 Simon study of the Marshall Islanders and that was</p> <p>7 inadvertent ingestion and actually I think Mr Johnston</p> <p>8 in one of his reports uses an inadvertent ingestion of</p> <p>9 1 gram of material per day. This is just people, you</p> <p>10 know, biting their fingernails and --</p> <p>11 MR JUSTICE BLAKE: Well, what is inadvertent ingestion?</p> <p>12 DR BUSBY: Inadvertent ingestion is where you bite your</p> <p>13 fingernails or suck your lips or use teaspoons that are</p> <p>14 contaminated or whatever, and therefore you swallow soil</p> <p>15 or other material?</p> <p>16 A. Well, I have included an assessment for eating soil.</p> <p>17 Q. Oh, you have?</p> <p>18 A. Yes.</p> <p>19 Q. Oh, that would be inadvertent ingestion. So I must have</p> <p>20 missed that. Okay, sorry.</p> <p>21 We'll leave that one now.</p> <p>22 I'd like to now take you to the question of rainout</p> <p>23 and seawater entrainment because I think you have</p> <p>24 assumed that the -- well, I'm not sure if you're the</p> <p>25 right person to talk to about this actually -- perhaps</p> <p style="text-align: center;">Page 92</p>

<p>1 you are not -- but if I could ask you to look at the 2 statement by Archie Ross at SB9/140, and comment on -- 3 right we haven't got it. Okay. (Pause) 4 It rather has to do with this business of running 5 about with Geiger counters and so forth. 6 A. Okay. 140? 7 Q. Have you seen this document? Have you read this? 8 A. I don't believe so. I've seen that diagram. 9 Q. Right. 10 A. Now whether I've seen it -- or I've seen a similar 11 diagram, an equivalent diagram, whether I've seen it in 12 this or somewhere else. I don't recall this document 13 but I've read so many documents that I may have seen it 14 and simply forgotten. 15 Q. I deeply sympathise. Can I just go to paragraph 9 and 16 he says: . 17 "... about 20 minutes or so we returned to the Main 18 Camp ..." 19 A. Yes. 20 Q. "... changed into shorts and went to pick up the 21 transport." 22 Then he goes on to say that the port area where he 23 had been had been under torrential rain from the very 24 same clouds produced by the bomb. 25 So do you accept that Mr Ross actually saw that,</p> <p style="text-align: center;">Page 93</p>	<p>1 page 29, from recollection? As it happens, a topic I've 2 marked up, by some extraordinary coincidence? 3 A. Yes, thank you, my Lord. Yes, that's exactly it. 4 MR JUSTICE BLAKE: Yes, right. 5 So do we get anything more from this document, 6 Dr Busby, than we have in that report? 7 DR BUSBY: Yes, well perhaps not this one. I was going to 8 go to the entrainment point, Mr Fiddaman. I was going 9 to start with this one and then go to Derek Fiddaman's 10 witness statement from HMS Cossack, which is at 139. 11 MR JUSTICE BLAKE: We move on from tab 140. Right. 12 DR BUSBY: Well, it's one back from that, 139. 13 MR JUSTICE BLAKE: 139. When I say "move on", we go to 14 a different tab, perhaps, if that's better. Yes. 15 DR BUSBY: Yes. 16 MR JUSTICE BLAKE: Tab 139. 17 DR BUSBY: Well, I clearly didn't need to take you to the 18 Archie Ross statement because you accepted that. 19 The arguments have been put forward that that 20 rainfall was a result of -- 21 MR JUSTICE BLAKE: Well, I don't think Mr Ross or anyone 22 else is going to be able to tell us that, others will, 23 but rainfall you have. Now, what do you want from 139? 24 DR BUSBY: I want to go to the third bullet point here on 25 the second page.</p> <p style="text-align: center;">Page 95</p>
<p>1 that this is evidence that there was torrential rain 2 produced by the bomb or not? 3 A. Well, I mean, I think it's accepted that there was 4 torrential rain. 5 MR JUSTICE BLAKE: Well, I think that may be the point. 6 What's the question? 7 DR BUSBY: Does he accept that that is evidence that there 8 was rain at the -- 9 MR JUSTICE BLAKE: Well, I think his report deals with rain. 10 A. Yes, and Mr Stretch's report contains several eye 11 witnesses' evidence. In fact, that may be where I've -- 12 MR JUSTICE BLAKE: I think you do, about the chap who went 13 to dig a trench or something. 14 A. Yes, and that's in Mr Stretch's report. 15 DR BUSBY: So this was 20 minutes after the bomb. 16 MR JUSTICE BLAKE: Why don't you go to his report because 17 that may be a more useful starting point on this topic 18 to see whether you have anything new on this document 19 than was contained in the report? 20 DR BUSBY: I think probably in that case everybody has 21 accepted that there has been torrential rain -- 22 MR JUSTICE BLAKE: Well, his report is based upon that. 23 I think you've really got to bring this to focus upon 24 what this witness has told you about in his report. 25 I think I was reading it -- isn't it paragraph 14 at</p> <p style="text-align: center;">Page 94</p>	<p>1 MR JUSTICE BLAKE: Page 2? 2 DR BUSBY: The first page is "I Derek Fiddaman", dah-di-dah. 3 Over on page 2 there are a number of bullet points, and 4 I want to go to the third bullet point. 5 MR JUSTICE BLAKE: Have you read this one? 6 A. I have, my Lord. 7 MR JUSTICE BLAKE: Good. 8 DR BUSBY: Fiddaman was on a ship -- 9 MR JUSTICE BLAKE: Yes, well, what's the question? 10 DR BUSBY: The question is it says in this bullet point: 11 "The cloud was boiling red and black, and it seemed 12 as if the stork was sucking up the Pacific Ocean." 13 Then various other things he said, terrifying, and 14 so forth. 15 MR JUSTICE BLAKE: What's the question? 16 DR BUSBY: Do you accept that this particular explosion 17 resulted in the entrainment of seawater? 18 MR JUSTICE BLAKE: Can you comment on that? 19 A. I can't, my Lord. I mean, I've read a considerable 20 amount of debate about that, particularly Mr Johnston's 21 reports. 22 MR JUSTICE BLAKE: Right. You've seen the debate about it. 23 Can you add to that debate from your own personal 24 expertise? 25 A. No, my Lord.</p> <p style="text-align: center;">Page 96</p>

<p>1 MR JUSTICE BLAKE: Right. I don't think we are going to get 2 any information from the witness on that topic. 3 DR BUSBY: Right. I asked a question, did I not? No. 4 A. Sorry -- 5 MR JUSTICE BLAKE: His answer is he can't assist you on the 6 question of entrainment by rainwater. 7 DR BUSBY: No, all right. 8 MR JUSTICE BLAKE: He's seen the information by the experts 9 on that topic and he can't add to it. 10 DR BUSBY: Okay. 11 MR JUSTICE BLAKE: Have we finished with SB9? 12 DR BUSBY: Yes, we've finished with that now, thank you. 13 We'll now go to photoelectrons, Professor Howard's 14 report, SB1/2.4. 15 MR JUSTICE BLAKE: SB1/2.4. 16 DR BUSBY: SB2/2.4? 17 A. SB2 or SB1? 18 MR JUSTICE BLAKE: No, it's SB1, it's 2.4 (Pause) It's SB1, 19 tab 2.4. For some reason we have a number of tabs in 20 bundle 1 and there they are. 21 Which page of Professor Howard? 22 DR BUSBY: Page 6, my Lord. 23 MR JUSTICE BLAKE: Right. Do you have page 6? 24 A. Yes, my Lord. 25 MR JUSTICE BLAKE: Fig 1, "photoelectron tracks"?"</p> <p style="text-align: center;">Page 97</p>	<p>1 A. It's emitted in the form of a beta particle. Well, to 2 all intents and purposes, it's a beta particle. It's 3 actually an electron from the atom, from the outer 4 shells of the atom, which is ejected from the atom. 5 Q. It's not a beta particle? 6 A. It's not a beta particle, because strictly beta 7 particles are produced in the nucleus but, unless you 8 knew what the source is, you would not be able to 9 distinguish it from a beta particle. 10 Q. Well, perhaps we could call it a photoelectron? 11 A. Yes, okay, call it a photoelectron, yes. 12 Q. But it is indistinguishable from a beta particle? 13 A. Yes, but -- 14 Q. So its effect on tissue would be the same as the effect 15 of a beta particle on tissue? 16 A. A beta particle of the same energy. 17 Q. Identical, in fact, yes. 18 So if you had, instead of one safety pin or a large 19 item of lead inside you that you could image, you had 20 lots of small items, the same effect would occur? 21 A. Yes. 22 Q. Correct? In fact, it would occur to a greater extent, 23 the smaller the size of the piece of material; correct? 24 A. Are you talking about small particles now? 25 Q. I am just trying to ask you if some of the energy --</p> <p style="text-align: center;">Page 99</p>
<p>1 A. Yes. 2 DR BUSBY: First of all, you were trained as a physicist? 3 A. Yes. 4 Q. So you understand the photoelectric effect? 5 A. I understand the photoelectric effect. 6 Q. You understand that elements of high atomic number have 7 a much higher ability to intercept radiation? 8 A. That's why lead is a good shield. 9 Q. Exactly, and in fact uranium is used also as shielding? 10 A. Uranium is a good shield as well. 11 Q. Yes. So if you had uranium inside you or lead inside 12 you and you were X-rayed that would intercept the 13 radiation, so you could see that as an image; correct? 14 A. Yes. 15 Q. That's why if you have -- 16 A. If -- 17 MR JUSTICE BLAKE: Yes. 18 A. -- to qualify that slightly, if you had a large enough 19 piece to be able to see it on an x-ray then you would 20 see it, and clearly it would stop the X-rays and 21 therefore it would be visible. If that's what you mean, 22 then the answer is yes. 23 Q. Yes. So where does the energy go when the X-ray or the 24 gamma ray hits the piece of uranium or lead that's 25 inside you? What happens to the energy?</p> <p style="text-align: center;">Page 98</p>	<p>1 let's put it like this -- some of the energy would be 2 lost because the beta particles or the photoelectrons 3 wouldn't get out of the -- 4 A. Ah, yes, if the piece of lead or piece of uranium in 5 this case was big enough such that the beta particles 6 couldn't get out then that's true, but if it was at 7 micron levels, or whatever, or smaller than that, then 8 I don't think the size of the particle would make much 9 difference. 10 Q. No. So in fact all of the energy that's absorbed by 11 these particles of lead, shall we say, would come out as 12 beta particles? 13 A. Yes. 14 Q. So somebody standing in the environment and receiving a 15 gamma radiation dose from natural background would have 16 more photoelectrons or beta particles, if you like, in 17 their body than if they didn't have these particles 18 inside them? 19 A. Sorry, can you just repeat the question? 20 Q. The hypothetical person that has these smaller pieces of 21 lead inside them now, and who was just living, like all 22 of us, being exposed to background radiation, gamma 23 radiation, they would have a bigger dose from 24 photoelectrons inside them, or beta particles inside 25 them, there would be more beta particles inside them</p> <p style="text-align: center;">Page 100</p>

<p>1 than if they didn't have the lead particles inside them?</p> <p>2 A. Yes, but the extent of that enhanced dose clearly would</p> <p>3 depend on how much uranium there was.</p> <p>4 Q. Or the number of particles there was?</p> <p>5 A. Yes, that's what I mean.</p> <p>6 Q. Yes. Of course.</p> <p>7 Is it fair to say -- I mean, can you tell me if the</p> <p>8 ICRP risk model takes into consideration any of these</p> <p>9 effects relating to particles of uranium or lead or</p> <p>10 platinum, or any highly-absorbing or radiation-blocking</p> <p>11 material?</p> <p>12 A. Again, you're going beyond my expertise because you are</p> <p>13 getting into the internal dosimetry. I'm not aware that</p> <p>14 it does, and from general comments I've heard,</p> <p>15 I think -- I'd better not because I'm getting into</p> <p>16 a field which I think is going beyond my expertise.</p> <p>17 MR JUSTICE BLAKE: You can't comment.</p> <p>18 A. I can't comment on the internal dosimetry aspects,</p> <p>19 my Lord. So I cannot answer that specific question.</p> <p>20 DR BUSBY: But as a physicist do you agree that all of the</p> <p>21 things that I've said so far you would agree with?</p> <p>22 A. Yes.</p> <p>23 Q. About the beta particles being the same as the</p> <p>24 photoelectrons --</p> <p>25 A. Of the same energy.</p> <p style="text-align: center;">Page 101</p>	<p>1 about went up?</p> <p>2 A. That you would get more beta particles --</p> <p>3 Q. Yes, more beta particles --</p> <p>4 A. Yes, I would accept that.</p> <p>5 MR JUSTICE BLAKE: Give him a chance to answer. Yes.</p> <p>6 What's the answer? Because I haven't got an answer now.</p> <p>7 A. The answer is yes, my Lord.</p> <p>8 So that you would expect to see more photoelectrons,</p> <p>9 as Dr Busby refers to them, you would expect to see</p> <p>10 significantly more photoelectrons from uranium than you</p> <p>11 would from gold, than you would from oxygen, the last</p> <p>12 one.</p> <p>13 MR JUSTICE BLAKE: Yes.</p> <p>14 A. It's a light element, anyway. I think it was oxygen.</p> <p>15 DR BUSBY: Yes, oxygen would be the component of the water</p> <p>16 that would be mostly responsible, you agree?</p> <p>17 A. There is a specific relationship between what is known</p> <p>18 as the atomic number, which is the number of protons in</p> <p>19 the nucleus and also the number of electrons orbiting</p> <p>20 the nucleus. That's called the atomic number.</p> <p>21 MR JUSTICE BLAKE: Yes.</p> <p>22 A. And the probability of a gamma ray being absorbed by the</p> <p>23 photoelectric effect is approximately the atomic number</p> <p>24 raised to the power of 4.</p> <p>25 MR JUSTICE BLAKE: Yes.</p> <p style="text-align: center;">Page 103</p>
<p>1 Q. -- and the gamma radiation background causing some</p> <p>2 increase in beta particles, if you like, than there</p> <p>3 would be if there was nothing inside you?</p> <p>4 A. Yes.</p> <p>5 Q. Yes. So we can't quantify it, but the general effect is</p> <p>6 acceptable physics in your --</p> <p>7 A. Yes. The photoelectric effect is one of several means</p> <p>8 in which gamma is absorbed by atoms.</p> <p>9 Q. Yes. In fact, that is -- yes.</p> <p>10 MR JUSTICE BLAKE: Right. We have that answer.</p> <p>11 DR BUSBY: Now, if we look at this picture, figure 1 here,</p> <p>12 which was provided by Professor Howard, the consequence</p> <p>13 of research that he's carried out at the University of</p> <p>14 Ulster. Have you seen this picture before?</p> <p>15 A. I have, yes.</p> <p>16 Q. Yes. So what this picture shows are three types of</p> <p>17 photoelectron emissions from water on the left, gold in</p> <p>18 the middle and a uranium particle on the right-hand</p> <p>19 side.</p> <p>20 A. Yes.</p> <p>21 Q. Do you accept that the results of this -- you know, that</p> <p>22 this shows approximately the kind of thing that we're</p> <p>23 talking about? Let's not get involved in qualitative,</p> <p>24 but just qualitatively is it what you would expect as</p> <p>25 the atomic number of the element that we're talking</p> <p style="text-align: center;">Page 102</p>	<p>1 A. It varies slightly, but what that means is that you then</p> <p>2 get a significant higher absorption of gamma in big</p> <p>3 atoms like uranium or like lead than you get in small</p> <p>4 atoms like oxygen.</p> <p>5 MR JUSTICE BLAKE: And does this phenomenon have an impact</p> <p>6 upon your calculations?</p> <p>7 A. I don't believe so, my Lord.</p> <p>8 MR JUSTICE BLAKE: Why is that?</p> <p>9 A. I've read a paper -- again, we're getting into the</p> <p>10 internal dosimetry, and in terms -- and the dose</p> <p>11 co-efficient that I've used is the ICRP dose</p> <p>12 co-efficient for uranium, for example.</p> <p>13 MR JUSTICE BLAKE: Well --</p> <p>14 A. But two more specific answers to your question, I think.</p> <p>15 I've read a paper -- two papers -- produced by</p> <p>16 Public Health England looking precisely at this effect.</p> <p>17 Although it's a while since I've read them, I think</p> <p>18 their final conclusion was they concluded that the dose</p> <p>19 from the alpha emissions from the uranium was more</p> <p>20 important than the beta emissions from this.</p> <p>21 MR JUSTICE BLAKE: Yes.</p> <p>22 A. But I think the other thing -- this more a qualitative</p> <p>23 statement -- it does very much depend on the -- in this</p> <p>24 case it would be the mass of uranium in the body rather</p> <p>25 than the activity.</p> <p style="text-align: center;">Page 104</p>

<p>1 Now, I'm not going to the point here of the uranium 2 sticking to the DNA because that's beyond my expertise, 3 and there's obviously been a debate on that. So I'm 4 just talking about the uniform distribution of uranium 5 throughout the body. There would need to be a lot of 6 uranium in the body for the number of beta particles 7 emitted from the uranium to be more than the other 8 carbon and oxygen atoms in the body, because although 9 the number of beta particles from those atoms is a lot 10 less, in this relationship to the power of 4, because, 11 for example -- perhaps I'll not go into the maths.</p> <p>12 MR JUSTICE BLAKE: Right, okay. That completes your answer, 13 does it?</p> <p>14 A. Yes.</p> <p>15 But in general terms my feeling is that there are so 16 many more atoms, that the proportion of the oxygen atoms 17 in the body are so much higher than the proportion of 18 the uranium atoms, unless there was a lot of uranium, 19 that the oxygen atoms would still tend to dominate.</p> <p>20 MR JUSTICE BLAKE: Yes.</p> <p>21 DR BUSBY: But you agree that you're not an expert in this 22 area?</p> <p>23 A. I'm certainly not an expert on the dosimetry side of it.</p> <p>24 Q. I just wanted you to agree that the process itself, as 25 you very --</p> <p style="text-align: center;">Page 105</p>	<p>1 A. Okay.</p> <p>2 Q. You didn't include any estimation of the doses from 3 carbon-14. Why was that?</p> <p>4 A. I felt it was outside my expertise to too great 5 an extent.</p> <p>6 MR JUSTICE BLAKE: When you say it's outside your 7 expertise --?</p> <p>8 A. Yes, my Lord, and I couldn't find any information which 9 I felt was helpful enough. Perhaps more recently --</p> <p>10 MR JUSTICE BLAKE: Information on what?</p> <p>11 A. Carbon-14.</p> <p>12 MR JUSTICE BLAKE: And its relevance to these calculations?</p> <p>13 A. Yes, it's relevance to -- I haven't produced any 14 assessment of dose based on carbon-14. I looked at it. 15 I have produced one for tritium, which has very high 16 levels of uncertainty, but when it came to carbon-14 17 I looked at it and just felt that I couldn't produce 18 an assessment of the dose.</p> <p>19 I have seen more recent information --</p> <p>20 MR JUSTICE BLAKE: But did you -- is that fact a fact you 21 have mentioned in your report?</p> <p>22 A. Yes, my Lord.</p> <p>23 MR JUSTICE BLAKE: Do you think that invalidates your report 24 in some respect?</p> <p>25 A. Well, it means that there a nuclide for which I've not</p> <p style="text-align: center;">Page 107</p>
<p>1 A. The process itself and the relationship, the power 4 2 relationship, approximately, power 4.</p> <p>3 Q. -- you very helpfully answered that question with regard 4 to the general process as a physicist.</p> <p>5 A. Yes.</p> <p>6 Q. Thank you.</p> <p>7 Just to be sure, the reason that you didn't -- 8 I thought you said, but just to be sure -- the reason 9 that you didn't use any consideration of this 10 photoelectron effect was because you used the ICRP 11 model, which doesn't consider it at all?</p> <p>12 A. Yes, I used the ICRP model, which I think I said 13 I couldn't answer the question on whether it actually 14 includes this or not, because I'm not sure and I would 15 have to speculate, effectively.</p> <p>16 MR JUSTICE BLAKE: Well, don't do that. Anyway, that's your 17 answer. We have the answer.</p> <p>18 A. That's my answer.</p> <p>19 MR JUSTICE BLAKE: Okay.</p> <p>20 A. And the papers by Tanner and Eakins also indicate that 21 alpha is more important.</p> <p>22 MR JUSTICE BLAKE: Right.</p> <p>23 DR BUSBY: Right. I think that's all we need to do about 24 photoelectrons.</p> <p>25 I just want to ask you now about carbon-14.</p> <p style="text-align: center;">Page 106</p>	<p>1 felt able to estimate a dose and I was disappointed by 2 that. But I just felt that I didn't have sufficient 3 information or sufficient expertise to be able to make 4 any kind of assessment on it.</p> <p>5 MR JUSTICE BLAKE: Right.</p> <p>6 DR BUSBY: Would you agree that carbon-14 is an extremely 7 important radiological hazard?</p> <p>8 A. It is. It's perhaps worth mentioning, I mean I nearly 9 mentioned it a moment ago but I thought better of it. 10 There is information on carbon-14 in one of the -- well, 11 two of the annexes to an UNSCEAR report, the UNSCEAR 12 2000 report, if my memory serves me correctly. I think 13 it's annex A and annex C, which I've read quite 14 carefully.</p> <p>15 MR JUSTICE BLAKE: Well, as a result of reading those 16 reports, does that give any information about the answer 17 you've just given us?</p> <p>18 A. There is a figure in annex C -- and again I need to be 19 very careful here because I've already gone beyond my 20 expertise --</p> <p>21 MR JUSTICE BLAKE: Well, at the moment the topic of 22 carbon-14 has come up.</p> <p>23 A. Yes.</p> <p>24 MR JUSTICE BLAKE: The answers I have from you: "I didn't 25 consider it. Outside my expertise. Yes, it is</p> <p style="text-align: center;">Page 108</p>

<p>1 an important radiological element." 2 A. Yes. 3 MR JUSTICE BLAKE: I sort of rather tried to draw your 4 answers on the relevant questions before us as to 5 whether that weakens, invalidates, your report in some 6 respect. To which the answer is? 7 A. It certainly weakens the report because there is 8 a nuclide which I've not attempted to estimate a dose 9 for. There is a figure. 10 MR JUSTICE BLAKE: Yes. 11 A. There is a figure, I think in the UNSCEAR annex C, 12 a figure -- two figures, in fact -- figures 10 and 11, 13 if my memory serves me correctly. With a great deal of 14 caution about my lack of expertise in this area, which 15 is considerable, there is an implication from those 16 figures that the short-term dose from carbon-14 may be 17 a factor of 2 to 3 greater than tritium. 18 That, I'm afraid, is the absolute best that I can 19 do, and even then I've gone well beyond my expertise, so 20 I do that with some considerable caution. 21 MR JUSTICE BLAKE: Right. Well, do you want to ask any 22 further questions on this topic? 23 DR BUSBY: Well, you said that it weakens your report. You 24 accepted that it weakens your report because you left 25 out one of the nuclides that you could possibly put in.</p> <p style="text-align: center;">Page 109</p>	<p>1 understood term. 2 MR JUSTICE BLAKE: M-O-L-L? 3 A. M-O-L-E. 4 MR JUSTICE BLAKE: Oh, L-E. 5 A. Yes, like the animal. 6 MR JUSTICE BLAKE: Like the animal as opposed to something 7 else. Mm-hm. 8 A. Yes. I think the simplest way to explain it -- it's a 9 concept that causes a lot of confusion -- that there is 10 a number, so-called avogadro's number -- 11 MR JUSTICE BLAKE: Well look, I don't particularly want to 12 receive a general lecture on this at the moment. 13 A. I beg your pardon, my Lord. 14 MR JUSTICE BLAKE: I am just trying to see how far this 15 relates to the issues in your report that are relevant 16 to our case. 17 A. Okay. 18 MR JUSTICE BLAKE: You have a gist from Johnston and 19 Regan -- 20 A. Yes. 21 MR JUSTICE BLAKE: -- 1500 plus or minus mole. Is that 22 a quantity? 23 A. That's a quantity. 24 MR JUSTICE BLAKE: You understand what the quantity is? 25 A. Yes, my Lord. So it's about -- so the upper limit would</p> <p style="text-align: center;">Page 111</p>
<p>1 But it's not just any old nuclide, is it? It's 2 generally conceded. Because we are all made of carbon, 3 I think, that's the point, to be an extremely, 4 potentially, serious exposure. 5 A. Again, with the caveat that this is well outside my 6 expertise, and I'm relying really on the information 7 from the two UNSCEAR annexes in this, I believe that the 8 dose from carbon -- the half life of carbon-14 is long, 9 about 5,700 years. Approximately 6,000 years. The dose 10 from carbon-14 is actually accumulated over long periods 11 rather than short periods, because of the half life and 12 the way that it's dealt with within the body. 13 But I really don't feel I could go beyond that 14 because, again, I feel very uncomfortable about my lack 15 of expertise in this area and therefore drawing specific 16 conclusions. 17 Q. There was an awful lot of carbon-14 produced in those 18 explosions; correct? 19 A. There was a significant amount. It's actually contained 20 in the -- there was a gist -- another gist, agreed 21 between Mr Johnston and Professor Regan, and that has 22 an estimate for the amount of carbon-14 produced from 23 the weapons. I think it said that there was something 24 like 1500, plus or minus 500 moles. Now, I'll just 25 explain the term "mole" because it's not a commonly</p> <p style="text-align: center;">Page 110</p>	<p>1 be 2,000 moles, from memory. 2 MR JUSTICE BLAKE: Upper limit of? 3 A. Of the carbon-14. 4 MR JUSTICE BLAKE: Released by one explosion, or a whole 5 lot? 6 A. I would need to check on that, my Lord. I think it's 7 the whole lot, but I would need to check on it. 8 MR JUSTICE BLAKE: Perhaps you could check. I mean, is this 9 an irrelevant question? Is this is a line of inquiry 10 you are pursuing? 11 DR BUSBY: I think we've got all we need out of this, 12 my Lord. 13 MR JUSTICE BLAKE: I am just trying to find out what you are 14 pursuing and what the answer is. 15 DR BUSBY: I only had one more question on this, was whether 16 it was included in the mix, in the Carter table that you 17 used for your mix of nuclides that emerged -- 18 A. No, it wasn't. 19 Q. So Carter didn't use it either? 20 A. No. I think it's principally -- no, no, he didn't use 21 it. 22 Q. Did Carter use tritium? 23 MR JUSTICE BLAKE: It's one o'clock. Is this the last 24 question on this topic? 25 DR BUSBY: Yes, it is.</p> <p style="text-align: center;">Page 112</p>

<p>1 MR JUSTICE BLAKE: Right. So Carter didn't use --</p> <p>2 A. Carter didn't use tritium because tritium is mainly</p> <p>3 produced in thermonuclear detonations.</p> <p>4 DR BUSBY: I have one more question and then we can leave it</p> <p>5 at that, my Lord. If that's all right with you? If</p> <p>6 I can creep over the line by --</p> <p>7 MR JUSTICE BLAKE: Ask your last question. I thought I'd</p> <p>8 identified that was the last question, but it was the</p> <p>9 penultimate one, was it? What's the last question,</p> <p>10 then?</p> <p>11 DR BUSBY: Well, is this on this subject or generally?</p> <p>12 MR JUSTICE BLAKE: On the topic before we break for lunch.</p> <p>13 DR BUSBY: Oh, I see, right. Yes, it is. We can break for</p> <p>14 lunch.</p> <p>15 MR JUSTICE BLAKE: I'm sorry, I'm losing the sense of</p> <p>16 whether we're having a sensible exchange here.</p> <p>17 I thought we were just bringing this topic of carbon to</p> <p>18 a close, and you said you had one last question and then</p> <p>19 another last question. But have you concluded the topic</p> <p>20 of carbon?</p> <p>21 DR BUSBY: Yes.</p> <p>22 MR JUSTICE BLAKE: And tritium?</p> <p>23 DR BUSBY: Yes, my Lord.</p> <p>24 MR JUSTICE BLAKE: We'll leave it there. Thank you. We</p> <p>25 will come back at the two o'clock. I'll just have</p> <p style="text-align: center;">Page 113</p>	<p>1 (1.05 pm)</p> <p>2 (The short adjournment)</p> <p>3 (2.00 pm)</p> <p>4 DR BUSBY: After some discussion over lunch, my Lord, we've</p> <p>5 decided that we won't have any further questions for</p> <p>6 Mr Hallard.</p> <p>7 MR JUSTICE BLAKE: Oh right.</p> <p>8 DR BUSBY: I think Mr Hallard was going to tell us the</p> <p>9 result of some calculation.</p> <p>10 MR JUSTICE BLAKE: I think he was. I am anxious with</p> <p>11 anticipation. You've been doing some calculations?</p> <p>12 A. I have.</p> <p>13 MR JUSTICE BLAKE: Right. So what do we have?</p> <p>14 A. Right, these are the total activities for the three</p> <p>15 nuclides. Uranium-238, the total activity -- these are</p> <p>16 approximate -- total activity is about 1 times 10 to the</p> <p>17 11 becquerels.</p> <p>18 MR JUSTICE BLAKE: Yes.</p> <p>19 A. Uranium-235 is about 3 times 10 to the 10 becquerels,</p> <p>20 and uranium-234 is about 2 times 10 to the</p> <p>21 12 becquerels.</p> <p>22 MR JUSTICE BLAKE: 2 times 10 to the 12 becquerels?</p> <p>23 A. Yes, my Lord.</p> <p>24 MR JUSTICE BLAKE: Thank you.</p> <p>25 DR BUSBY: Good, thank you.</p> <p style="text-align: center;">Page 115</p>
<p>1 a quick conversation about timing now. So please go.</p> <p>2 I think -- was there anything that we wanted to</p> <p>3 calculate? The becquerel --</p> <p>4 THE WITNESS: Ah yes.</p> <p>5 MR JUSTICE BLAKE: -- of uranium?</p> <p>6 THE WITNESS: The total number of becquerels of uranium.</p> <p>7 MR JUSTICE BLAKE: I think that remained a potentially</p> <p>8 relevant answer.</p> <p>9 THE WITNESS: I will do that, my Lord. It won't take very</p> <p>10 long.</p> <p>11 MR JUSTICE BLAKE: Thank you.</p> <p>12 (The witness withdrew)</p> <p>13 MR JUSTICE BLAKE: Right. We are going to have to stop this</p> <p>14 afternoon at 4.15. You will have completed your</p> <p>15 cross-examination by then?</p> <p>16 DR BUSBY: I'm very nearly finished, my Lord.</p> <p>17 MR JUSTICE BLAKE: The whole cross-examination?</p> <p>18 DR BUSBY: Yes.</p> <p>19 MR JUSTICE BLAKE: I see. I mean, I was asking about</p> <p>20 questions to find a convenient moment to pause for</p> <p>21 lunch. Okay. Well, then let's see how we go.</p> <p>22 DR BUSBY: I will just be discussing some issues --</p> <p>23 MR JUSTICE BLAKE: Fine, fine, fine, we'll take the lunch</p> <p>24 break and see how we go.</p> <p>25 DR BUSBY: Yes, my Lord.</p> <p style="text-align: center;">Page 114</p>	<p>1 MR JUSTICE BLAKE: Right.</p> <p>2 DR BUSBY: Thank you for your patience.</p> <p>3 A. I'm sorry?</p> <p>4 DR BUSBY: Thank you for your patience.</p> <p>5 MR JUSTICE BLAKE: I think that completes -- we had a nice</p> <p>6 photograph but we didn't go there.</p> <p>7 MR HEPPINSTALL: We didn't get there.</p> <p>8 MR JUSTICE BLAKE: Right.</p> <p>9 MR HEPPINSTALL: Does the Tribunal have any questions before</p> <p>10 I re-examine?</p> <p>11 MR JUSTICE BLAKE: We did have some. Would you prefer us to</p> <p>12 put those now?</p> <p>13 MR HEPPINSTALL: Yes.</p> <p>14 MR JUSTICE BLAKE: Sometimes it may be and sometimes it is</p> <p>15 not.</p> <p>16 Let me just deal with one topic and then my</p> <p>17 colleagues can decide.</p> <p>18 Questions from the Tribunal</p> <p>19 MR JUSTICE BLAKE: Yesterday, we were dealing with the</p> <p>20 Shackleton results.</p> <p>21 A. Ah yes.</p> <p>22 MR JUSTICE BLAKE: And you helpfully took us through the</p> <p>23 chart and explained that. I began to understand that.</p> <p>24 You provided the blow-up chart.</p> <p>25 A. Yes.</p> <p style="text-align: center;">Page 116</p>

<p>1 MR JUSTICE BLAKE: You cite reference 14 for information at 2 the time about the Shackleton results in your evidence. 3 A. Ah yes. 4 MR JUSTICE BLAKE: Yes? 5 A. Yes. 6 MR JUSTICE BLAKE: You are looking very blank there. 7 A. I was trying to remember what reference 14 was, but 8 I think I can remember. 9 MR JUSTICE BLAKE: I'll tell you what it is, if necessary. 10 Well, I will tell you what it is. Let's turn it up now. 11 Well, let's turn up your report on it. It is easier to 12 pose the question when we have the report in front of 13 us. 14 A. I think I actually have that reference with me, my Lord, 15 if you wish me to get information out of it. 16 MR JUSTICE BLAKE: That might be helpful. I am setting the 17 scene but I will pose a question. 18 A. Yes. 19 MR JUSTICE BLAKE: It's Jones and others and the reference 20 is at page 280 of the paper. You deal with it at 21 page 72 of 285, yes? Let's go to page 72. 22 A. Right, yes, and I have actually got that reference with 23 me if we need it. 24 MR JUSTICE BLAKE: Okay, (iv). You tell us here, and it 25 was the topic that you explained:</p> <p style="text-align: center;">Page 117</p>	<p>1 explosion -- the previous Grapple was about nine months 2 beforehand? 3 A. It was. It was the previous year, the end of the 4 previous year. 5 MR JUSTICE BLAKE: Yes, so question mark what might have 6 been the source of that contamination? Let me ask the 7 question that may be relevant to you, and it may be that 8 it evaporates so it don't get there. But if there was 9 another pre-existing source of contamination, is that 10 something that you have to take into account when 11 assessing contamination pathways on Christmas Island? 12 A. No. To answer that final question, my Lord, no, it 13 isn't. 14 MR JUSTICE BLAKE: Right. 15 A. As I recall, and I can go to the reference if that would 16 help -- 17 MR JUSTICE BLAKE: Well, if we deal with the question then 18 we'll see whether we need to go back. 19 A. Okay. 20 MR JUSTICE BLAKE: I've given you all that information so 21 you have the context and then what the direct question 22 is. 23 A. I think if my memory serves me correctly, my Lord, it 24 was a similar source, they were flying earlier in the 25 day and experienced light rain. The big difference was</p> <p style="text-align: center;">Page 119</p>
<p>1 "The aircraft is therefore assumed to have already 2 been contaminated before take-off." 3 A. Yes, my Lord. 4 MR JUSTICE BLAKE: Now I appreciate you have got that 5 information from reference 14. 6 A. Yes. 7 MR JUSTICE BLAKE: Jones and others, rather than -- you 8 weren't there -- 9 A. Yes. 10 MR JUSTICE BLAKE: But from what you understand, and 11 I haven't read the reference, was the hypothesis of 12 prior contamination a hypothesis of contamination before 13 the explosion that was being investigated on that day? 14 It wasn't an earlier flight, H plus three hours or H 15 plus four hours? 16 A. No, as I recall it was still after the original Grapple 17 Y detonation, but it was for other maritime 18 reconnaissance and security operations before this 19 specific survey. 20 MR JUSTICE BLAKE: Right. I mean -- 21 A. So it was earlier in the same day, I believe. 22 MR JUSTICE BLAKE: Earlier in that same day? 23 A. Yes. 24 MR JUSTICE BLAKE: But I think my colleagues who have 25 a better grasp of the chronology, there was no other</p> <p style="text-align: center;">Page 118</p>	<p>1 that they were not making radiation measurements earlier 2 in the day and therefore there would have been nothing 3 to indicate that they had flown through fallout 4 contamination. Whereas later in the day -- this was 5 approximately seven hours after the detonation -- they 6 were specifically doing radiation -- they were 7 specifically measuring the radiation downwind of the 8 detonation. 9 MR JUSTICE BLAKE: All right. Well, if I understand that 10 answer then that may have dealt with a question which 11 was in the preceding background-setting questions. 12 Does that mean they flew out through the same 13 explosion earlier that day or a -- 14 A. That's my recollection, my Lord, that they flew out 15 through a similar contaminated light rain. 16 MR JUSTICE BLAKE: Right. So I think when I actually put to 17 you earlier, therefore, was the flight something like H 18 plus 1, 2, 3, 4, 5 or 6 hours, the answer would be yes? 19 A. Yes, it was. It was about seven hours, I believe. 20 MR JUSTICE BLAKE: The one we're dealing with is seven 21 hours. The previous contamination, where did that come 22 from? 23 A. From the same detonation. 24 MR JUSTICE BLAKE: Right. So, after that detonation, but 25 not seven hours after?</p> <p style="text-align: center;">Page 120</p>

<p>1 A. That's correct. 2 MR JUSTICE BLAKE: So a flight between the detonation and 3 seven hours? 4 A. That's my recollection, my Lord. 5 MR JUSTICE BLAKE: Right. So it's the same source? 6 A. Yes. 7 MR JUSTICE BLAKE: So we don't have to therefore look for 8 another contaminant? 9 A. No. 10 MR JUSTICE BLAKE: Right. 11 DR RAYNER: It will be really helpful for us if you could 12 just go through some of your calculations to help us 13 understand how exactly -- I am not going to go into the 14 detail. 15 A. Okay. 16 DR RAYNER: So if we look at your revised dose assessment 17 for Mr Abdale, for example, so this is page 67 of your 18 revised report. Do you have that? 19 A. This is for Mr Abdale? 20 DR RAYNER: Yes. 21 A. Right. 22 DR RAYNER: Okay? So first of all if you could just talk us 23 through how you come to those figures for the total 24 external dose. Because yesterday I think you explained 25 how we work out from absorbed dose to equivalent dose to</p> <p style="text-align: center;">Page 121</p>	<p>1 DR RAYNER: I need to know now what you timesed it by. 2 A. Then, right, so that is one component. 3 The other principal component is something -- it's 4 not often done, but I've done it here because I wanted 5 to make sure that I'd got an upper limit. 6 The other main component is I've taken the skin 7 dose, which I've estimated to be 22 millisieverts, and 8 I've then multiplied that by the tissue weighting factor 9 for skin, which is 0.01, to get an effective dose to the 10 skin. And, again, I could expand on that. That isn't 11 normally done, but I wanted to make sure that there was 12 no component that I'd missed here. 13 And that would be based on the assumption that all 14 of the skin was contaminated rather than just 15 a proportion of the skin which is more common. 16 DR RAYNER: So can I just clarify that I've understood what 17 you've said. 18 A. Right. 19 DR RAYNER: The equivalent dose timesed by the tissue 20 weighting factor comes to the effective dose? 21 A. Yes. 22 DR RAYNER: You agree. So what you've done is you've 23 timesed it by the tissue weighting factor of skin and 24 then added a bit? 25 A. Well, I've added that to the effective dose from the</p> <p style="text-align: center;">Page 123</p>
<p>1 effective dose. 2 A. Yes. 3 DR RAYNER: So if you could just give us an idea of how you 4 got to the total equivalent dose? 5 A. Okay. (Pause). 6 Sorry, I am just struggling to find the page that 7 I was looking for. There we go. 8 MR JUSTICE BLAKE: The Abdale page. 9 A. Yes. I was just also just making sure I got all the 10 components that went into that figure of 11 400 microsieverts. 12 The main contribution -- 13 DR RAYNER: One minute. On page 67 I have "total skin 14 equivalent dose" -- in the second column -- "of less 15 than 110". 16 A. That's correct. 17 DR RAYNER: Are we looking at the same thing? 18 A. I was looking at the line above that where it says 19 "total effective dose". 20 DR RAYNER: "Effective dose". 21 A. So the main component of that would be direct gamma 22 radiation from the activity deposited on the ground. 23 DR RAYNER: Mm-hm. 24 A. And I can explain more about that, if you wish. Is that 25 enough, or do you want to go deeper than that?</p> <p style="text-align: center;">Page 122</p>	<p>1 ground deposition. 2 DR RAYNER: Right. 3 A. And then rounded it up to 400. 4 DR RAYNER: Yes. 5 A. So it would have come to 285 and I just called that 400. 6 DR RAYNER: That's very useful, thank you. 7 A. Then multiplied that by 5, because he has had five 8 tests. 9 DR RAYNER: Thank you for that. 10 A. Does that answer your question? 11 DR RAYNER: Yes, that's all I had. 12 Re-examination by MR HEPPINSTALL 13 MR HEPPINSTALL: Right at the beginning of your 14 cross-examination you mentioned that you did find that 15 some of the arrangements at Christmas Island were 16 satisfactory and I think you referred to the forward 17 area health control. 18 A. Yes. 19 Q. I am just going to hand up a document which I think you 20 will know as the Oldbury report. It's from the library, 21 B4/19. Copies are on their way to everybody else. I'll 22 just hand one to you. (Handed) 23 A. Thank you. 24 Q. Mr Hallard, whilst everybody else is receiving this, 25 would you turn to page 30, please?</p> <p style="text-align: center;">Page 124</p>

<p>1 A. Page 30, yes. 2 Q. Page 30. 3 So just looking at page 30, am I right, were you 4 referring to the forward area health control? 5 A. I was. 6 Q. Yes, and if you turn forward to page 45, we get some 7 photographs, and was it images of this nature that you 8 were commenting on to the Tribunal? 9 A. In terms of the forward control point? 10 Q. The forward control point and anything else that you 11 have seen. 12 A. Ah, images of this nature, but also the video which was 13 on the Imperial War Museum website, which was very 14 informative, because it was contemporary video footage. 15 And it shows the forward health control point in 16 operation, for example, it shows the kind of monitoring 17 that they were doing. It was a very useful video. 18 Q. If you could take up SB17 now, please, tab 9. 19 MR JUSTICE BLAKE: Are we keeping this document open? 20 MR HEPPINSTALL: Yes, you can put that one to one side. 21 MR JUSTICE BLAKE: Is this another candidate for SB22? 22 MR HEPPINSTALL: Yes, SB22, tab 12. 23 MR JUSTICE BLAKE: Is that all we need to know about it or 24 do we need to know other things about it? 25 MR HEPPINSTALL: Not for this witness.</p> <p style="text-align: center;">Page 125</p>	<p>1 -- 2 A. Yes. 3 Q. -- at the bottom. That says: 4 "A policy decision was taken during the planning 5 stages of the operation to restrict the issue of [I keep 6 putting my stickers over the words] film badges to those 7 who could be expected to receive dose in excess of the 8 threshold. This was in light of the situation of the 9 Australian trials where a large number of film badges 10 were returned with threshold doses. Accordingly, film 11 badges were issued to personnel who handled radioactive 12 materials, the Canberra air sampling crews and those on 13 board ships in the targeted area. In the event, cloud 14 tracking and monitoring indicated that no ships were 15 exposed to fallout. Film badges issued to those on 16 board ship were returned but not processed." 17 Do you understand that to be a correct description 18 of the dosimeter issue policy at the time of the tests 19 with which we are concerned? 20 A. Yes, I believe so. 21 This is the Woodville and Harden. Yes, yes, so that 22 would be a correct statement. 23 Q. If we turn now to tab 16 in this bundle, please, we 24 should find the Jones paper, residual radiation 25 measurements, to which reference was made a moment ago.</p> <p style="text-align: center;">Page 127</p>
<p>1 MR JUSTICE BLAKE: Just give us a moment, please. 2 A. So SB17. 3 MR HEPPINSTALL: SB17, tab 9. 4 A. Tab 9. 5 Q. If we turn to page 177, you were asked questions 6 yesterday about radiation -- sorry. 7 A. 177. Is that the handwritten 177? 8 Q. Yes, and those who are familiar with this jurisdiction 9 will know that sometimes numbering is only on one page. 10 So it is 177 in reverse, the page opposite 178, 13.1. 11 A. Yes. 12 Q. The first test at Christmas Island with which this 13 Tribunal is concerned is Grapple X. That's right, isn't 14 it? 15 A. Yes. 16 Q. And we can see that at 13.4 it states: 17 "Film badge issue was restricted to selected groups 18 as at during Operation Grapple." 19 A. Yes. 20 Q. Now, if you turn back some pages you'll see that the 21 description of Operation Grapple, which was the first 22 three operations, starts on the page opposite 176. 23 A. (Nodded assent). 24 Yes, I've got that. 25 Q. Then if you turn forward to 177, you should find 11.17</p> <p style="text-align: center;">Page 126</p>	<p>1 A. Ah right. 2 Q. This is for Grapple Y, we see from the first page, which 3 is actually the second substantive page in the tab. 4 If we turn to what's actually page 1 of the report, 5 which has at the top "Introduction", we see that it 6 records that: 7 "Grapple Y was planned as a moderately high air 8 blast. Nevertheless it was highly desirable on 9 political as well as scientific grounds to know the 10 measured levels of fallout contamination even if these 11 were insignificant in terms of radiological hazard." 12 There's A through to F; do you see that? 13 A. Yes. 14 Q. There we have a list of measures which were taken. 15 A being sticky paper fallout collectors at a number 16 of sites on Christmas Island. 17 B: 18 "A ground survey of parts of Christmas Island with 19 sensitive radiation-detecting instruments to supplement 20 data obtained from the sticky paper fallout collected." 21 A. Yes. 22 Q. Now was that the ground survey that you referred to 23 during your answers in cross-examination? 24 A. It was, and I think it's -- sorry, do you want me to go 25 on?</p> <p style="text-align: center;">Page 128</p>

<p>1 Q. Well, we can just note also that samples of seawater 2 taken. There was an aerial radiological survey. I 3 think that was the survey that you also referred to in 4 cross-examination? 5 A. Principally, yes, it's the Shackleton survey but there 6 was actually effectively a helicopter survey done over 7 the sea in order to take a seawater sample. The 8 helicopter located the point of maximum radiation and 9 took the seawater sample at that point. 10 Q. We also see E, and I think you referred to this during 11 cross-examination, that there was also a separate 12 exercise going on with sticky papers, air samplers and 13 rainwater across the Pacific; is that right? 14 A. That's correct. 15 Q. Again also you referred to in cross-examination: 16 "Monitoring of fish of radioactive contamination in 17 a number of sites in the Pacific." 18 A. Yes. 19 MR JUSTICE BLAKE: Am I right in thinking that B, the 20 sensitive radiation-detecting instrument is a Geiger 21 counter? 22 A. Yes, my Lord. 23 MR HEPPINSTALL: We can look at that in a moment. 24 Just dealing with 2.2 first at the bottom. Is this 25 a correct description of the sticky paper method you see</p> <p style="text-align: center;">Page 129</p>	<p>1 read that information. Is that the information you were 2 referring to? 3 A. Yes. 4 Q. Now, still in that document, please, to page 9. 5 Page 9, please. At page 9, do you find there 6 a description of the Shackleton flight? 7 A. Yes. 8 Q. And you were asked questions a moment ago about whether 9 or not the Shackleton was previously contaminated. The 10 third sentence of that second paragraph, could you read 11 that to the Tribunal, please? It starts "This can 12 only..." 13 A. "This can only be justified on the grounds that the 14 aircraft was contaminated before the survey flight, 15 which is a possibility in view of the operations carried 16 out by the aircraft after weapon firing. Correction of 17 dose rate for variations and altitude ..." 18 I think that's not relevant. I think I've covered 19 the point. 20 Q. Yes. Then further on in the next paragraph, the final 21 sentence please. 22 A. Starting "The dose rates ..."? 23 Q. Yes. 24 A. "The dose rates at the maximum between B and C and at 25 the end of the flight were presumably due to</p> <p style="text-align: center;">Page 131</p>
<p>1 there at the bottom of the page: 2 "Fallout trace ..." 3 MR TER HAAR: With the greatest of respect, my learned 4 friend is asking if this is a correct description, it's 5 a matter of historical record for the Tribunal to 6 assess, not for this witness. 7 MR HEPPINSTALL: Does this description at the bottom of 8 page 1 match your understanding of the sticky paper 9 procedure that was carried out on Christmas Island? 10 A. It does. 11 Q. Then if you go over the page at paragraph 2, there's 12 a heading, 2.3, "Results," do you see that? 13 A. I do. 14 Q. It says: 15 "The maximum activity detected, which was at the 16 Decca site at Vaskess Bay, was 1.5 times 10 to the power 17 of minus 2 microcuries per metre squared." 18 Then could you read out, please, the next paragraph? 19 A. "In addition to these measurements, surveys using 20 portable monitors, in particular the 1320, were carried 21 out over the Island. Activity was only detected in the 22 area of Vaskess Bay. The level of activity at one hour 23 was below the maximum permissible level for an 24 uncontrolled area." 25 Q. Now, you referred in your cross-examination to having</p> <p style="text-align: center;">Page 130</p>	<p>1 contamination of the aircraft, the presence of which was 2 demonstrated by monitoring when it returned to the 3 airfield at Christmas Island." 4 Perhaps for clarity I'll just point out that the 5 points A, B and C are marked on this diagram. Point A 6 is there. These are the originals. 7 MR JUSTICE BLAKE: That's the blow-up you gave -- 8 A. It's on the other one too but it's much easier to see on 9 this. 10 MR JUSTICE BLAKE: If I can cross-refer that might make it 11 more easy to understand. So point A? 12 A. Point A is there, my Lord. (Indicated). 13 MR JUSTICE BLAKE: Got it. I've found it. Yes. I have B. 14 A. B and C is there. (Indicated). 15 MR JUSTICE BLAKE: That's it there. All right. 16 There's no scale on this plan. Is there any 17 description of the scale? 18 A. I think on the original I put a description of the 19 scale. The scale that was marked on the original 20 diagram is not correct. My assumption is that it 21 probably had been drawn on A3 and we had A4. But the 22 way that I scaled it, if I remember correctly, the -- 23 MR JUSTICE BLAKE: I'm afraid my copy of your diagram, it 24 suffers from the old photocopy cut-off so it says "The 25 scale, 1 per cent and", so I'm left on tenterhooks.</p> <p style="text-align: center;">Page 132</p>

<p>1 A. I think if I remember correctly what I did on the 2 original diagram you can see 1 degree and 2 degrees 3 latitude. 4 MR JUSTICE BLAKE: Right. Well, I don't want to take you 5 out of your course. I was just trying to correlate the 6 information from the diagram to this. 7 A. The crucial thing is that the distance, again if my 8 memory serves me, the distance between 1 degree and 9 2 degrees latitude is 110 kilometres on the earth. 10 I believe that's the right value. 11 I think that's actually mentioned in the report, so 12 hopefully we'll be able to clarify that. 13 MR JUSTICE BLAKE: All right, so the very informed reader 14 can add that in when trying to -- 15 A. Yes, because I went through the same exercise and it was 16 obvious that what I was getting was not correct, but 17 that was what I came up with in the end. 18 MR JUSTICE BLAKE: Right. 19 MR HEPPINSTALL: Sticking with the Shackleton topic, if you 20 could turn to tab 13, please. 21 A. Right. 22 Q. This is the Operation Grapple Y interim report, part 7, 23 radiological measurements. 24 Can you turn to page 4 of 11. The numbers are in 25 the top-right hand corner.</p> <p style="text-align: center;">Page 133</p>	<p>1 paragraph, it states: 2 "The sticky paper fallout sampling on 3 Christmas Island indicates a very real fallout at the 4 Decca Master Site on the south west point of the Island 5 and this was confirmed by a survey on foot." 6 Is that the survey that you were referring to? 7 A. Yes. 8 Q. "The levels were, however, within those laid down for an 9 uncontrolled area. It is not known whether the 10 contamination was the result of dry fallout or rainout 11 in a light shower." 12 Is that also your understanding? 13 A. Yes. 14 Q. Can we just look at the Clare report that you mentioned 15 several times when being cross-examined? It's at tab 8 16 of this bundle, please. 17 Turn to page 78, internal, the top centre of the 18 pages. The first paragraph on that page says: 19 "During Operation Grapple Y the greatest and only 20 significant measured value of 150 microcuries per square 21 metres was obtained at the uninhabited site at Vaskess 22 Bay. However, records indicate that subsequent surveys 23 using handheld instruments did not confirm this high 24 figure." 25 Is that also the same survey that you are referring</p> <p style="text-align: center;">Page 135</p>
<p>1 A. Right. 2 Q. Do you have 4 of 11? 3 A. I do. 4 Q. Then there's section 2.8, "Radiological survey", and the 5 third paragraph there, there's another description of 6 the flight and a further explanation, which no doubt the 7 Tribunal will note, but if you have a look at that, is 8 that again the description you were referring to? 9 A. Yes, it was. 10 I think for completeness, and to avoid confusion, 11 they did consider another possibility and that was that 12 some of the radiation that they measured could have come 13 from contamination in the sea, but they concluded that 14 it was the contamination on the aircraft which was the 15 principal source. 16 MR JUSTICE BLAKE: Contamination in the sea affecting the 17 radiation measured by the aircraft? 18 A. Yes. 19 MR JUSTICE BLAKE: So sea rising up into the cloud? 20 A. Radiation coming from the sea. But that's likely to be 21 a small component. I didn't mention that before because 22 I didn't want to overcomplicate it but perhaps just to 23 be clear because it's mentioned here. 24 MR HEPPINSTALL: If you turn over a few pages to 6 of 11, 25 please. Under the heading "3.4. Fallout", second</p> <p style="text-align: center;">Page 134</p>	<p>1 to? 2 A. I am. There's clearly an inconsistency between the two 3 documents that this says that the subsequent survey 4 using handheld instruments did not confirm the high 5 figure, whereas the document we've just looked at said 6 that it did. 7 I think the explanation that's been posed for that 8 is that at the time the Clare report was written that 9 second piece of information may have been unavailable to 10 her for whatever reason. 11 Q. Page 96 of the Clare report, please. We see this is 12 entitled "Results of local surveys for Operation Grapple 13 Y reproduced from contemporary documents". 14 You were cross-examined about contemporary documents 15 and you said you had seen compilations based on 16 contemporary documents. 17 A. Yes. 18 Q. Is this what you had in mind? 19 A. Yes. 20 Q. And we see at the bottom there this Decca Master Site 21 Vaskess Bay result. You also said you had seen times 22 for the sticky papers being put out and taken away? 23 A. That's correct. 24 Q. Is this what you had in mind in those middle two 25 columns?</p> <p style="text-align: center;">Page 136</p>

<p>1 A. Yes. 2 Q. Finally, just to complete looking at Vaskess Bay, at 3 page 99 we find a plan of Christmas Island and I think 4 if we look at the key, the Decca site at Vaskess Bay is 5 number 4; is that correct? 6 MR JUSTICE BLAKE: At page 99? 7 MR HEPPINSTALL: At page 99 there should be a plan of 8 Christmas Island. 9 MR JUSTICE BLAKE: I have the plan. 10 MR HEPPINSTALL: Underneath four, Decca Slave. 11 MR JUSTICE BLAKE: Decca Slave. That's Vaskess Bay, is it? 12 MR HEPPINSTALL: The numbers on my copy are not -- 13 A. I thought the Decca Master Site was number 8. 14 MR HEPPINSTALL: Ah, you are absolutely right, which is 15 Vaskess Bay? 16 A. It's very faint, it's hard to read it, but I think that 17 is also an 8. 18 MR HEPPINSTALL: You are absolutely right. 19 MR JUSTICE BLAKE: Sorry -- 20 MR HEPPINSTALL: Too many Deccas. 21 MR JUSTICE BLAKE: Yes, right, Decca Slave and Decca Monitor 22 and Decca Master Site. 23 A. Yes. 24 MR JUSTICE BLAKE: So if one goes to the text for the key, 25 can you just point out where the figure 8 is?</p> <p style="text-align: center;">Page 137</p>	<p>1 MR HEPPINSTALL: Sorry, you are asking me a different 2 question. I would keep it handy. 3 MR JUSTICE BLAKE: Right. I'll put it in "will return to". 4 MR HEPPINSTALL: We will return. 5 So this is two papers, I think, by the oft cited 6 Major, Royal Artillery, MacDougall which you mentioned 7 several times during cross-examination. 8 A. Yes. 9 Q. Hopefully this is the paper you are referring to. The 10 first one is "Air, water and sticky paper samplings" and 11 if we look at section 3 under 3.2, we find the words: 12 "This method is also fully described in the 13 pamphlet. The paper is adversely affected by rain. It 14 should if possible be taken under cover when rain is 15 actually falling." 16 Was that the passage that you had in mind? 17 A. Yes. Again I'm not clear, does this refer to the 18 Pacific? It must be because of course it's talking 19 about rainwater sampling. 20 MR HEPPINSTALL: Yes. 21 MR JUSTICE BLAKE: We looked at another report for 22 Major MacDougall, but that's not this one, and you made 23 the point about you thought the context of that was the 24 Pacific sampling rather than the 25 Christmas Island-specific sampling.</p> <p style="text-align: center;">Page 139</p>
<p>1 A. That one there, my Lord, I believe (indicated). 2 MR JUSTICE BLAKE: It looks like a 9 to me. 3 A. It's barely legible but I believe that is the Decca 4 Master Site. 5 MR JUSTICE BLAKE: I see. 6 So the only numeral left of Vaskess Bay in the box 7 actually is an 8, although I wouldn't have bet money on 8 that if I had been asked to make that without the 9 benefit of -- 10 MR HEPPINSTALL: I think actually if you go back to 96 they 11 have the same numbers, and 8 there is Decca Master Site, 12 Vaskess Bay, so it's definitely number 8. 13 MR JUSTICE BLAKE: Yes, yes. 14 A. Number 9 is Port London, in fact. 15 MR HEPPINSTALL: Indeed, which is up in the north. 16 MR JUSTICE BLAKE: Yes, I have that. It was just the 17 legibility of the numeral. 18 A. Indeed. 19 MR HEPPINSTALL: It was photocopied so many times. 20 Right, we are now going to look at something else 21 from the library. B8B61. Copies are on their way to 22 everybody. (Handed) 23 MR JUSTICE BLAKE: Have we finished with SB17? 24 MR HEPPINSTALL: SB22, tab 13. 25 MR JUSTICE BLAKE: Yes, have we finished with SB17?</p> <p style="text-align: center;">Page 138</p>	<p>1 A. I thought that appeared more logical, my Lord. 2 MR JUSTICE BLAKE: I remember I marked that up to think 3 about that. But this is a different document, anyway. 4 MR HEPPINSTALL: If we look at the introduction we can see: 5 "Christmas Island has been and may again be used as 6 a base for a task force employed on testing nuclear 7 weapons." 8 I think the document falls between Grapple 3 and 9 Grapple X. 10 "Although it is considered that the risk of other 11 islands in the Pacific becoming contaminated is 12 negligible it is necessary to collect data with which to 13 reassure the population and AWRE." 14 So that may help put this document in context. 15 Then you also were asked questions by my Lord in 16 respect of fish sampling and therefore the second paper 17 is about the method of fish sampling. 18 Indeed, there's a section in that report called 19 "Methods of testing fish", where a Type 1257 20 contamination meter is used in order to detect radiation 21 from the fish. Is that what you had in mind when you 22 were answering questions about how the fish sampling was 23 carried out? 24 A. It was. The two main types of instrument, the 1257 and 25 the 1320, are similar.</p> <p style="text-align: center;">Page 140</p>

<p>1 MR JUSTICE BLAKE: But they are both Geiger counters?</p> <p>2 A. They are both Geiger counters. I think again if</p> <p>3 I remember correctly the 1257 is effectively a</p> <p>4 bench-mounted instrument and the 1320 is a portable one.</p> <p>5 You will able to put different probes on them, that</p> <p>6 is different types of detectors but I think they would</p> <p>7 have been -- but yes, but it would have been a Geiger</p> <p>8 detector that they were using. The information I gave</p> <p>9 you yesterday was based on a more detailed description</p> <p>10 of the limit of detection.</p> <p>11 MR JUSTICE BLAKE: Right.</p> <p>12 MR HEPPINSTALL: Just staying with Geiger counters, please,</p> <p>13 can you take up SB14, 5.1, page 129.</p> <p>14 A. Which tab?</p> <p>15 Q. SB14, tab 5.1.</p> <p>16 This is me cross-examining Professor Regan on</p> <p>17 4 February 2013, and in fact if we look at page 129,</p> <p>18 line 20, you'll see that actually I was going through</p> <p>19 the Jones paper, the (a) to (f), with Professor Regan.</p> <p>20 A. Page 129?</p> <p>21 Q. 129, they are split into four. Sorry, just wait for</p> <p>22 others to maybe catch up. (Pause)</p> <p>23 So at page 129 I asked a question:</p> <p>24 "I won't go through (a) to (f) because we've all</p> <p>25 just read them."</p> <p style="text-align: center;">Page 141</p>	<p>1 "But the 4 counts per second sensitivity, would that</p> <p>2 seem reasonable given that we're talking about 1958?"</p> <p>3 He says:</p> <p>4 "Yes. I mean 4 becquerels, 4 clicks per second is</p> <p>5 again reasonable. That's for the efficiency."</p> <p>6 Do you agree that that level of sensitivity for the</p> <p>7 1320 is reasonable for the work that it was doing?</p> <p>8 A. Yes. If you look at what the background count is likely</p> <p>9 to be based on another note from Clare on the gamma dose</p> <p>10 rate on Christmas Island, that would indicate that the</p> <p>11 background on that instrument would be, I think from</p> <p>12 memory, less than 1 count a second. And therefore</p> <p>13 I would expect that you would be able to detect 1 to 2</p> <p>14 counts a second above that, certainly 2 counts a second</p> <p>15 above that, because the background on the instrument</p> <p>16 would be there permanently at probably about half</p> <p>17 a count a second, of that order half to 1, and there</p> <p>18 will be some movement on the needle. So any amount of</p> <p>19 contamination would have to be detectable above that</p> <p>20 background. So there would need to be enough there so</p> <p>21 you could say: yes, there was contamination there above</p> <p>22 the background. And I would say particularly at 2</p> <p>23 counts a second it would be pretty clear, 1 count</p> <p>24 a second you maybe need to check it above background.</p> <p>25 Q. And again on that topic if you could turn to the Carter</p> <p style="text-align: center;">Page 143</p>
<p>1 I think I was going through the Jones (a) to (f).</p> <p>2 Then:</p> <p>3 "Have you realised that there was a ground survey in</p> <p>4 addition to the sticky?"</p> <p>5 His answer was:</p> <p>6 "My understanding was that they had handheld</p> <p>7 monitors for measurement but they don't tell you the</p> <p>8 nature of what that radiation is."</p> <p>9 I asked the question:</p> <p>10 "No, I think the workhorse ..."</p> <p>11 Sorry.</p> <p>12 "My understanding was that they had handheld</p> <p>13 monitors for the ground survey so, yes. I don't know</p> <p>14 where they surveyed or over what area they surveyed but</p> <p>15 I was aware there was a ground survey."</p> <p>16 Then on page 131 I put a question saying:</p> <p>17 "I think the workhorse is called the 1320, which is</p> <p>18 sensitive to four counts per second. I think that's</p> <p>19 1 microcurie per square metre. You can look at that if</p> <p>20 you want."</p> <p>21 He says:</p> <p>22 "I did mention that in one of my reports previously,</p> <p>23 that this ...(Reading to the words)... comments on</p> <p>24 that."</p> <p>25 Then my next question at the end of 131 is:</p> <p style="text-align: center;">Page 142</p>	<p>1 report, please, which is at SB10, tab 161.</p> <p>2 MR JUSTICE BLAKE: Can we put any of these things away?</p> <p>3 MR HEPPINSTALL: Yes.</p> <p>4 MR JUSTICE BLAKE: SB14?</p> <p>5 MR HEPPINSTALL: Yes.</p> <p>6 A. SB10.</p> <p>7 Q. Yes, SB10, tab 161. This is volume 1 of the Australian</p> <p>8 participants in British nuclear tests in Australia</p> <p>9 report, volume 1 being the dosimetry part as opposed to</p> <p>10 volume 2 which is epidemiology with different authors.</p> <p>11 If we turn to page 182.</p> <p>12 MR JUSTICE BLAKE: 180?</p> <p>13 MR HEPPINSTALL: 182.</p> <p>14 MR JUSTICE BLAKE: 182.</p> <p>15 A. Can I just confirm, did you say tab 160?</p> <p>16 MR HEPPINSTALL: 161.</p> <p>17 A. 161. Turn to page 183?</p> <p>18 MR HEPPINSTALL: 182. There's a table and halfway down the</p> <p>19 table, the 1320, what I described as "the workhorse" in</p> <p>20 my questions for Professor Regan, is there described.</p> <p>21 Is that the correct instrument that we're talking</p> <p>22 about?</p> <p>23 A. Yes.</p> <p>24 Q. We see that it detects alpha, beta and gamma?</p> <p>25 A. That would depend on the probe.</p> <p style="text-align: center;">Page 144</p>

<p>1 Q. Right.</p> <p>2 A. It indicates here that it can be either used with a GM,</p> <p>3 which is a Geiger-Muller probe, so that's a probe that</p> <p>4 looks a little like this microphone.</p> <p>5 MR JUSTICE BLAKE: Have I misremembered? Did you tell us</p> <p>6 a little earlier today or some time that the Geiger</p> <p>7 counters didn't detect alpha, you had to work back to</p> <p>8 get alpha?</p> <p>9 A. Exactly, my Lord. The scintillation probe which they're</p> <p>10 referring to would have detected alpha. But I've not</p> <p>11 seen any evidence that a scintillation probe was</p> <p>12 actually used on that instrument. All the references</p> <p>13 that I've seen are to a Geiger-Muller probe.</p> <p>14 The 1320 --</p> <p>15 MR JUSTICE BLAKE: All right, hang on, I just need to get</p> <p>16 all this information together.</p> <p>17 Carter tells us:</p> <p>18 "In this table the 1320 battery-operated portable</p> <p>19 contamination monitor, GM ..."</p> <p>20 That is Geiger-Muller, is it?</p> <p>21 A. Yes.</p> <p>22 MR JUSTICE BLAKE: And scintillation probes.</p> <p>23 A. Yes.</p> <p>24 MR JUSTICE BLAKE: Radiation, that's what it can detect?</p> <p>25 A. Yes, my Lord.</p> <p style="text-align: center;">Page 145</p>	<p>1 geometries.</p> <p>2 It's not a particularly easy concept to think about</p> <p>3 all of these different type of instruments which is why</p> <p>4 I've tried to avoid it.</p> <p>5 MR JUSTICE BLAKE: Mr Heppinstall will no doubt get out what</p> <p>6 he wants to. But we've gone to Carter in order to get</p> <p>7 some more information --</p> <p>8 A. Yes.</p> <p>9 MR JUSTICE BLAKE: -- as I understand it as to what the</p> <p>10 capacity of the Geiger-Muller probe is.</p> <p>11 A. Yes.</p> <p>12 MR JUSTICE BLAKE: And are we led to believe that with the</p> <p>13 scintillation probe it can detect alpha directly?</p> <p>14 A. I think almost certainly, my Lord.</p> <p>15 MR JUSTICE BLAKE: Right.</p> <p>16 A. Almost certainly, I think that must be what he refers</p> <p>17 to.</p> <p>18 MR JUSTICE BLAKE: During this report it looks as if he</p> <p>19 thought it was detecting that in Australia.</p> <p>20 Question: is it able to detect that in Christmas Island?</p> <p>21 Then you say that depends whether they used the</p> <p>22 scintillation probes, or otherwise doing other forms of</p> <p>23 calculation of how much alpha you've got from your gamma</p> <p>24 and beta?</p> <p>25 A. Yes. The normal Geiger I think they would use is</p> <p style="text-align: center;">Page 147</p>
<p>1 MR JUSTICE BLAKE: Alpha, beta, gamma, but are you telling</p> <p>2 me that it only does alpha with the scintillation probe?</p> <p>3 A. Yes, my Lord.</p> <p>4 MR JUSTICE BLAKE: You don't think they used scintillation?</p> <p>5 A. I've not seen any evidence that they did.</p> <p>6 MR JUSTICE BLAKE: All right. Two steps forward and one</p> <p>7 step sideways.</p> <p>8 A. The description 1320, again I've done quite a lot of</p> <p>9 research to try and understand this, but I think it</p> <p>10 refers to the box, the so-called rate meter, the thing</p> <p>11 with a handle and a dial on the front which shows you</p> <p>12 the counts per second with a needle. A simple analogue</p> <p>13 instrument. I think that is what the term "1320" will</p> <p>14 refer to.</p> <p>15 From that you will then get a cable going to</p> <p>16 a probe, if I can just use that to imitate the probe.</p> <p>17 So the probe, very crudely will look something like</p> <p>18 that with a handle on it. The Geiger-Muller will look</p> <p>19 like that. There will be an open window here and if you</p> <p>20 look into the open window you will see a glass tube</p> <p>21 inside and that is the actual Geiger tube. That</p> <p>22 I believe is the probe that they would have used most of</p> <p>23 the time.</p> <p>24 The scintillation -- but there were other types of</p> <p>25 Geigers, Geiger-Mullers used on the Island of different</p> <p style="text-align: center;">Page 146</p>	<p>1 similar to the one that I used when I first started in</p> <p>2 my profession and that would not detect alpha.</p> <p>3 MR JUSTICE BLAKE: Right.</p> <p>4 MR HEPPINSTALL: And I think you mention this in your report</p> <p>5 Mr Hallard. If we just put SB10 to one side, we'll be</p> <p>6 coming back to the Carter report in due course, but in</p> <p>7 your report at SB2/2.14, page 50, you mention the 1320</p> <p>8 at section 2 there on page 50.</p> <p>9 A. Yes, I do.</p> <p>10 Q. And you give some data at the top of page 51. But then</p> <p>11 at (a) you say:</p> <p>12 "The results above are approximate values to</p> <p>13 indicate the background concentrate on any instrument in</p> <p>14 use on the day of either GY or GZ1 and 4."</p> <p>15 Can you just explain to the Tribunal background</p> <p>16 count rate, please?</p> <p>17 A. Right.</p> <p>18 MR JUSTICE BLAKE: That's the background radiation?</p> <p>19 A. Yes.</p> <p>20 MR JUSTICE BLAKE: Yes.</p> <p>21 A. So --</p> <p>22 MR JUSTICE BLAKE: I think you've attempted to give that</p> <p>23 explanation.</p> <p>24 A. Okay, but in essence Geigers respond to gamma as well as</p> <p>25 beta. They are more sensitive to beta than gamma by</p> <p style="text-align: center;">Page 148</p>

<p>1 about a factor 5. But the gamma radiation will create 2 a count rate on the instrument. 3 The point is if the gamma count rate had gone up 4 significantly as a result of high levels of fallout, 5 uniform fallout in the area where these instruments were 6 being used, the background count rate on the instrument 7 would rise significantly. Because the gamma dose rate 8 from the activity deposited on the ground would be 9 significantly higher than normal and therefore the 10 background count rate would go up proportionately. 11 MR HEPPINSTALL: So at page 52(f) is that what you are 12 explaining? 13 A. It is, and this is further information to comment that 14 (f) is not just related to the background. This 15 a contamination probe which detects both beta and gamma. 16 It's a mobile probe, and therefore had that probe been 17 put in direct contact with contamination of the level 18 which I've assumed in this report, the count rate would 19 have been above its maximum of 1,00 counts a second. 20 And therefore it would have been very obvious, had that 21 detector been used in the area of this contamination, 22 the contamination level that I've assumed, it would be 23 very obvious to anyone using it that there were high 24 levels of contamination present. 25 Q. So can you explain to us, please, the link between that</p> <p style="text-align: center;">Page 149</p>	<p>1 A. Yes. 2 Q. Is that a correct description of the re-suspension 3 factor? 4 A. Yes. 5 Q. Unit is per metre and an example is given. 6 Then there's factors that can affect re-suspension 7 and the factors that includes and there's four there. 8 Do you agree those are the correct factors? 9 A. Yes. 10 Q. Then it says: 11 "Reported re-suspension factors range from 10 to 12 minus 8 per ..." 13 Should that be metre"? 14 A. Per metre, yes. 15 Q. "... which is a very low ratio ...(Reading to the 16 words)... an extremely high ratio." 17 Then there are three references, Turner, Lindsey, 18 and Walsh. 19 Are any of those references that you were referring 20 to when you were giving your evidence? 21 A. I think it is the Lindsey and the -- well, the Turner is 22 described in the report and from memory it is the 23 Lindsey and the Walsh papers which are the NRPB papers. 24 We could soon confirm that from the references in the 25 document.</p> <p style="text-align: center;">Page 151</p>
<p>1 and what you say at paragraph (v) at page 56? 2 A. Right, then that's an extension to what I've just said, 3 that had there been widespread fallout, that is fallout 4 over the Island which therefore would have also fallen 5 out in the area where these probes were being used, that 6 the increase in background, in the gamma background 7 would have been very significant and the increase in the 8 beta plus gamma background on the Geiger-Muller 9 contamination probes would have been extremely 10 significant. 11 Q. I promised to go back to Carter and I will. SB10/161. 12 You were asked questions by both Mr ter Haar and 13 Dr Busby about re-suspension rates and you said you had 14 used Carter. Can you turn, please, to page 70 in 161. 15 A. Page 70? 16 Q. Yes. At page 70, halfway down the page, there's 17 a passage that starts: 18 "When a radioactively contaminated surface is 19 disturbed ..." 20 Do you see that? 21 A. Yes. 22 Q. "... the radioactive material may be raised into the 23 air. The re-suspension factor is the ratio of the level 24 of radioactive material in the area above the surface to 25 the level of contamination on the surface."</p> <p style="text-align: center;">Page 150</p>	<p>1 Q. Yes. If you look at the references, I think the Walsh 2 one is NRPB. I confess that I don't know about the 3 Lindsey. 4 In fact, I have given my pages away because as 5 Dr Haylock is present and is an employee of that 6 successor body, he has gone off to find the Walsh for 7 you. 8 A. Ah. 9 Q. We may get the Walsh. 10 A. The Lindsey is also referred to as an NRPB paper, 11 NRPB/75, and Walsh is NRPB/W1. 12 Q. Right, well -- 13 A. I think they were the two that I tried to find. 14 Q. We can add to Dr Haylock's homework. 15 Then you say that Turner is described. Is that what 16 then follows in the next few paragraphs? I think you 17 mentioned in cross-examination a dragging experiment. 18 A. I did, I did. Yes, this is the description from the 19 bottom of page 70 to the first part of page 71. 20 Q. And it concludes: 21 "In this work a re-suspension factor of 10 to the 22 power of minus 5 per meter square has been used." 23 Is that what you have used? 24 A. No. In the next sentence it says: 25 "It is possible that for short periods</p> <p style="text-align: center;">Page 152</p>

<p>1 a re-suspension factor of 10 to the minus 4 may have 2 occurred but average long-term levels would have been 3 close to 10 to the minus 6 per metre or less." 4 I've used that peak value of 10 to the minus 4. 5 Q. And you also told the Tribunal about decay rates. 6 Page 188 in this paper, table A1. 7 MR JUSTICE BLAKE: I have lost the reference again. 8 MR HEPPINSTALL: 188. 9 MR JUSTICE BLAKE: 188. 10 MR HEPPINSTALL: Are these the decay rates you were 11 referring to? 12 A. Yes. 13 Q. And we can see it's given for one hour, 12 hours, one 14 day, two days, five days, 10 days; is that right? 15 A. That's correct, and that's the mix that Carter uses and 16 I've added to that in my supplementary report by adding 17 uranium-240, neptunium-240 and plutonium-240. 18 Q. Sorry, this is for the nominal atomic weapon but for the 19 thermonuclear you've added to this mix. Is that what 20 you're saying? 21 A. That's what I'm saying and that was done in the 22 supplementary report. 23 Q. We can see that these decay rates fall away rapidly. Is 24 that the behaviour that you were describing? 25 A. Yes.</p> <p style="text-align: center;">Page 153</p>	<p>1 MR HEPPINSTALL: Well, maybe if we just deal with this one 2 point then. 3 MR JUSTICE BLAKE: Right. 4 MR HEPPINSTALL: So SB11, tab 2, this is Professor Regan's 5 first report. 6 A. Right. 7 MR HEPPINSTALL: Page 15, paragraph 46, please. He says: 8 "For higher altitude bursts much of the nuclear 9 weapon's debris is carried into the upper atmosphere 10 following the initial explosion due to the large heat of 11 the nuclear fireball. This causes a strong convection 12 effect in the air surrounding the nuclear explosion 13 which causes some of the reaction products to be lifted 14 to high altitudes where they are dispersed around the 15 globe." 16 Do you agree or disagree with that statement? 17 A. I believe that to be correct. But I have no specific 18 expertise in that area. But nevertheless from what I've 19 understood I believe that to be correct. 20 Q. Well, I think questions were put to you several times in 21 cross-examination about that statement. 22 A. Yes. 23 Q. Is this one of the sources that you rely upon? 24 A. Yes. 25 MR JUSTICE BLAKE: So you rely upon it as reliable even</p> <p style="text-align: center;">Page 155</p>
<p>1 Q. Now, it was put to you by Dr Busby that Mr Johnston had 2 first said that there was no uranium naturally occurring 3 on Christmas Island. Can you turn to -- 4 MR JUSTICE BLAKE: He said in coral, that's what he actually 5 said. 6 MR HEPPINSTALL: Coral. Can we turn to SB13/38, please, 7 page 8. 8 If you just look at paragraph 3.9 on page 8, is it 9 right that he there says that there is a body of 10 evidence that coral, despite some leaching when it dies, 11 has a natural uranium content in the region of 2 parts 12 per metre? 13 A. 2 parts per million. 14 Q. 2 parts per million? 15 A. Yes, that's what it says. 16 Q. Right, if we just go to one of Professor Regan's 17 reports, please, SB11/2. 18 A. Which bundle was it? 19 Q. SB11. 20 MR JUSTICE BLAKE: You are going to be more than a few 21 moments with this witness, are you? 22 MR HEPPINSTALL: Yes. 23 MR JUSTICE BLAKE: So somewhere between the next five to 24 10 minutes, a break for the stenographers would be 25 appropriate.</p> <p style="text-align: center;">Page 154</p>	<p>1 though you don't have the expertise to contradict it? 2 A. That's correct, my Lord. But there was similar 3 information from Mr Johnston. 4 MR JUSTICE BLAKE: Right. 5 A. And other -- well, in fact quite a lot of information in 6 UNSCEAR reports and also in a book, "The Effects of 7 Nuclear Weapons" by Glasstone. 8 MR JUSTICE BLAKE: All pointing the same way? 9 A. Yes, my Lord. 10 MR HEPPINSTALL: That's a convenient moment, my Lord. 11 MR JUSTICE BLAKE: Yes, 25 past. Thank you. 12 (3.08 pm) 13 (A short break) 14 (3.25 pm) 15 MR HEPPINSTALL: Back to SB14, please, again to the 16 cross-examination of Professor Regan at 5.1, this time 17 page 189. 18 MR JUSTICE BLAKE: Sorry, which tab? 19 MR HEPPINSTALL: Sorry, tab 5.1, the first tab. 20 MR JUSTICE BLAKE: Right. 21 A. Then which page? 22 Q. Page 189. 23 Now I don't think you gave it a name when you were 24 being cross-examined but I am just turning to look at 25 line 19 on page 189 and the start of my question on that</p> <p style="text-align: center;">Page 156</p>

<p>1 day was "Let's move on to co-deposition".</p> <p>2 I think when you were being cross-examined you were</p> <p>3 describing the idea that the alpha, the beta and the</p> <p>4 gamma are always together when they fall out of</p> <p>5 a nuclear weapon detonation; is that correct?</p> <p>6 A. Yes, that's correct.</p> <p>7 Q. You said that you thought the debate had moved on at the</p> <p>8 last Tribunal so that Professor Regan actually agreed</p> <p>9 with Ken Johnston that there was co-deposition?</p> <p>10 A. That was my recollection from what I read.</p> <p>11 Q. Let's see. At page 189 I say:</p> <p>12 "Let's move on to co-deposition because as</p> <p>13 I understand it you are now -- I think you were</p> <p>14 sceptical about co-deposition but now in your third</p> <p>15 report at paragraph 10 you say:</p> <p>16 'I tend to agree that the likelihood of</p> <p>17 plutonium...'"</p> <p>18 Then I read out the words at paragraph 10 of his</p> <p>19 report.</p> <p>20 "I think I would agree with that. Okay, there are</p> <p>21 different levels. We've discussed fractionation effects</p> <p>22 which are known, but I think if you make a big explosion</p> <p>23 and then you have a variation of droplet sizes and</p> <p>24 vapour levels in hundreds of kilograms of radioactive</p> <p>25 materials I think the likelihood of having no</p> <p style="text-align: center;">Page 157</p>	<p>1 a "75" at the top and a "4" at the bottom by way of page</p> <p>2 numbers.</p> <p>3 If we look at paragraphs 12 and 13 it says:</p> <p>4 "It was well known at the time that radioactivity</p> <p>5 materials such as plutonium emitting alpha radiation</p> <p>6 were present in fallout from a nuclear detonation as</p> <p>7 well as beta and gamma emitters. In view of the</p> <p>8 relative ease of detection of beta and gamma radiation</p> <p>9 compared with alpha radiation it was therefore decided</p> <p>10 that the form would be measured to monitor the</p> <p>11 environment. Additionally, it was known that the hazard</p> <p>12 from beta and gamma emitting radionuclides</p> <p>13 overwhelmingly dominated in the short-term that posed by</p> <p>14 alpha emitters.</p> <p>15 "The only scenario when alpha emitting nuclides</p> <p>16 might have been present in the absence of beta and gamma</p> <p>17 emitters would have been in the event of an accident to</p> <p>18 a nuclear device, dispersing plutonium without a nuclear</p> <p>19 detonation ...(Reading to the words)... this</p> <p>20 contingency."</p> <p>21 Which happily never was required.</p> <p>22 But is that an accurate description of co-deposition</p> <p>23 being used as a reason for monitoring only beta and</p> <p>24 gamma?</p> <p>25 A. It is, it is. I think it's reasonable to add that of</p> <p style="text-align: center;">Page 159</p>
<p>1 co-deposition is quite small. Yes, I would think that."</p> <p>2 Then I think I have another go at page 191 at the</p> <p>3 top, line 6:</p> <p>4 "Co-deposition is the Secretary of State's answer to</p> <p>5 your criticism that there was no separate measurement of</p> <p>6 alpha radionuclides because if there is co-deposition</p> <p>7 then if you are finding amounts of gamma you know</p> <p>8 there's alpha 2."</p> <p>9 He says:</p> <p>10 "That is a reasonable scientific statement I would</p> <p>11 say."</p> <p>12 Although he goes on to give some qualifications.</p> <p>13 So was that the evidence that you were referring to?</p> <p>14 A. Largely, yes.</p> <p>15 MR HEPPINSTALL: My Lord, I don't wish to appear to be</p> <p>16 selective, I am sure the Tribunal will read on,</p> <p>17 Professor Regan said what he said and then said more</p> <p>18 things, but I don't propose to detain you further. If</p> <p>19 anybody wants to draw attention to those other things</p> <p>20 I am sure they will in due course.</p> <p>21 That is also -- the idea of co-deposition is also</p> <p>22 picked up in the Clare report, so if you pop back to</p> <p>23 SB17/8. Perhaps the best thing to use in this</p> <p>24 multi-numbered report, page-numbered report, is the</p> <p>25 paragraph numbers. It's paragraphs 12 and 13. Mine has</p> <p style="text-align: center;">Page 158</p>	<p>1 course the activity is decaying, and therefore the gamma</p> <p>2 measurement will drop off relatively quickly. The beta</p> <p>3 level will drop off rather more slowly. So the</p> <p>4 measurement has to be made at a time when you are still</p> <p>5 going to -- when you still have enough of the fission</p> <p>6 products to be measured.</p> <p>7 MR JUSTICE BLAKE: If you are doing this after the half life</p> <p>8 of beta and gamma have gone then that's a bit of</p> <p>9 a pointless exercise?</p> <p>10 A. Exactly.</p> <p>11 MR JUSTICE BLAKE: You are not going to pick up any -- you</p> <p>12 can't then work out whether there was alpha because your</p> <p>13 alert mechanism has gone?</p> <p>14 A. Exactly, my Lord. So while there is enough fission</p> <p>15 products there, the gamma level will drop off fairly</p> <p>16 quickly, in perhaps one to two days, if I remember</p> <p>17 correctly. The beta level will, because it's 5 times</p> <p>18 greater, so the surface level of beta contamination will</p> <p>19 be present for rather longer.</p> <p>20 MR JUSTICE BLAKE: Yes. This is just to test my own state</p> <p>21 of understanding. When the author of this report says</p> <p>22 at paragraph 12 "additionally it was known that the</p> <p>23 hazard from beta and gamma emitting radionuclides</p> <p>24 [et cetera] overwhelmingly dominated in the short-term",</p> <p>25 they are talking about external radiation, are they not?</p> <p style="text-align: center;">Page 160</p>

<p>1 A. And also some inhalation and ingestion as well. I mean, 2 a number of the pathways that I've looked at in my 3 report, initially the fission product levels would 4 actually dominate both externally internally. 5 But, with time, particularly with extended periods 6 of time, the fission products will have decayed to such 7 a point that it's only actually either the long-lived 8 fission products such as caesium or strontium, but 9 particularly the plutonium nuclides, and we're talking 10 inhalation. 11 MR JUSTICE BLAKE: Or, it could be argued, uranium? 12 A. Sorry, or uranium, although the beta concentrations tend 13 to be rather lower. 14 MR JUSTICE BLAKE: So in the longer term, which may, 15 depending on upon our view of the arguments and the 16 evidence be this case, that then the alpha emitters 17 or -- become more relevant? 18 A. Yes, they do. 19 MR JUSTICE BLAKE: Right. 20 MR HEPPINSTALL: You were cross-examined about hot particles 21 and you referred to a paper by Charles and Harrison. 22 Can you turn to SB3, tab 5, please. 23 MR JUSTICE BLAKE: We might still dip back into 17 at some 24 point, might we? 25 MR HEPPINSTALL: There is always a risk, my Lord.</p> <p style="text-align: center;">Page 161</p>	<p>1 single, highly active particles. 2 A. Yes. 3 MR JUSTICE BLAKE: The table that we are looking at at the 4 moment occurs under the subheading "7.1 skin Exposure". 5 A. Yes. 6 MR JUSTICE BLAKE: They are estimates of time taken for 7 stationary MTR? 8 A. MTR is a type of particle, I am just trying to remember 9 which it is. Sorry, it's a source of the particle. 10 MR JUSTICE BLAKE: Is it, second line, CSMTR? 11 A. MTR stands for "material test reactor", which was 12 a reactor at Dounreay. All of this is written around 13 particles which were found at Dounreay. So the previous 14 page, page 3, the start of the last but one paragraph 15 refers to the materials test reactor, MTR, and the 16 Dounreay fast reactor, DFR fuel. That's what the 17 acronyms mean. 18 MR JUSTICE BLAKE: So we borrow the acronyms from the 19 earlier discussion. 20 A. Yes, so that is the acronym. 21 MR JUSTICE BLAKE: The table, which is where you've been 22 asked to comment. 23 A. Yes, the activity, when it says "activity becquerel 24 137CS", that means caesium 137. 25 MR JUSTICE BLAKE: Yes.</p> <p style="text-align: center;">Page 163</p>
<p>1 MR JUSTICE BLAKE: I will put it up there in case it becomes 2 unstable. 3 MR HEPPINSTALL: Right. Is this the Charles and Harrison 4 paper that you were referring to? 5 A. Yes, it is. 6 Q. Is there anything that you want to draw to the 7 Tribunal's attention from this paper? 8 A. There's some useful information on the paper. 9 Particularly table 1, which is on page 5, which gives 10 dose rates. You need to -- sorry. 11 MR JUSTICE BLAKE: Yes. I'm there now. 12 A. -- you do need to interpret the dose rates a little 13 because the activity they are quoting is a caesium 14 activity, and for many of these particles there is 15 a similar level of strontium and yttrium 90. So the 16 actual activity is twice the activity that's mentioned 17 there. But that's only a factor of 2. 18 MR JUSTICE BLAKE: Sorry, I am trying to get my bearings -- 19 MR HEPPINSTALL: Let's perhaps just orientate ourselves 20 first. This paper is about hot particle dosimetry. 21 A. It is. 22 Q. So a single, highly active particle, I think you 23 explained when you were being cross-examined. 24 A. It is. A single, highly active particle. Yes, sorry -- 25 MR JUSTICE BLAKE: So the context is hot particles or</p> <p style="text-align: center;">Page 162</p>	<p>1 A. It quotes a certain level of activity, and below that it 2 mentions the fact that there is an activity ratio of 0.9 3 for strontium and yttrium and caesium 137, which I've 4 interpreted as meaning that there's roughly the same 5 level again of strontium yttrium as the level of 6 caesium, which is a factor of 2. 7 Perhaps in this context I'm going -- that isn't 8 really important. 9 MR JUSTICE BLAKE: What do we get, in fairly simple 10 language, from this table that is relevant to our 11 inquiry? 12 A. What it gives you is an activity and then a dose rate, 13 in the next column, in gray per hour. The column after 14 that, the threshold means the time it would take to get 15 a skin dose, for example, of 2 gray from any one of 16 these particles. You can see that as the particle goes 17 up in activity, the time to get to 2 gray goes down. 18 Then, finally -- 19 MR JUSTICE BLAKE: Yes. 20 A. -- in the last column there is the time it would take to 21 get to ED -- to a value of 10 gray where you would 22 expect to see significant reactions to the skin 23 blistering, that kind of thing. Probably skin burns. 24 MR HEPPINSTALL: So, just to check, it would take two weeks 25 to get to skin burns if you encountered one of these hot</p> <p style="text-align: center;">Page 164</p>

<p>1 particles of caesium 137 with an activity of 10 to the 2 power of 4 becquerels? 3 A. Yes. The total activity would probably be 2 times 10 to 4 the 4, because of the other materials present. 5 MR JUSTICE BLAKE: If you had the similar thing with 6 an activity of 10 to the power of 8 it would be 7 10 minutes? 8 A. Yes. But the order of magnitude of the particles that 9 we are talking about, some calculations were done for 10 the First Tier Tribunal, there was an exchange of 11 letters between Professor Regan and Mr Johnston, and the 12 size of -- and the activity -- I am going from memory -- 13 but the activity of a 1 micron particle was estimated to 14 be of the order of about 5 times 10 to the 4, from 15 memory. So it's about halfway between the 10 to the 4 16 and 10 to the 5 particles, roughly. 17 MR JUSTICE BLAKE: The activity of a -- just let me get that 18 down. 19 A. That was a 1 micron particle. 20 MR JUSTICE BLAKE: A 1 micron particle. 21 A. Yes. So that's a particle of 1 micrometres. 22 MR JUSTICE BLAKE: Right. 23 A. They were asked to do that calculation by one of the 24 members of the First Tier Tribunal. 25 MR JUSTICE BLAKE: Right.</p> <p style="text-align: center;">Page 165</p>	<p>1 looking for that. I have read the whole paper, but 2 I just wanted to confirm that it was the same paper. 3 And this is the same paper. 4 Q. So when it said in your report "this study", and, as it 5 says in table 4.1 "this study", we're talking about the 6 paper we're now in, are we? 7 A. We are. 8 Q. I see. 9 A. Sorry, I should have picked that up when I did the copy 10 and paste that there was some ambiguity there, but 11 I just didn't notice. 12 Q. Well, I think, actually, Mr Hallard, if you turn back 13 over the page in your report to page 129, you -- 14 A. I did explain it there, yes. 15 Q. Anyway, let's look at the summary and conclusions of 16 this paper, please. 17 "ICRP is clear on the intended use of equivalent and 18 effective dose as reference quantities, without 19 uncertainty, for use in internal radiation protection." 20 Is that your understanding? 21 A. Sorry, which? 22 Q. Under 5, "Summary and Conclusions", the words, the first 23 sentence; do you agree with that? 24 MR JUSTICE BLAKE: Which page are you reading from? 25 MR HEPPINSTALL: Sorry, page 43, my Lord.</p> <p style="text-align: center;">Page 167</p>
<p>1 MR HEPPINSTALL: It's the medical member then, Dr Anscombe. 2 A. Yes. 3 Q. Somewhat opened Pandora's box with his question: what's 4 the activity of a 1 micron particle? The results are in 5 the bundle. 6 A. Yes. 7 MR JUSTICE BLAKE: Okay. But your recollection, it was 10 8 to the power of -- 9 A. I think it was about 5 times 10 to the 4 becquerels. 10 I believe so. We'd better check it in the bundle. 11 MR JUSTICE BLAKE: So, in this list, that goes between two 12 weeks and 33 hours? 13 A. Yes. 14 MR JUSTICE BLAKE: Right. 15 MR HEPPINSTALL: Right. I think Mr Harrison then 16 re-features when you were looking at these uncertainty 17 levels in terms of the dose co-efficients. If you turn 18 to SB3/10, I think you kept mentioning a paper by 19 Puncher and Harrison. 20 A. Yes. 21 Q. I think this is the paper. Or, you tell us, is this the 22 paper that you were referring to? 23 If it helps, if you turn to page 43, I think, from 24 looking at a comparison, that might be your table 4.1? 25 A. Ah, yes. It is, thank you very much. I was just</p> <p style="text-align: center;">Page 166</p>	<p>1 MR JUSTICE BLAKE: Right. 2 MR HEPPINSTALL: In tab 10? 3 MR JUSTICE BLAKE: Yes, I have the tab. I was starting at 4 the beginning. 5 MR HEPPINSTALL: I beg your pardon, I fear we probably don't 6 have time. 7 MR JUSTICE BLAKE: No, no. 8 MR HEPPINSTALL: So at page 43 we find table 4.1, which is 9 now perhaps familiar to us. 10 MR JUSTICE BLAKE: Yes, I have the table, I've caught up 11 with you now. 12 MR HEPPINSTALL: I am grateful. The first sentence of 13 section 5: 14 "ICRP is clear on the intended use of equivalent and 15 effective dose as reference quantities, without 16 uncertainty, for use in internal radiation protection." 17 Do you agree with that? 18 A. Yes. That's the section I was thinking of in this 19 section and there was equivalent comments in ICRP 103. 20 Q. "However, ICRP and others also recognised there are 21 uncertainties in the process of estimating dose and risk 22 that affect the derivation and application of these 23 quantities." 24 Do you agree with that? 25 A. Yes.</p> <p style="text-align: center;">Page 168</p>

<p>1 Q. "This report addresses this issue as follows." 2 Then the first point they make is: 3 "The issue of relevance for regulators and other 4 stakeholders is not the magnitude of the uncertainty on 5 dose estimates but how reliable dose co-efficients are 6 for protection purposes as a protection device." 7 Do you agree with that? 8 A. Yes. 9 Q. "It is argued that a dose co-efficient as applied to a 10 defined exposure pathway is considered reliable if it 11 ensures exposures comply with dose limits and 12 constraints." 13 Do you agree with that? 14 A. Yes. 15 Q. Over the page. 16 "The best estimate of risk and its uncertainty for 17 a given internal exposure pathway is a prerequisite for 18 making an informed judgment on the reliability of a 19 particular dose co-efficient in the context of 20 a specified exposure pathway." 21 Again, do you agree with that? 22 A. Sorry, I just want to read that again. 23 Q. Yes, please read it to yourself. (Pause) 24 In fact, do you want to read the whole of that 25 paragraph to save me reading it to you. (Pause)</p> <p style="text-align: center;">Page 169</p>	<p>1 alongside the likely levels of exposure that is expected 2 from them and the dose limit for planned exposures to 3 members of the public, 1,000 microsieverts." 4 So is it correct or incorrect that the conclusion 5 here is that, because of -- the unreliability factors 6 are 2 to 3, 2 to 6 and so forth, that the ICRP dose 7 co-efficients are reliable? 8 A. Sorry, could you just repeat the question? 9 Q. Well, let's -- do you agree with that -- 10 MR JUSTICE BLAKE: That seems -- 11 MR HEPPINSTALL: -- do you agree with what the authors are 12 saying at paragraph 6, that "the derived UF values for 13 the radionuclides considered here seem acceptable when 14 considered alongside the likely levels of exposure 15 expected from them"? 16 A. Yes, I think that's reasonable. 17 MR JUSTICE BLAKE: What do you think they are saying that 18 you agree with? 19 A. I think they are saying that the factors, that the 20 uncertainty factors which they have derived -- well, 21 seem acceptable when considered alongside the likely 22 levels of exposure that we're talking about. 23 So when we're talking about exposures of the order 24 of a 1,000 microsieverts, which is about a millisievert, 25 that these uncertainty factors are acceptable for the</p> <p style="text-align: center;">Page 171</p>
<p>1 A. I agree with the paragraph. I probably don't have 2 sufficient expertise in internal dosimetry to be able to 3 make a definitive statement, but the paragraph makes 4 sense to me. 5 Q. Then at paragraph 3: 6 "A general assessment of the reliability of dose 7 co-efficients can be made by assessing the reliability 8 of dose co-efficients that applied to the more 9 significant exposure pathways." 10 So is it correct or incorrect that what is happening 11 here is a review of the uncertainties in order to 12 establish the reliability of the ICRP dose 13 co-efficients? 14 A. That's my reading of it. 15 Q. We can see at 5: 16 "The analyses indicate UF values of around 2 to 3 17 for ingestion and 2 to 6 for inhalation. The UF values 18 are the same for the three age groups considered, 19 1-year-olds, 10-year-olds and adults. The UF values are 20 consistent with those inferred from other studies, 21 although a general assessment of reliability of the 22 protection quantities is beyond the scope of this 23 report. 24 "The derived UF values for the radionuclides 25 considered here seem acceptable when considered</p> <p style="text-align: center;">Page 170</p>	<p>1 purposes of radiation protection. 2 MR JUSTICE BLAKE: Obviously I want to try and marry up the 3 answers you are giving me with the answers we had 4 a little earlier this afternoon. 5 A. Right. 6 MR JUSTICE BLAKE: I may be getting this wrong, and I'm 7 sorry, if I do, I apologise. 8 The uncertainty factors, are they the uncertainty 9 factors that the authors have previously set out in the 10 table at 4.1 which found its way into your answers to 11 questions? 12 A. Yes. 13 MR JUSTICE BLAKE: Right. I was trying to find out where 14 the table goes in terms of relationship. 15 They are saying, given those uncertainty factors, 16 nevertheless the planned exposures to members of the 17 public are acceptable. 18 A. Yes. 19 MR JUSTICE BLAKE: Despite the uncertainty factors mentioned 20 in 4.1 earlier. 21 A. That's my reading of it. 22 MR JUSTICE BLAKE: What is the relevance of 1,000 23 microsieverts and such like and annual dose of 2,700? 24 A. 1,000 microsieverts is the normal limit for a member of 25 the public.</p> <p style="text-align: center;">Page 172</p>

<p>1 MR JUSTICE BLAKE: Set by who?</p> <p>2 A. By the ionising radiation regulations.</p> <p>3 MR JUSTICE BLAKE: Based on what?</p> <p>4 A. Based on ICRP recommendations.</p> <p>5 MR JUSTICE BLAKE: Right.</p> <p>6 So we've therefore got through that rather lengthy</p> <p>7 route to an ICRP recommended level?</p> <p>8 A. Yes, that's the ICRP recommended limit for a member of</p> <p>9 a the public.</p> <p>10 MR JUSTICE BLAKE: Right. And at 6 the authors, therefore,</p> <p>11 you understand to be saying, despite the uncertainty</p> <p>12 factors earlier, that doesn't affect the overall safety</p> <p>13 limits ultimately coming from ICRP?</p> <p>14 A. Yes.</p> <p>15 MR JUSTICE BLAKE: Right.</p> <p>16 MR HEPPINSTALL: When you were giving your evidence on this</p> <p>17 subject earlier, you said there was some doubt about the</p> <p>18 United States Environmental Protection Authority</p> <p>19 figures.</p> <p>20 A. There was doubt expressed in this paper.</p> <p>21 Q. Is that at the top of page 42?</p> <p>22 A. Yes, it is. I haven't read the whole paragraph but that</p> <p>23 is the paragraph which I was recollecting.</p> <p>24 Q. It says:</p> <p>25 "The UCPA analysis calculated age and gender average</p> <p style="text-align: center;">Page 173</p>	<p>1 it just didn't go into the same depth.</p> <p>2 Q. Thank you very much.</p> <p>3 Details of the Washington survey from 1975 were put</p> <p>4 to you. I don't want to go back to that but I do want</p> <p>5 to show you another document, another one we will be</p> <p>6 handing up from B8B62.</p> <p>7 A. Which bundle is this?</p> <p>8 Q. It's going to arrive just in a moment. (Handed)</p> <p>9 Operation Dominic.</p> <p>10 MR JUSTICE BLAKE: So this is extra to our core bundles so</p> <p>11 another candidate for 22?</p> <p>12 MR HEPPINSTALL: Yes, SB22/14. It comes from the library.</p> <p>13 MR JUSTICE BLAKE: Yes.</p> <p>14 MR HEPPINSTALL: It's an extract. The full report is in the</p> <p>15 library, but I've just extracted it. This is a report</p> <p>16 on Operation Dominic, which I think I can lead, which is</p> <p>17 the series of operations that followed on</p> <p>18 Christmas Island --</p> <p>19 MR JUSTICE BLAKE: We've come across Operation Dominic.</p> <p>20 MR HEPPINSTALL: Yes. We were looking at an environmental</p> <p>21 survey of Christmas Island on 1975. If you turn to the</p> <p>22 last page of this extract --</p> <p>23 A. Page 2?</p> <p>24 Q. Yes. You will see that between 25 April 1962 and</p> <p>25 11 July 1962 there was a range of other nuclear tests</p> <p style="text-align: center;">Page 175</p>
<p>1 risk co-efficient but used an obsolete representation of</p> <p>2 the lung and did not use a probabilistic approach when</p> <p>3 including bio-kinetic uncertainties."</p> <p>4 Is that the sort of doubt or criticism that you were</p> <p>5 referring to?</p> <p>6 A. Yes. Again I'm not an internal dosimetry expert and so</p> <p>7 I couldn't amplify that but yes, it is.</p> <p>8 Q. I'm not entirely sure how a representation of the lung</p> <p>9 becomes obsolete but there we are.</p> <p>10 A. The dose models and the models that they use have been</p> <p>11 developed over the years and a more sophisticated model</p> <p>12 has been adopted now, has been developed now.</p> <p>13 Q. Now there's another paper in the next tab that I confess</p> <p>14 to be a little confused by. It's by Puncher. But the</p> <p>15 text and Harrison disappears, although he is credited --</p> <p>16 thanks are given to him for reviewing and providing</p> <p>17 comments on the manuscript. But it seems to me that</p> <p>18 this is the same text or very text. For example, table</p> <p>19 4.1 seems to now be table 6. Those conclusions at the</p> <p>20 end of the paper appear to be the same conclusions.</p> <p>21 Is it as far as you are concerned the same paper?</p> <p>22 A. I believe it is a summary paper of the more detailed</p> <p>23 paper which we just looked at.</p> <p>24 Q. Right, fine.</p> <p>25 A. It's designed for publication in a journal and I think</p> <p style="text-align: center;">Page 174</p>	<p>1 conducted on, over or off Christmas Island.</p> <p>2 A. Yes.</p> <p>3 Q. Is it incorrect or correct that when you are considering</p> <p>4 the results of environmental surveys at Christmas Island</p> <p>5 after 1962 you'd have to take into account the fact that</p> <p>6 there had been both British tests and these US tests?</p> <p>7 A. You would have to, and the scale of the US tests was</p> <p>8 larger than the British test.</p> <p>9 Q. I should say that in that list, just to be clear, there</p> <p>10 are two tests on 11 May and 8 July which were not in</p> <p>11 fact related to Christmas Island. One was south west of</p> <p>12 San Diego and the other one was --</p> <p>13 MR JUSTICE BLAKE: We'd better --</p> <p>14 MR HEPPINSTALL: -- Johnson Island. So Swordfish --</p> <p>15 MR JUSTICE BLAKE: Swordfish is non-Christmas Island.</p> <p>16 MR HEPPINSTALL: That's an underwater, yes. And Starfish</p> <p>17 is --</p> <p>18 MR JUSTICE BLAKE: Starfish?</p> <p>19 MR HEPPINSTALL: -- Johnson Island.</p> <p>20 MR JUSTICE BLAKE: 8 July.</p> <p>21 MR HEPPINSTALL: 8 July.</p> <p>22 MR JUSTICE BLAKE: But all the rest are Christmas Island,</p> <p>23 are they?</p> <p>24 MR HEPPINSTALL: Yes. In fact, if you look at the text it</p> <p>25 says:</p> <p style="text-align: center;">Page 176</p>

<p>1 "Christmas Island ... Accept as noted." 2 MR JUSTICE BLAKE: And the curious reader will be informed 3 as to the nature of the explosive activity going on? 4 MR HEPPINSTALL: At the time when this report was published, 5 or made unclassified by the United States Government, 6 the description of the yield is only given as 7 intermediate, low megaton, low. I think there is public 8 domain information that gives you more information, but 9 I don't think it is verified by the United States 10 Government. So I think they stick to intermediate, low, 11 high. 12 MR JUSTICE BLAKE: Without being specific as to -- 13 MR HEPPINSTALL: What I can tell you is that Yeso, 14 10 June -- I can get you the reference -- Mr Johnston 15 worked on that test and that is equivalent to the R3 16 megaton explosion in Grapple Y so they described that as 17 low megaton. 18 Hopefully that doesn't get me into any trouble. 19 Right. SB11/2, please. 20 MR JUSTICE BLAKE: Since I am just about to put this in my 21 tab 14, just give me a second. 22 MR HEPPINSTALL: Certainly. (Pause) 23 MR JUSTICE BLAKE: Which tab are we looking at? 24 MR HEPPINSTALL: 2. 25 MR JUSTICE BLAKE: 2.</p> <p style="text-align: center;">Page 177</p>	<p>1 humans?" 2 He answers: 3 "The first step would be simply [I think he means to 4 use] the decay half life effect to reduce the activity 5 associated with ... fission fragments and neutron 6 activation products with time." 7 I think you've already referred to that yourself. 8 A. I have, yes. 9 Q. Then he says: 10 "Fallout on the sea would be dispersed quite quickly 11 through the natural motion of the sea." 12 Do you agree with that? 13 A. Again, I've made a similar point. 14 Q. "This effect would be less apparent in the case of 15 freshwater where the radioactivity from the fallout 16 would collect in the sediment and where it could be 17 transferred to the food chain by feeding off fish and 18 shellfish." 19 Do you agree with that? 20 A. Yes. 21 Q. Have you taken into account that last sentence in your 22 report? 23 A. Yes, I've considered the potential ingestion dose from 24 activity falling into a lagoon, and then assumed that 25 somebody would drink 4 litres of water, drinking water,</p> <p style="text-align: center;">Page 179</p>
<p>1 MR HEPPINSTALL: Tab 2, Professor Regan's first report. 2 MR JUSTICE BLAKE: Yes, Regan 1. 3 MR HEPPINSTALL: Turn to page 44 and paragraph 189, please. 4 MR JUSTICE BLAKE: Yes. 5 MR HEPPINSTALL: You were asked questions about 6 radionuclides being in the sea, Mr Hallard, and here we 7 have Professor Regan considering that question. He 8 says: 9 "There are no reports in the defence papers 10 [referring to the Secretary of State's papers] of 11 contamination of fish following the Grapple test. 12 Direct neutron activation of sodium 23 and chlorine 13 nuclei in the seawater would give rise to some 14 relatively short-lived activity which should have been 15 evident in any flyover of the region close to the 16 explosion using gamma ray dosimetry equipment. For 17 fallout which fell on to open seawater this would most 18 likely be dispersed quite quickly and diluted down by 19 the natural wave motion of the seawater." 20 Do you agree? 21 A. Yes, I do. 22 Q. Then at 193 he is answering the question: 23 "What steps should have been taken to remove all 24 fallout that fell out on to land and on to freshwater in 25 the sea to make these areas safe to occupy and use by</p> <p style="text-align: center;">Page 178</p>	<p>1 a day from that lagoon and that's one of the pathways 2 that I've considered in my report. 3 MR JUSTICE BLAKE: A lagoon? 4 A. The lagoon water. There are lagoons on the Island, 5 my Lord. 6 MR JUSTICE BLAKE: Freshwater lagoons, are they? 7 A. I think most of them are saltwater lagoons but -- 8 MR JUSTICE BLAKE: Quite. But people drink 4 litres of 9 seawater? 10 A. There are one or two lagoons which are referred to as 11 freshwater near the southern part of the Island. The 12 reason I've included it is again the video that 13 I referred to earlier from the Imperial War Museum 14 actually showed water being sucked from a lagoon into 15 a bowser which was then going to be treated and used as 16 freshwater. So the assumption that I made -- and 17 perhaps I didn't make this very explicit in my report -- 18 the assumption that I made is that it would either have 19 gone through some sort of desalination plant, although 20 that would have removed the activity, or that they were 21 sampling from the small number of freshwater lagoons on 22 the Island. I believe that most of the lagoons are 23 actually saltwater but it was a conservative assessment 24 that I made based on that assumption. 25 MR JUSTICE BLAKE: Yes.</p> <p style="text-align: center;">Page 180</p>

<p>1 MR HEPPINSTALL: On that topic of seawater monitoring that 2 Professor Regan mentions, SB17, tab 8, back to the Clare 3 report, please. 4 At page 7 at the bottom of that page we pick up the 5 heading "Seawater monitoring". Paragraph 34: 6 "Seawater immediately below a nuclear detonation is 7 exposed to neutrons. These neutrons are absorbed by 8 sodium in the water to give rise to sodium-24 which is 9 radioactive and has a half life of 15 hours." 10 Is that correct? 11 A. Yes. 12 Q. "Seawater was monitored by three methods. Firstly, 13 sensitive monitoring instruments were carried by low 14 flying aircraft in flight patterns designed to locate 15 any radioactivity that might be present in the sea 16 immediately after the detonation." 17 Is that your understanding? 18 A. Yes, it is and I think that was one of the principal 19 purposes of the Shackleton survey. 20 Q. "Secondly, samples of seawater were collected by 21 helicopter in the vicinity of Surface Zero shortly after 22 the detonations and [something] at Christmas Island. 23 "Thirdly, Her Majesty's ships made measurements of 24 radioactivity in waters through which they sailed." 25 Is that your understanding?</p> <p style="text-align: center;">Page 181</p>	<p>1 The reason that the sea was radioactive, if I can 2 put it like that, was that the neutrons which were 3 emitted from the detonation would have been absorbed in 4 the sodium in sea, the seawater obviously contained 5 sodium chloride, but that sodium is obviously not 6 radioactive but that would have absorbed 1 neutron from 7 the detonation which would have then turned it into 8 a radioactive nuclide. 9 MR JUSTICE BLAKE: That's why they are particularly 10 interested in seawater. 11 A. Yes, so it's effectively converted from 1 nuclide, 12 called sodium-23, which is stable sodium into another 13 nuclide called sodium-24 which is radioactive sodium. 14 That is the nuclide which has got a half life of about 15 15 hours. 16 MR JUSTICE BLAKE: Okay. I am just trying to get back to 17 drinking water. 18 A. Right. 19 MR JUSTICE BLAKE: Drinking water would not be seawater 20 unless it's been desalinated. 21 A. That's correct, my Lord. 22 MR JUSTICE BLAKE: If it's been desalinated then the very 23 hypothesis that you are exploring would have been 24 contraindicated because it would have filtered out -- 25 A. It would have taken out the radioactive salt. But they</p> <p style="text-align: center;">Page 183</p>
<p>1 A. Yes. I'm less certain about the last sentence but 2 certainly the helicopter. I believe the last sentence 3 is also true but I am just less certain about that. 4 I suspect that the missing word at the start is probably 5 "counted". I think it's probably "counted at 6 Christmas Island" because the seawater samples certainly 7 were taken back to the Joint Operations Centre and 8 counted. 9 MR JUSTICE BLAKE: I am reading this whilst holding in my 10 head the answers that you just have given me about 11 lagoons. Am I right in thinking that this report 12 doesn't refer to freshwater lakes, as I shall call them? 13 They refer to rainwater monitoring and something about 14 recommended drinking water, but I don't think we've got 15 anything about lakes? 16 A. No. There's nothing in this report at all from memory 17 about the lakes. What they are particularly talking 18 about here, particularly at the bottom of page 7, that 19 final sentence, "The samples of seawater were collected 20 by helicopter", again that's described in some detail in 21 the residual radiation measurements paper which we 22 looked at earlier. So a helicopter flew over Surface 23 Zero, it effectively flew on a grid pattern until it 24 found the highest level of radiation from the sea and 25 then took a sample of that.</p> <p style="text-align: center;">Page 182</p>	<p>1 wouldn't have been drinking this material. If 2 I remember correctly -- ah yes, they do and I think this 3 is probably what's causing the confusion. Although 4 they're talking about sodium-24, radioactive sodium in 5 seawater, they are then comparing the level that they 6 measured with the maximum level for drinking water. 7 I think simply because they probably had nothing else to 8 compare it with. 9 MR JUSTICE BLAKE: Yes. 10 A. So there is an element of apples and pears there. 11 MR HEPPINSTALL: I think what my Lord is doing is pursuing 12 the question of whether drinking water itself was 13 tested. 14 A. Ah, I see. 15 Q. In your reports, correct me if I'm wrong, but you 16 consider possible contamination to a water lens below 17 the surface. 18 A. That's one of the two. 19 Q. And the allegation made in respect of that water lens 20 that I think you take into account is that it was 21 potentially contaminated from effluent from where the 22 planes were being decontaminated. Is that right? 23 A. That's correct. 24 Q. Have you taken into account that potential contamination 25 of that water lens which was used for drinking water?</p> <p style="text-align: center;">Page 184</p>

<p>1 Have you taken that into account in your dose 2 assessment?</p> <p>3 A. I have. But there is also a second element, which is 4 the one I was just referring to, where I looked at 5 direct deposition of activity. If the activity is 6 deposited on the ground then it would also be deposited 7 on a lagoon, a lake if you prefer. Although a lot of 8 the lakes were saltwater --</p> <p>9 MR JUSTICE BLAKE: I always thought a lagoon was the area 10 between the coral reef and the island which is where the 11 fish go. But never mind about that.</p> <p>12 A. I am just looking at the map actually.</p> <p>13 MR HEPPINSTALL: Please use it. It has been sat there.</p> <p>14 A. This is the same map I've been using although it's not 15 a particularly clear copy.</p> <p>16 MR HEPPINSTALL: Mr Verma will hold it for you.</p> <p>17 A. So it was particularly the fact that I saw on the video 18 that they were extracting small quantities of water from 19 the lagoons and that's the reason that I've included it.</p> <p>20 Now, I think quite a lot of these lagoons are 21 referred to in two places. One is the Lorna Arnold 22 report. She makes a very passing reference to lagoons 23 being saltwater, and I think the other place that refers 24 to lagoons being salt, again a passing reference, is in 25 the New Zealand survey it just refers to lagoons as</p> <p style="text-align: center;">Page 185</p>	<p>1 very rapid calculation that would be the equivalent to 2 28,000 grams of carbon-14.</p> <p>3 Q. 28,000 grams of carbon-14 in all UK shots?</p> <p>4 A. That's based on the upper end, the 2,000 moles.</p> <p>5 Q. So 1,500 plus 500?</p> <p>6 A. Yes.</p> <p>7 MR JUSTICE BLAKE: So 1,500 plus 500 moles is 20?</p> <p>8 A. That's 28,000 grams --</p> <p>9 MR JUSTICE BLAKE: 28,000 grams?</p> <p>10 A. -- of carbon-14.</p> <p>11 MR JUSTICE BLAKE: 2.8 kilograms?</p> <p>12 A. 28 kilograms.</p> <p>13 MR JUSTICE BLAKE: 28.</p> <p>14 MR HEPPINSTALL: 28,000.</p> <p>15 MR JUSTICE BLAKE: Yes.</p> <p>16 MR HEPPINSTALL: Mr Hallard, the only note of caution which 17 you may wish to express is that that paragraph is 18 entitled "Mosaic, Buffalo, et cetera", so "from all UK 19 shots" I think is at best, perhaps you would agree, 20 ambiguous as to what shots are being considered?</p> <p>21 A. Yes, it is. I hadn't remembered that detail from this 22 report, but you are quite right, that does raise 23 a question mark as to what they are referring to. In 24 fact they go on to the Grapple series later so I'd 25 forgotten that detail.</p> <p style="text-align: center;">Page 187</p>
<p>1 being salt.</p> <p>2 But again I looked at this and in some places it 3 does refer to shallow freshwater lagoons.</p> <p>4 So I've just made a conservative assumption that 5 that is where the drinking water was being extracted 6 from that I saw on the video and that then formed the 7 basis for that second assessment of drinking water.</p> <p>8 MR JUSTICE BLAKE: Right, okay. But the shallow freshwater 9 lagoons did not appear to have been mentioned in the 10 Clare report?</p> <p>11 A. No.</p> <p>12 MR JUSTICE BLAKE: Right, okay. Thank you.</p> <p>13 MR HEPPINSTALL: Just as the cross-examination was 14 completing you mentioned that you thought in the 15 documents somewhere there was a measurement of 16 carbon-14. If you turn to SB13, tab 43 --</p> <p>17 A. Tab 43?</p> <p>18 Q. SB13, tab 43. I think, or rather I know, this is the 19 record of the exercise undertaken to gist information in 20 classified documents into open, and I think you 21 mentioned the gist in answer to questions.</p> <p>22 A. I did.</p> <p>23 Q. And at paragraph 3 there is a last sentence there. Is 24 that what you had in mind?</p> <p>25 A. It is. That's the sentence that I remembered and from a</p> <p style="text-align: center;">Page 186</p>	<p>1 Q. Yes, that was my fear.</p> <p>2 A. Thank you for identifying that.</p> <p>3 Q. There we are. That's the figure that you recall.</p> <p>4 A. Yes, but it may not be relevant to the Grapple series 5 from what you are saying.</p> <p>6 Q. You have not used ECRR dose co-efficients in your 7 assessment. Why not?</p> <p>8 A. I think for the reasons that I said before, that the 9 ICRP is taken as the international standard, the 10 international benchmark, and the data from that is used 11 directly in the International Atomic Energy Agency, 12 that's the IAEA basic safety standards, in the EU 13 Directive basic safety standards. It's used 14 internationally.</p> <p>15 MR JUSTICE BLAKE: I mean certainly if you are doing 16 something in the UK about emissions of radiating ions 17 you'd have to use the EU regulations --</p> <p>18 A. You would.</p> <p>19 MR JUSTICE BLAKE: -- and their enabling provisions. Well, 20 the regulations are directly effective, aren't they?</p> <p>21 A. Yes.</p> <p>22 MR JUSTICE BLAKE: Because that's the legal requirement, and 23 the tracing of the parentage of that legal requirement 24 is the ICRP?</p> <p>25 A. Yes.</p> <p style="text-align: center;">Page 188</p>

1 MR JUSTICE BLAKE: And you told us about the other body.
2 MR HEPPINSTALL: You were cross-examined for a lengthy
3 period of time, Mr Hallard. Is there anything that
4 causes you to materially alter your upper dose
5 assessment set out in your report?
6 **A. I don't think so. Not from memory, no.**
7 MR HEPPINSTALL: No further questions, my Lord.
8 MR JUSTICE BLAKE: Well, thank you very much. That
9 concludes your evidence, you'll be pleased to know.
10 Thank you for joining us over the last three days.
11 THE WITNESS: It has been a pleasure, my Lord.
12 (The witness withdrew)
13 MR JUSTICE BLAKE: You can return to Cumbria. I hope it's
14 not raining there.
15 Good. Thank you. It's 4.15. I shall rise.
16 So shall we resume tomorrow at 10.00 or 10.30?
17 MR HEPPINSTALL: Dr Haylock, 10 o'clock?
18 MR JUSTICE BLAKE: 10 o'clock.
19 MR HEPPINSTALL: Yes.
20 MR JUSTICE BLAKE: We'll see where we get to at 4.30. Thank
21 you very much. 10 o'clock tomorrow then, please.
22 (4.15 pm)
23 (The court adjourned until
24 Wednesday, 22 June 2016 at 10.00 am)
25

Page 189

1 INDEX
2
3 MR RICHARD HALLARD (continued)1
4 Cross-examination by DR BUSBY (continued)3
5 Questions from the Tribunal116
6 Re-examination by MR HEPPINSTALL.124
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

Page 190

A	179:21 184:20,24 185:1	additionally 159:11 160:22	123:22 143:6 151:8 155:16	8:22 48:9
A1 153:6	accumulated	addressed 11:2	157:16,20 167:23	altitude 131:17 155:8
A3 132:21	110:10	addresses 169:1	168:17,24 169:7	altitudes 155:14
A4 132:21	accurate 77:11	adequately 44:1	169:13,21 170:1	altogether 67:11
AB6 78:1	159:22	adjoined 189:23	171:9,11,18	aluminium 28:19
AB61275 77:19	accurately 12:3	adjournment 51:11	178:20 179:12,19	ambiguity 167:10
abandon 72:23	acronym 163:20	82:22 115:2	187:19	ambiguous 187:20
Abdale 121:17,19	acronyms 163:17	adopt 11:24	agreed 85:23 88:17	amount 18:17,19
122:8	163:18	adopted 12:19	110:20 157:8	20:14 25:11 84:5
ability 36:22 98:7	activation 68:21	174:12	agreeing 88:12	89:8 96:20 110:19
able 9:25 25:3	178:12 179:6	adopting 12:23	ah 31:4 64:10 100:4	110:22 143:18
31:10 35:21 43:25	active 162:22,24	adult 32:24	114:4 116:21	amounts 158:7
58:14 59:7 76:9	163:1	adults 170:19	117:3 125:12	amplification 5:16
95:22 98:19 99:8	activities 115:14	adverse 29:17	128:1 137:14	amplify 174:7
108:1,3 133:12	activity 15:7 18:7	adversely 139:13	152:8 166:25	analogue 146:12
141:5 143:13	18:11 22:11,20	aerial 129:2	184:2,14	analysed 81:11
147:20 170:2	25:1 28:14 30:12	aerosol 59:25 60:17	aimed 35:17	analyses 170:16
absence 11:25	34:22 50:4 80:3,4	affect 32:5 151:6	air 60:24 84:20	analysis 26:17
36:16 159:16	81:14 82:1,3,17	168:22 173:12	88:1 127:12 128:7	61:22 71:25 74:12
absent 14:8	84:18,20 86:24	afraid 1:9 29:3	129:12 139:10	173:25
absolute 109:18	87:5,10 89:14,17	33:5 34:17 90:20	150:23 155:12	animal 111:5,6
absolutely 137:14	89:23 90:1 104:25	109:18 132:23	aircraft 1:19 2:13	animals 64:18
137:18	115:15,16 122:22	131:14,16 132:1	89:25 90:1 118:1	annex 108:13,13,18
absorbed 100:10	130:15,21,22	134:14,17 181:14	131:14,16 132:1	109:11
102:8 103:22	149:8 160:1	airfield 132:3	134:14,17 181:14	annexes 108:11
121:25 181:7	162:13,14,16,16	Aldermaston 75:20	air 60:24 84:20	110:7
183:3,6	163:23,23 164:1,2	alert 160:13	88:1 127:12 128:7	annual 172:23
absorption 104:2	164:12,17 165:1,3	129:12 139:10	150:23 155:12	Anscombe 166:1
abstract 66:17,24	165:6,12,13,17	150:23 155:12	184:2,14	answer 6:19 7:17
90:20	166:4 177:3	184:2,14	aircraft 1:19 2:13	8:18 10:13,22
abundant 62:24	178:14 179:4,24	134:14,17 181:14	89:25 90:1 118:1	12:21 14:24 19:16
accept 4:13 39:17	180:20 185:5,5	Agency's 6:10	131:14,16 132:1	22:25 24:17 31:3
93:25 94:7 96:16	actual 39:16 68:22	ago 6:12 64:9 75:23	134:14,17 181:14	31:20 34:1 35:10
102:21 103:4	69:18,25 146:21	85:11 92:2 108:9	airfield 132:3	38:19,21 43:20,23
177:1	162:16	127:25 131:8	Aldermaston 75:20	45:16,19 46:23,25
acceptable 102:6	add 96:23 97:9	188:11	alert 160:13	75:7 85:22 91:2,6
170:25 171:13,21	133:14 152:14	Agency's 6:10	allegation 184:19	97:5 98:22 101:19
171:25 172:17	159:25	ago 6:12 64:9 75:23	allowed 18:8 21:10	102:10 103:5,6,6
accepted 28:12	added 123:24,25	85:11 92:2 108:9	allowing 34:24	103:7 105:12
29:5,7 56:2 94:3	153:16,19	127:25 131:8	alongside 171:1,14	106:13,17,17,18
94:21 95:18	adding 153:16	188:11	171:21	108:16 109:6
109:24	addition 130:19	agree 9:13 14:9	171:21	112:14 114:8
accident 159:17	142:4	21:11 25:10 29:2	alpha 20:6 27:13	119:12 120:10,18
account 54:11	additional 8:25	43:11 47:15 56:9	27:15,19 28:6,11	124:10 142:5
59:11 70:21	36:9 70:21	57:7 59:13 66:20	104:19 106:21	158:4 186:21
119:10 176:5		67:5 72:10 73:3	144:24 145:7,8,10	
		79:14 84:4,15	146:1,2 147:13,23	
		85:12,23 86:5	148:2 157:3 158:6	
		87:23 88:25 89:3	158:8 159:5,9,14	
		90:9,11 91:19	159:15 160:12	
		101:20,21 103:16	161:16	
		105:21,24 108:6	alphas 27:25 28:1	
			alter 189:4	
			alternative 7:2 8:10	

answered 12:17 106:3	174:2	arrive 175:8	25:18,20 60:11	72:17 73:4 74:20
answering 15:12 81:17 140:22 178:22	approaches 7:2	arrived 16:2	87:16,17 92:24	85:14 88:1
answers 20:4 37:15 38:15 44:12 104:14 108:24 109:4 128:23 172:3,3,10 179:2 182:10	appropriate 7:8 36:11 154:25	Artillery 139:6	118:1 149:18,22 179:24	average 153:2 173:25
anticipation 115:11	appropriateness 28:10	ash 14:6	assuming 84:17	avogadro's 111:10
anxious 115:10	approximate 2:22 18:16 40:22 69:5 69:9,15 115:16 148:12	ashore 85:14 88:1 90:25	assumption 23:4 56:9 123:13 132:20 180:16,18 180:24 186:4	avoid 134:10 147:4
anybody 37:1 47:8 158:19	approximately 2:23 3:7,8 20:19 22:17 81:22,23,25 102:22 103:23 106:2 110:9 120:5	asked 3:23 7:3 17:25 19:25 22:10 24:8 32:21 37:17 38:20 39:2,18 44:16 51:10 56:15 82:20 91:4 97:3 126:5 131:8 138:8 140:15 141:23 142:9 150:12 163:22 165:23 178:5	assumptions 13:15 52:11 54:23	aware 6:25 7:13,18 8:14,16 11:19 12:6,12,13,18,22 14:16 16:11,16 47:20 68:4,8,10 71:11 85:2 86:8 101:13 142:15
anyway 15:10 27:9 39:17 42:4 85:18 88:9 103:14 106:16 140:3 167:15	April 175:24	asking 4:10 17:2,11 47:2,14 58:13 72:10 73:1 85:21 114:19 130:4 139:1	atmosphere 60:18 61:1 89:19 155:9	AWE 3:14 18:23
apart 41:8,10 66:2 76:13	Archie 93:2 95:18	aspects 101:18	atoll 14:25	awful 110:17
apologise 172:7	archive 56:24	assent 65:6 126:23	atom 99:3,4,4	awkward 46:24
apparent 179:14	archives 61:13	Assert 11:17	atomic 6:10 69:4 78:16 98:6 102:25 103:18,20,23 153:18 188:11	AWRE 140:13
appear 65:2 158:15 174:20 186:9	area 4:9 9:15 22:7 22:11,16,18,22 24:3 27:9 29:16 34:25 37:22 61:4 67:9 71:14 93:22 105:22 109:14 110:15 124:17 125:4 127:13 130:22,24 135:9 142:14 149:5,21 150:5,24 155:18 185:9	assertion 16:7 23:8	atoms 102:8 104:3 104:4 105:8,9,16 105:16,18,19	<hr/> B <hr/>
appeared 29:22 64:12 140:1	areas 22:14 26:20 36:25 50:4 66:21 178:25	assess 130:6	attempt 53:10	B 38:19 128:17 129:19 131:24 132:5,13,14
appears 65:18	argue 24:13 40:23	assessing 119:11 170:7	attempted 109:8 148:22	B4/19 124:21
appellant 42:18	argued 161:11 169:9	assessment 46:13 71:20 86:22 92:16 107:14,18 108:4 121:16 170:6,21 180:23 185:2 186:7 188:7 189:5	attempts 8:5	B8B61 138:21
appellants 1:10 20:12	arguing 39:16	assist 20:1 77:5 97:5	attention 27:21 67:12 158:19 162:7	B8B62 175:6
apples 184:10	argument 9:17 38:24	assistance 1:11	attenuation 32:4	back 23:9 39:14 43:18,24 53:18 61:7,7 64:8 77:18 77:20 84:18 87:10 95:12 113:25 119:18 126:20 138:10 145:7 148:6 150:11 156:15 158:22 161:23 167:12 175:4 181:2 182:7 183:16
application 168:22	arguments 95:19 161:15	associated 23:5,19 179:5	Australia 144:8 147:19	background 100:15,22 102:1 143:8,11,15,20,22 143:24 148:13,15 148:18 149:6,10 149:14 150:6,6,8
applied 70:1,2 169:9 170:8	arisen 25:21 47:3	association 65:18	Australian 127:9 144:7	background-setti... 120:11
apply 12:2 45:19 46:3	Arnold 185:21	assume 9:1 16:4 18:18 22:19,25 23:24 26:16 60:3 79:17	author 160:21	badge 126:17
applying 29:19,22 36:9 54:1	arrangements 124:15	assumed 22:1	authoritative 13:9 41:13,14 43:15 47:9 64:12 71:17 76:4	
appreciate 58:17 118:4			authorities 11:23	
approach 8:11 9:22 10:4 11:25 36:5 45:24 46:12 51:15 51:18,24 54:1			authority 12:19,23 55:4 173:18	
			authors 144:10 171:11 172:9 173:10	
			available 36:23	

badges 127:6,9,11 127:15	behaviour 153:24	better 9:23 41:16	27:20,24 28:3,21	103:5,13,21,25
balance 51:2	believe 5:12 7:8	41:19 43:16 48:20	28:24 29:4,13,16	104:5,8,13,21
balancing 43:4	13:11 14:22,24	62:4 72:20 95:14	29:20,24 30:15,20	105:12,20 106:16
barely 138:3	21:15 23:7,23	101:15 108:9	31:3,5,12,20,25	106:19,22 107:6
base 140:6	24:17 26:21 28:7	118:25 166:10	32:21 33:2,5,20	107:10,12,20,23
based 7:10 17:11	35:1,20 36:24	176:13	34:1 35:2,4,10,12	108:5,15,21,24
18:22 25:9 43:9	37:18,22 42:24	Bevis 18:23 71:2	37:25 38:4,6,10	109:3,10,21 111:2
45:7 52:10 57:10	50:11,16,24 52:9	81:10,11,21	38:13 40:4,7,9,11	111:4,6,11,14,18
57:17 59:10 64:15	74:20 75:17 86:12	beyond 46:22 53:22	40:15,17,21 43:20	111:21,24 112:2,4
81:20 92:1 94:22	88:5 93:8 104:7	60:22 72:21 88:5	43:23 44:2,6,12	112:8,13,23 113:1
107:14 123:13	110:7 118:21	91:24 101:12,16	44:16,20,24 45:11	113:7,12,15,22,24
136:15 141:9	120:19 127:20	105:2 108:19	45:15,23 46:1,4	114:5,7,11,13,17
143:9 173:3,4	133:10 138:1,3	109:19 110:13	46:10,12,15 47:2	114:19,23 115:7
180:24 187:4	146:22 147:12	170:22	47:8,13,19,25	115:10,13,18,22
bases 55:1	155:17,19 166:10	big 100:5 104:2	48:17,23 49:5,16	115:24 116:1,5,8
basic 6:10,15	174:22 180:22	119:25 157:22	49:19 50:13,15	116:11,14,19,22
188:12,13	182:2	bigger 33:25	51:9 52:1,3,12,15	117:1,4,6,9,16,19
basis 25:12 36:24	believed 25:7 34:12	100:23	52:19,25 53:3,6,9	117:24 118:4,7,10
38:24 54:24 57:22	bench-mounted	bind 5:8	53:12,17,19,25	118:20,22,24
80:17 186:7	141:4	binding 4:7 5:18	54:15,18 55:11,15	119:5,14,17,20
Battersby 39:13	benchmark 6:8	8:7	55:17 58:9,13,17	120:9,16,20,24
42:19 44:4	188:10	binds 4:4	58:21,24 59:3	121:2,5,7,10
Battersby's 42:6	benefit 138:9	bio-kinetic 174:3	61:9,19,25 62:4,7	122:8 125:19,21
45:3,24	best 36:22 72:17	biological 4:11	62:10,12,17,20,22	125:23 126:1
Battersby/Smith	73:3 74:19 109:18	biologists 11:13	63:2,4,20,23 64:1	129:19 132:7,10
38:21	158:23 169:16	bit 1:13 36:20	64:5,7 65:10,20	132:13,15,23
battery-operated	187:19	37:19 42:9 49:8	67:1,14,20 70:3,7	133:4,13,18
145:18	bet 138:7	51:6 123:24 160:8	71:7 72:19 73:1	134:16,19 137:6,9
Bay 27:3 130:16,22	beta 20:7 28:10	bite 92:12	73:12,17,20,25	137:11,19,21,24
135:22 136:21	29:8 30:9,12,17	biting 92:10	74:5,13 75:6,15	138:2,5,13,16,23
137:2,4,11,15	30:23 31:5,11,13	black 66:12,21,22	76:24 77:2,8,13	138:25 139:3,21
138:6,12	31:21 32:3,4,12	67:6 96:11	77:21,24 78:8,10	140:2 141:1,11
bearings 162:18	32:14,15 99:1,2,5	blah 33:9,9,9 79:9	78:12,14 79:2,4,6	144:2,4,12,14
becoming 140:11	99:6,6,9,12,15,16	79:9	82:11,14,19,22,25	145:5,15,22,24
becquerel 22:5	100:2,5,12,16,24	BLAKE 1:15,17,22	83:2,6,9,12,16,21	146:1,4,6 147:5,9
80:4,8 82:17,18	100:25 101:23	2:2,5,7,9,11,17,25	83:25 84:24 85:20	147:12,15,18
114:3 163:23	102:2 103:2,3	3:17 6:19 7:13	86:5,7,15,19	148:3,18,20,22
becquerels 80:6,11	104:20 105:6,9	8:14,18 10:13,22	88:12,15 90:18,22	153:7,9 154:4,20
82:8,9 114:6	144:24 146:1	11:1,9 12:6,13,17	91:4,7,10,14,22	154:23 155:3,25
115:17,19,21,22	147:24 148:25,25	12:22 13:1 14:21	92:3,11 94:5,9,12	156:4,8,11,18,20
143:4 165:2 166:9	149:15 150:8	14:23 15:3,6,10	94:16,22 95:4,11	160:7,11,20
beg 111:13 168:5	157:3 159:7,8,12	15:12,15,18 16:15	95:13,16,21 96:1	161:11,14,19,23
began 3:6 116:23	159:16,23 160:2,8	16:18,22 17:1,6	96:5,7,9,15,18,22	162:1,11,18,25
beginning 124:13	160:17,18,23	19:2,7,9,12,16,21	97:1,5,8,11,15,18	163:3,6,10,18,21
168:4	161:12	19:24 20:16 21:1	97:23,25 98:17	163:25 164:9,19
	betas 30:13 32:11	21:12 23:15 27:17	101:17 102:10	165:5,17,20,22,25

166:7,11,14	181:4 182:18	49:6,17,20 50:20	28:11 31:15 56:17	careful 108:19
167:24 168:1,3,7	bound 4:22,24	54:19 55:12,14,16	69:18 114:3	carefully 108:14
168:10 171:10,17	bounds 12:3	55:18 58:10,12	calculated 20:19	carried 15:21 68:4
172:2,6,13,19,22	bowser 180:15	59:4 61:10,12,20	23:11 45:7 173:25	102:13 130:9,20
173:1,3,5,10,15	box 82:15 86:22	62:1,5,9,11,13,18	calculating 45:8	131:15 140:23
175:10,13,19	89:6 138:6 146:10	62:21,23 63:5	calculation 18:10	155:9 181:13
176:13,15,18,20	166:3	64:2,23 65:11,13	19:13,25 20:8	Carter 9:8 57:3,4
176:22 177:2,12	break 48:17,18,20	65:24 67:5,16,21	22:12,21,24 23:1	57:14,15 58:20
177:20,23,25	48:25 49:3 85:21	70:6 71:8 72:24	25:25 46:21 50:17	59:8,10 68:14,19
178:2,4 180:3,6,8	113:12,13 114:24	73:2,3 75:9,10,14	50:23 51:3 52:6	69:10,23 70:18
180:25 182:9	154:24 156:13	75:16 77:14,23,25	68:12 72:11 82:10	71:17 72:7,15
183:9,16,19,22	breakdown 18:20	78:3,9,15 79:3,5,8	82:16,19 115:9	73:3,15 74:2,10
184:9 185:9 186:8	briefly 3:23 67:23	82:13,18 83:3,8	147:23 165:23	74:14 75:11 77:2
186:12 187:7,9,11	bring 24:11 25:11	83:11,13 84:1	187:1	112:16,19,22
187:13,15 188:15	26:8 94:23	85:2 86:8 87:23	calculations 13:16	113:1,2 143:25
188:19,22 189:1,8	bringing 113:17	88:22 90:21,24	22:5 47:22 50:12	145:17 147:6
189:13,18,20	brings 24:15,16	91:8,11,16 92:4	50:13,14 54:2	148:6 150:11,14
blank 117:6	Britain 64:20	92:12 94:7,15,20	55:2 67:25 70:9	153:15
blast 128:8	British 144:8 176:6	95:6,7,12,15,17	72:12 73:21 76:19	case 15:5 17:10
blistering 164:23	176:8	95:24 96:2,8,10	104:6 107:12	18:5 22:16 39:2
blow-off 88:7	broadly 29:7 76:10	96:16 97:3,7,10	115:11 121:12	45:3,24 55:5
blow-up 116:24	brought 85:13	97:12,16,22 98:2	165:9	66:15 67:9 79:15
132:7	87:25 90:24	101:20 102:11	call 77:18 99:10,11	79:20,22 88:5
blowing 90:19	Buffalo 187:18	103:9,15 105:21	182:12	91:8 94:20 100:5
blown 84:19	built 45:9	106:23 108:6	called 2:3 18:22	104:24 111:16
board 41:21 56:17	bullet 95:24 96:3,4	109:23 112:11,15	28:16 62:23 69:12	161:16 162:1
127:13,16	96:10	112:25 113:4,11	84:11,19,22,24	179:14
bodies 90:5	bundle 33:4 77:17	113:13,21,23	103:20 124:5	casing 68:22
body 41:7,13,14	97:20 127:23	114:16,18,22,25	140:18 142:17	casual 35:6
87:1,2 100:17	135:16 154:18	115:4,8,25 116:2	183:12,13	catch 141:22
104:24 105:5,6,8	166:5,10 175:7	116:4 150:13	Camp 27:8 93:18	caught 168:10
105:17 110:12	bundles 175:10	154:1 190:3	Canada 64:21	cause 39:1 91:20,21
152:6 154:9 189:1	burns 164:23,25	Busby's 1:4 15:12	Canberra 127:12	causes 111:9
boiling 96:11	bursts 155:8	16:13	cancers 39:1	155:11,13 189:4
bomb 28:18 68:13	Busby 2:10 3:18,19	business 93:4	candidate 125:21	causing 11:24
68:20,22 70:15,16	6:21 7:21 9:3	Butterworth 79:10	175:11	102:1 184:3
70:19 82:4 93:24	11:11 12:11 13:4		capable 88:17	caution 35:17
94:2,15	15:21 16:11,16,19	C	capacity 147:10	36:17,18 109:14
bombs 18:7 20:12	16:24 17:5,6,17	C 38:19 108:13,18	carbon 105:8 110:2	109:20 187:16
73:4,5,7,7	20:3,21 21:3,14	109:11 131:24	110:8 113:17,20	cautious 34:19
book 69:12 156:6	23:16 27:24 29:13	132:5,14	carbon-14 106:25	35:16
borrow 163:18	29:25 30:19 31:18	cable 146:15	107:3,11,14,16	caveat 110:5
bottom 14:1 79:3	31:23 32:4 33:1,4	caesium 161:8	108:6,10,22	cent 26:4 39:14
127:3 129:24	33:6,21 34:2	162:13 163:24	109:16 110:8,10	50:2 54:12 132:25
130:1,7 136:20	35:15 38:14 40:22	164:3,6 165:1	110:17,22 112:3	centimetres 30:22
152:19 159:1	43:22 48:1,12,20	calculate 18:11	186:16 187:2,3,10	30:25 31:16,17,22

32:10 centre 43:1 135:17 182:7 CERRIE 3:22 10:3 10:5,8,15 11:8,9 36:6,7 37:7 41:8 42:23 46:16 47:6 47:8 certain 11:20 60:25 71:18 164:1 182:1 182:3 certainly 15:11 25:3 26:25 27:2 32:15 39:25 72:15 78:24 105:23 109:7 143:14 147:14,16 177:22 182:2,6 188:15 cetera 44:10 76:9 77:11 87:3 160:24 187:18 chain 179:17 challenge 75:7 chance 75:8 103:5 change 39:11,13 changed 39:9,11 56:13 93:20 chap 94:12 characterised 84:16 Charles 16:17 161:21 162:3 chart 116:23,24 check 112:6,7,8 143:24 164:24 166:10 chemistry 4:12 childhood 91:20 chloride 183:5 chlorine 178:12 choices 37:4 chosen 37:2 Christmas 15:16 21:1,2,4,19,24 22:8 37:3 61:15 61:17,18,21 62:5	63:1 67:13 69:11 89:13 91:1 119:11 124:15 126:12 128:16,18 130:9 132:3 135:3 137:3 137:8 139:25 140:5 143:10 147:20 154:3 175:18,21 176:1,4 176:11,22 177:1 181:22 182:6 chronology 118:25 circumstances 60:14 citation 58:21,22 cite 117:1 cited 57:7 59:9 66:16 139:5 Clare 135:14 136:8 136:11 143:9 158:22 181:2 186:10 clarification 1:13 clarify 123:16 133:12 clarity 132:4 classification 19:3 classified 72:17 186:20 clear 39:19 40:1 134:23 139:17 143:23 167:17 168:14 176:9 185:15 clearer 2:13 clearly 21:25 23:3 24:1 35:6 60:20 89:15 95:17 98:20 101:2 136:2 clicks 143:4 close 43:1 83:9 85:15 113:18 153:3 178:15 closer 9:21 cloud 21:22 22:12 22:13,15,16,22	24:14,14 25:1 28:14,15 50:4 96:11 127:13 134:19 clouds 93:24 co-deposition 157:1,9,12,14 158:1,4,6,21 159:22 co-efficient 8:23 49:23 53:13 104:11,12 169:9 169:19 174:1 co-efficients 5:22 6:2,3,14 8:9 32:23 33:9 36:8 38:3,5,7 41:10 44:9 45:6 46:18 47:23 48:3 69:20,23,24 70:1 70:2 88:3 166:17 169:5 170:7,8,13 171:7 188:6 co-written 34:10 coal 14:5 coal-fired 14:6 coast 85:3 coefficient 42:25 coincidence 95:2 colleagues 116:17 118:24 collect 140:12 179:16 collected 128:20 181:20 182:19 collective 56:18 collectors 128:15 column 34:9 39:21 40:7 41:1 48:7 50:18 51:24,25 52:7,13 63:10 122:14 164:13,13 164:20 columns 33:11 35:7 35:8 45:1 136:25 COMARE 10:3,11 10:14,18 42:24	44:13 combination 84:17 come 5:17 9:4 21:12 22:23 23:9 64:8 77:18 87:10 100:11 108:22 113:25 120:21 121:23 124:5 134:12 175:19 comes 43:24 44:6 123:20 175:12 comfortable 74:13 coming 25:12 54:21 74:9 84:18 134:20 148:6 173:13 comment 8:22 10:1 12:5 17:2 29:17 34:12 42:24 43:18 54:9 60:23 64:5 67:8 80:2 91:23 93:2 96:18 101:17 101:18 149:13 163:22 commenting 125:8 comments 21:13 101:14 142:23 168:19 174:17 committee 6:3 8:5 10:6,8,11,15 11:8 11:9 41:9,25,25 46:16 47:6 Committee's 7:15 common 34:20 123:15 commonly 110:25 communicating 47:16 communication 47:18 compare 4:1 76:9 184:8 compared 159:9 comparing 184:5 comparison 32:22 33:8 86:13 166:24 competent 11:3	compilations 136:15 complete 137:2 completed 114:14 completeness 134:10 completes 105:12 116:5 completing 186:14 comply 169:11 component 23:21 87:22 103:15 122:21 123:2,3,6 123:12 134:21 components 122:10 concede 58:1 conceded 16:13 17:5 59:23 110:2 concentrate 148:13 concentration 23:16 concentrations 60:18 62:3 63:6 63:11,16,18 68:23 68:23,24 69:19,25 70:23 161:12 concept 59:14 88:7 111:9 147:2 concern 18:4 concerned 77:8 126:13 127:19 174:21 concerns 42:1 84:11 conclude 15:25 concluded 34:23 59:8 72:8 104:18 113:19 134:13 concludes 152:20 189:9 conclusion 24:22 29:21 104:18 171:4 conclusions 32:5 36:7,7 110:16 167:15,22 174:19
---	--	---	--	---

174:20 condensation 59:24 condense 21:22 condensing 28:14 conditions 56:20 58:2 conducted 176:1 confess 152:2 174:13 confidence 36:12 38:10 44:21 confident 36:4 confirm 48:2 64:8 64:14 75:20 135:23 136:4 144:15 151:24 167:2 confirmed 75:22 135:5 confused 36:20 51:7 174:14 confusion 111:9 134:10 184:3 connection 53:12 consensus 17:14 consequence 59:24 102:12 conservative 19:4 51:1 52:10 57:17 57:19,25 180:23 186:4 consider 3:25 6:2 10:14,18 13:9 41:12 47:9 60:15 64:2 75:10 76:13 86:20 106:11 108:25 134:11 184:16 considerable 86:24 86:25 96:19 109:15,20 consideration 43:13 101:8 106:9 considerations 32:9 41:8 considered 4:5 10:5	57:17,19,24 60:19 61:2 91:16 140:10 169:10 170:18,25 170:25 171:13,14 171:21 179:23 180:2 187:20 considering 176:3 178:7 consistent 64:19 170:20 constituent 66:1 constrained 36:15 constraints 56:17 169:12 contact 86:1 149:17 contained 17:12 67:6,7 74:8 94:19 110:19 183:4 contains 6:13 14:7 79:24 94:10 contaminant 79:25 121:8 contaminate 37:2 contaminated 21:24 92:14 118:2 120:15 123:14 131:9,14 140:11 150:18 184:21 contamination 22:3,3 25:7,8,19 25:20 26:13,16,22 27:1 87:15,17 88:2 118:12,12 119:6,9,11 120:4 120:21 128:10 129:16 132:1 134:13,14,16 135:10 140:20 143:19,21 145:19 149:15,17,21,22 149:24 150:9,25 160:18 178:11 184:16,24 contemporary 125:14 136:13,14 136:16	content 154:11 context 44:2 46:20 119:21 139:23 140:14 162:25 164:7 169:19 contingency 159:20 continue 48:15 49:1 continued 1:3 3:18 190:2,3 continues 1:5 continuously 48:22 contradict 156:1 contraindicated 183:24 contrast 31:25 contribution 122:12 control 124:17 125:4,9,10,15 convection 155:11 convenient 114:20 156:10 conversation 75:19 75:19 114:1 conversion 2:22 convert 18:12 41:4 converted 51:21 183:11 copies 78:9 124:21 138:21 copy 132:23 137:12 167:9 185:15 coral 14:8,19,21,22 14:23,25 15:1,4,9 15:11,18,25 16:14 63:15,16 64:3 65:14 154:4,6,10 185:10 core 74:24 175:10 corner 133:25 correct 8:12 13:8 16:6 19:6 37:18 40:25 42:2 54:22 65:1 69:2,21 70:10,16,19 72:1	73:8 75:21 76:15 80:16 81:5 98:13 99:22,23 110:18 121:1 122:16 127:17,22 129:14 129:25 130:4 132:20 133:16 136:23 137:5 144:21 151:2,8 153:15 155:17,19 156:2 157:5,6 170:10 171:4 176:3 181:10 183:21 184:15,23 corrected 56:11 Correction 131:16 correctly 12:9 29:6 34:10 64:13 108:12 109:13 119:23 132:22 133:1 141:3 160:17 184:2 correlate 133:5 Cossack 95:10 cough 60:21 count 143:8,12,17 143:23 148:16 149:2,3,6,10,18 counted 182:5,5,8 counter 28:5 30:2 31:5 129:21 counters 27:11 30:6,17 31:21 93:5 141:1,2,12 145:7 counting 51:16 counts 142:18 143:1,14,14,23 146:12 149:19 couple 75:24 course 4:6,17,19 7:4 18:8 21:22 32:16 48:22 65:13 65:13 66:24 76:4 76:18,20 81:21 87:6 89:24 101:6	133:5 139:18 148:6 158:20 160:1 court 189:23 cover 139:14 covered 131:18 covering 60:20 create 24:1 149:1 credited 174:15 creep 113:6 crews 127:12 critical 13:14 criticism 158:5 174:4 cross-examination 1:4 3:18 114:15 114:17 124:14 128:23 129:4,11 129:15 130:25 139:7 152:17 155:21 156:16 186:13 190:3 cross-examined 135:15 136:14 156:24 157:2 161:20 162:23 189:2 cross-examining 141:16 cross-refer 132:10 crucial 133:7 crudely 146:17 cruel 72:4 CSMTR 163:10 cubed 60:25 Cumbria 85:4 189:13 curious 177:2 current 6:13 10:21 12:4 90:12,15,18 90:24 currently 10:20 47:23 currents 87:3 90:9 90:10,11,17 cut 49:16 73:12
--	---	---	---	---

cut-off 132:24	Decca 130:16 135:4	deposited 60:5,9	detect 31:11 32:14	141:5,6 144:10
cytoplasm 4:25	136:20 137:4,10	122:22 149:8	32:15 140:20	146:25 147:3
	137:11,13,21,21	185:6,6	143:13 145:7,24	157:21
	137:22 138:3,11	deposition 25:14,22	147:13,20 148:2	difficult 46:22
D	Deccas 137:20	57:10 60:6 124:1	detectable 29:12	86:21
D 38:19 190:1	decide 116:17	185:5	143:19	difficulty 22:11
dah-di-dah 96:2	decided 8:10 38:17	deposits 14:5	detected 31:14	23:2
data 41:17 64:8	115:5 159:9	depth 31:12 72:6	130:15,21 145:10	dig 94:13
70:18 71:17 72:7	decision 37:20 43:9	75:5 175:1	detecting 147:19	diluted 89:11
72:15,16,17 73:3	127:4	Derek 95:9 96:2	detection 141:10	178:18
73:3,7,11 74:11	decisions 13:15	derivation 168:22	159:8	diluting 4:2
74:12,19,19,22	Declaration 12:7	derived 5:23	detector 141:8	dilution 86:23
76:4 81:21 82:24	12:15 37:9 41:9	170:24 171:12,20	149:21	87:12,20
128:20 140:12	decontaminated	desalinated 183:20	detectors 141:6	dip 161:23
148:10 188:10	184:22	183:22	detects 144:24	direct 26:22 119:21
date 58:19 79:17	deduction 27:5	desalination	149:15	122:21 149:17
daughter 14:7	deep 30:22 31:7	180:19	detonation 21:21	178:12 185:5
day 1:6 66:24 76:24	32:10	describe 52:16	28:15 89:16,16	Directive 6:16
92:9 118:13,21,22	deeper 31:22	described 1:8 9:5	118:17 120:5,8,23	188:13
119:25 120:2,4,13	122:25	10:4 52:8 84:16	120:24 121:2	directly 147:13
148:14 153:14	deeply 93:15	139:12 144:19,20	157:5 159:6,19	188:11,20
157:1 180:1	defence 178:9	151:22 152:15	181:6,16 183:3,7	disagree 17:9 47:14
days 68:25 87:8	defined 169:10	177:16 182:20	detonations 89:15	81:2 155:16
153:14,14,14	definite 24:25	describing 153:24	113:3 181:22	disappeared 77:17
160:16 189:10	definitely 138:12	157:3	develop 75:7	disappears 174:15
deal 63:24 78:23	definitive 170:3	description 52:14	developed 174:11	disappointed 59:6
109:13 116:16	degree 75:2 133:2,8	126:21 127:17	174:12	108:1
117:20 119:17	degrees 133:2,9	129:25 130:4,7	device 159:18	discovered 68:16
155:1	delay 12:2	131:6 132:17,18	169:6	discuss 10:19 24:19
dealing 83:17	Delete 62:12	134:5,8 141:9	devices 73:18	26:18,18 72:6
116:19 120:20	demonstrated	146:8 151:2	DFR 163:16	discussed 26:24
129:24	132:2	152:18 159:22	diagram 93:8,11,11	53:23 57:15 66:24
deals 83:16 94:9	density 21:5	177:6	132:5,20,23 133:2	70:17 77:5 83:19
dealt 77:3 110:12	depend 60:23 68:25	design 76:22,23	133:6	157:21
120:10	79:15 101:3	designed 174:25	dial 146:11	discussing 114:22
debate 29:20 96:20	104:23 144:25	181:14	Diego 176:12	discussion 4:7
96:22,23 105:3	dependable 13:9	desirable 128:8	dies 154:10	16:11 18:5 28:8
157:7	55:4	despite 154:10	difference 76:16	28:13 32:7 51:10
debris 155:9	dependent 59:19	172:19 173:11	100:9 119:25	57:14 115:4
decay 69:3,16 74:3	59:20	detail 67:24 73:9	differences 17:14	163:19
74:4 87:9,20	depending 30:25	73:24 121:14	different 5:17 8:13	discussions 59:15
153:5,10,23 179:4	30:25 70:12 90:18	182:20 187:21,25	38:18 41:2 51:15	dispersed 87:5
decayed 29:11	161:15	detailed 5:4 34:11	51:18 62:1 66:14	89:19 155:14
161:6	depends 27:15	141:9 174:22	70:9,10,14 73:8	178:18 179:10
decaying 87:7	76:22 147:21	details 79:9 175:3	73:20 76:3,5	dispersing 159:18
160:1	deposit 74:7	detain 158:18	95:14 139:1 140:3	dissipated 89:11
decays 4:22				

dissolve 28:19	38:3,5,7,19,19,19	173:17,20 174:4	112:25 113:4,11	182:22
dissolved 84:18	38:19 39:7,10,12	Dounreay 163:12	113:13,21,23	earth 60:3 133:9
distance 85:6 90:2	39:15 42:6,19,25	163:13,16	114:16,18,22,25	ease 159:8
133:7,8	44:8 45:6,8 46:2	downwind 120:7	115:4,8,25 116:2	easier 117:11 132:8
distances 90:5	46:18 47:23 49:23	Dr 1:4 2:10 3:18,19	116:4 121:11,16	east 90:13
distinguish 99:9	50:2,19 51:23	6:21 7:21 9:3	121:20,22 122:3	easy 132:11 147:2
distinguished 5:9	53:13,16,21 54:11	11:11 12:11 13:4	122:13,17,20,23	eating 92:16
distributed 60:12	56:17 57:10 68:11	15:12,21 16:11,13	123:1,16,19,22	ECR/210 7:18,23
distribution 68:12	69:22,24 70:2,9	16:16,19,24 17:5	124:2,4,6,9,11	ECRR 8:3,5 9:20
71:4 105:4	76:13 77:10	17:6,17 20:3,21	150:13 152:5,14	9:22 10:24 12:2
disturbed 150:19	100:15,23 101:2	21:3,14 23:16	154:1 166:1	41:9 188:6
DNA 4:4,8,12,13	104:10,11,18	24:20,21,24 27:24	189:17 190:3	ECRR/210 12:8
4:14,20,22,24 5:1	107:14,18 108:1	29:13,25 30:19	dragging 152:17	ED 164:21
5:9,18 105:2	109:8,16 110:8,9	31:18,23 32:4	draw 27:21 28:4	effect 4:22,24 69:11
document 1:8 6:11	121:16,24,25,25	33:1,4,6,21 34:2	67:12 109:3	69:12 98:4,5
8:17,24 10:3 12:9	122:1,4,14,19,20	35:15 38:14,25	158:19 162:6	99:14,14,20 102:5
18:23,24 62:4	123:7,9,19,20,25	40:22 43:22 47:17	drawing 51:9	102:7 103:23
70:5 71:2,2,12	127:7 131:17,22	48:1,12,20 49:6	110:15	104:16 106:10
72:20 73:22 77:3	131:24 143:9	49:17,20 50:20	drawn 32:5 132:21	155:12 179:4,14
77:6,21 78:5,10	149:7 162:10,12	54:19 55:12,14,16	drink 179:25 180:8	effective 53:16
83:6 93:7,12	164:12,15 166:17	55:18 58:10,12	drinking 179:25	56:18 122:1,19,20
94:18 95:5 124:19	167:18 168:15,21	59:4 60:7 61:10	182:14 183:17,19	123:9,20,25
125:19 131:4	169:5,5,9,11,19	61:12,20 62:1,5,9	184:1,6,12,25	167:18 168:15
136:5 140:3,8,14	170:6,8,12 171:2	62:11,13,18,21,23	186:5,7	188:20
151:25 175:5	171:6 172:23	63:5 64:2,23	drop 160:2,3,15	effectively 28:19
documents 54:8	174:10 179:23	65:11,13,24 67:5	droplet 157:23	34:5,7 44:23 45:9
83:13 93:13 136:3	185:1 188:6 189:4	67:16,21 70:6	dry 25:14,22 60:6	57:20 79:25
136:13,14,16	doses 5:8,24,24	71:8 72:24 73:2,3	135:10	106:15 129:6
186:15,20	8:13 9:13 36:23	75:9,10,14,16	due 25:21 26:20	141:3 182:23
doing 36:4,14,19	36:25 37:5 38:25	77:14,23,25 78:3	56:20 131:25	183:11
64:11 74:1 115:11	39:9,16 40:24	78:15,17,20 79:3	148:6 155:10	effects 11:18 33:8
120:6 125:17	42:16 54:22 57:9	79:5,8,8,10 81:6	158:20	101:9 156:6
143:7 147:22	68:5 69:18 72:14	82:13,18 83:3,8	dust 59:13,15 60:16	157:21
160:7 184:11	107:2 127:10	83:11,13 84:1	dusty 56:20 58:2	efficiency 143:5
188:15	dosimeter 127:18	85:2 86:8 87:23	59:20 60:14	effluent 184:21
domain 177:8	dosimetry 4:5,10	88:22 90:21,24		eighth 62:21
dominate 70:12	5:5,11 7:9,14 11:6	91:8,11,16 92:4	E	either 41:5 90:12
105:19 161:4	36:14 45:24 46:13	92:12 94:7,15,20	E 129:10 190:1	112:19 145:2
dominated 159:13	101:13,18 104:10	95:6,7,12,15,17	Eakins 5:14 85:8	148:14 161:7
160:24	105:23 144:9	95:24 96:2,8,10	106:20	180:18
Dominic 175:9,16	162:20 170:2	96:16 97:3,7,10	earlier 32:7 59:14	ejected 99:4
175:19	174:6 178:16	97:12,16,22 98:2	68:11 84:1 118:14	electron 99:3
dose 3:24,25 5:21	double 51:16	101:20 102:11	118:21,22 119:24	electrons 103:19
5:22 6:1,2,14 8:22	doubt 9:18 43:11	103:9,15 105:21	120:1,13,17 145:6	element 102:25
9:23,24 23:11	43:17 46:22 67:3	106:23 108:6	163:19 172:4,20	103:14 109:1
32:23 33:8 36:1,8	134:6 147:5	109:23 112:11,15	173:12,17 180:13	184:10 185:3

<p>elements 98:6 elusive 77:17 emerge 30:12 emerged 77:21 78:5 112:17 eminent 11:13,15 emissions 27:13 30:9 102:17 104:19,20 188:16 emitted 99:1 105:7 183:3 emitters 10:16 159:7,14,17 161:16 emitting 20:6,7 32:6 159:5,12,15 160:23 employed 140:6 employee 152:5 employing 11:17 empty 78:7 enabling 188:19 encountered 164:25 ended 55:20 energy 6:10 30:13 30:25 78:16 98:23 98:25 99:16,25 100:1,10 101:25 188:11 England 5:14 58:25 59:2 104:16 enhanced 101:2 enormous 89:8 enriched 79:11,16 79:18,19,22 81:9 ensures 169:11 entirely 1:9,10 14:23 15:4,8 174:8 entitled 19:24 136:12 187:18 entrainment 24:12 92:23 95:8 96:17 97:6 environment 59:21</p>	<p>64:3 100:14 159:11 environmental 14:10,10,11 33:22 34:22 37:10 41:12 41:24 42:2 43:15 63:18 88:6 173:18 175:20 176:4 EPA 76:14 epidemiology 144:10 equipment 178:16 equivalent 2:23 3:7 3:8,9,10,12,13 51:22 93:11 121:25 122:4,14 123:19 167:17 168:14,19 177:15 187:1 Er 72:2 era 58:18 error 11:21 38:12 44:18 errors 11:18 especially 43:14 essence 45:5 148:24 essentially 59:25 66:16 establish 170:12 Establishment 78:16 estimate 19:5,7,12 22:10 39:12 50:24 54:10 108:1 109:8 110:22 169:16 estimated 49:23 50:2 123:7 165:13 estimates 10:17 36:1 39:10,15 41:16,18 46:2 51:14 53:25 163:6 169:5 estimating 48:11 168:21 estimation 53:21 107:2</p>	<p>et 44:10 76:9 77:11 87:3 160:24 187:18 EU 188:12,17 European 6:3,15 7:15 evaporates 119:8 evasive 46:24 event 127:13 159:17 everybody 37:18 94:20 124:21,24 138:22 evidence 2:14 13:8 22:1 23:8 24:22 25:6 26:19,24 28:21,23 41:7 94:1,7,11 117:2 145:11 146:5 151:20 154:10 158:13 161:16 173:16 189:9 evident 178:15 exact 30:23 exactly 3:4 95:3 98:9 121:13 145:9 160:10,14 example 5:9 14:4 15:3 45:2 53:16 85:3 104:12 105:11 121:17 125:16 151:5 164:15 174:18 excess 127:7 exchange 113:16 165:10 exercise 7:14 129:12 133:15 160:9 186:19 exist 50:12 exists 85:12 expand 12:20 123:10 expanded 1:18 expect 63:14 102:24 103:8,9</p>	<p>143:13 164:22 expected 127:7 171:1,15 experience 89:25 experienced 119:25 experiment 152:17 experiments 57:17 expert 7:1 13:8 18:8,9 19:21 71:13 72:5,13 75:10 89:2 105:21 105:23 174:6 expertise 4:9 5:4 7:9 9:25 10:23 11:2,4 13:11,13 16:9 24:18,24,24 25:5 29:3,17 34:17,24 35:21 36:3,16 37:23 43:25 53:22 55:7 55:8 60:22 61:4 63:17 67:10 71:15 71:19,22,25 88:6 88:7 91:25 96:24 101:12,16 105:2 107:4,7 108:3,20 108:25 109:14,19 110:6,15 155:18 156:1 170:2 experts 7:1 11:13 97:8 explain 7:3 40:20 71:18 110:25 111:8 122:24 148:15 149:25 167:14 explained 8:19 10:23 54:24 73:14 116:23 117:25 121:24 162:23 explaining 7:4 149:12 explains 40:15 explanation 134:6 136:7 148:23 explicit 180:17</p>	<p>exploded 20:15 22:14 explodes 68:20 exploring 183:23 explosion 59:25 96:16 112:4 118:13 119:1 120:13 155:10,12 157:22 177:16 178:16 explosions 13:12 66:6 89:9 110:18 explosive 177:3 exposed 100:22 127:15 181:7 exposure 11:20 23:13 38:17 45:3 73:5 83:5,10,11 83:15 89:12 110:4 163:4 169:10,17 169:20 170:9 171:1,14,22 exposures 11:24 23:22 38:17 83:15 169:11 171:2,23 172:16 express 187:17 expressed 173:20 extended 161:5 extension 150:2 extent 13:7,13 16:19 21:24,25 99:22 101:2 107:5 external 23:11 76:7 121:24 160:25 externally 161:4 extra 49:8 175:10 extract 17:9 80:15 175:14,22 extracted 40:19 175:15 186:5 extracting 185:18 extraordinary 95:2 extreme 18:25 43:7 54:12 extremely 108:6</p>
---	---	---	---	--

110:3 150:9 151:16 eye 94:10	faint 137:16 fair 16:19 24:2 43:11 71:19 92:4 101:7 fairly 13:14 18:9 28:17 64:19 160:15 164:9 fall 22:25 23:3,5,6 89:10 153:23 157:4 fallen 24:7,9 89:24 150:4 falling 22:11 86:24 90:1 139:15 179:24 fallout 14:5 71:5,5 71:21,25 73:5 120:3 127:15 128:10,15,20 130:2 134:25 135:2,3,10 149:4 149:5 150:3,3 159:6 178:17,24 179:10,15 falls 90:15 140:8 false 16:23 familiar 71:9 73:22 88:7 89:21 126:8 168:9 famous 78:22 85:9 fantasy 16:11 far 4:25 51:24,25 58:8 66:23 91:12 101:21 111:14 174:21 fast 163:16 fatal 23:13,21 father 78:22 fear 168:5 188:1 February 141:17 feed 47:22 feeding 179:17 feel 36:3,11,14 110:13,14 feeling 43:24 105:15	fell 22:20 23:10,25 24:3 66:22 84:2,3 84:4,5,8 90:25 178:17,24 felt 22:19 24:25 34:23 41:15,16,18 107:4,9,17 108:1 108:2 Fiddaman 95:8 96:2,8 Fiddaman's 95:9 field 10:24 101:16 fields 56:21 Fig 97:25 figure 1:22,24,25 1:25 2:4,4 43:12 43:16 58:1 102:11 108:18 109:9,11 109:12 122:10 135:24 136:5 137:25 188:3 figures 41:1,6 44:13 81:16 109:12,12,16 121:23 173:19 film 126:17 127:6,9 127:10,15 filtered 183:24 filters 26:1,9 final 9:15,16 33:24 34:9 39:10 41:1 43:4 48:1 50:18 52:7,13 53:10 104:18 119:12 131:20 182:19 finally 137:2 164:18 find 37:6 40:6 52:21 56:5,23 57:1,9 58:19 59:7 59:7 63:14 81:11 81:12 107:8 112:13 114:20 122:6 124:14 126:25 127:24 131:5 137:3	139:11 152:6,13 168:8 172:13 finding 74:4 158:7 fine 31:23 60:2,4 114:23,23,23 174:24 fingernails 92:10 92:13 finish 49:8,9 finished 3:21 61:9 83:6 97:11,12 114:16 138:23,25 fireball 155:11 firing 131:16 first 1:6 4:12 13:22 13:22 23:7 28:8 38:14 49:22 55:9 55:11,15 87:4 89:14 96:2 98:2 121:22 126:12,21 128:2 129:24 135:18 139:10 148:1 152:19 154:2 155:5 156:19 162:20 165:10,24 167:22 168:12 169:2 178:1 179:3 firstly 41:13 181:12 fish 64:25 65:3,7,19 129:16 140:16,17 140:19,21,22 178:11 179:17 185:11 fission 22:2 23:4,10 23:17,20,25 28:16 29:11 68:21 69:4 70:16,19 71:4 73:4,7 74:22,22 74:25 75:12 87:7 160:5,14 161:3,6 161:8 179:5 five 124:7 153:14 154:23 flagged 18:5 flew 90:1 120:12,14	182:22,23 flight 118:14 120:17 121:2 131:6,14,25 134:6 181:14 flown 120:3 fly 14:6 flying 119:24 181:14 flyover 178:15 focus 94:23 fold 11:19 followed 175:17 following 155:10 178:11 follows 152:16 169:1 food 179:17 foot 135:5 footage 125:14 footnote 40:15 force 140:6 forgotten 93:14 187:25 form 26:21 46:13 86:1 88:15 99:1 159:10 formed 186:6 forms 147:22 forth 56:19 68:25 93:5 96:14 171:6 forward 95:19 124:16 125:4,6,9 125:10,15 126:25 146:6 Foskett 78:2 found 15:15,20 16:1 25:25 62:3 64:11 132:13 163:13 172:10 182:24 foundation 17:4 four 118:15 137:10 141:21 142:18 151:7 fractionation
---	--	---	--	---

157:21 fragments 179:5 frankly 74:20 fresh 63:24 freshwater 178:24 179:15 180:6,11 180:16,21 182:12 186:3,8 friend 130:4 front 117:12 146:11 fuel 163:16 full 76:8 175:14 fully 7:17 16:16 52:5 72:3 139:12 further 23:23 24:2 109:22 115:5 131:20 134:6 149:13 158:18 189:7 fusion 70:14 74:24	145:20 146:18 147:10 150:8 Geiger-Mullers 146:25 Geigers 27:14 146:25 148:24 gender 173:25 general 71:22 85:1 85:1 86:10 88:19 88:23,25 89:1 92:1 101:14 102:5 105:15 106:4 111:12 170:6,21 generally 18:5 59:23 60:21 72:15 89:12 110:2 113:11 geometries 147:1 getting 73:13 101:13,15 104:9 133:16 172:6 gist 18:23,24 19:4 71:2 75:21 81:11 110:20,20 111:18 186:19,21 give 1:12 9:22 10:13 46:25 63:7 82:5 103:5 108:16 122:3 126:1 148:10,22 158:12 177:21 178:13 181:8 given 2:21 8:18 10:22 19:4 24:7 33:6 37:16 63:15 87:20,20 108:17 119:20 143:2 151:5 152:4 153:13 169:17 172:15 174:16 177:6 182:10 gives 63:10 162:9 164:12 177:8 giving 17:7 62:7 151:20 172:3 173:16	glass 146:20 Glasstone 69:13 156:7 globe 89:20,20 155:15 GM 145:2,19 go 3:22 7:21 9:6 13:2 16:1 17:16 17:24 26:5 30:8 32:17 39:14 43:18 45:3 48:24 49:22 50:3 56:2 58:8 62:20 66:8 67:16 68:17 69:20 77:14 77:16 79:1 83:4 83:14 88:10 89:15 93:15 94:16 95:8 95:9,13,24 96:4 97:13 98:23 105:11 110:13 114:1,21,24 116:6 117:21 119:15,18 121:12,13 122:7 122:25 128:24 130:11 138:10 141:24 149:10 150:11 154:16 158:2 175:1,4 185:11 187:24 goatfish 65:2,3 goes 50:1 93:22 137:24 158:12 164:16,17 166:11 172:14 going 3:22 4:3 6:23 16:1,8,15,22,22 16:24 17:1 24:10 27:6,8 30:8,24 47:23 48:24 49:6 53:10 60:22 61:7 64:4 67:14 72:22 73:12 82:14 83:22 91:2 95:7,8,22 97:1 101:12,16 105:1 114:13 115:8 121:13	124:19 129:12 138:20 141:18 142:1 146:15 154:20 160:5,11 164:7 165:12 175:8 177:3 180:15 gold 102:17 103:11 good 3:19,20 41:7 48:12 51:6 64:12 72:16 96:7 98:8 98:10 115:25 189:15 Google 64:11 Government 177:5 177:10 gram 63:11 92:9 grams 21:6 60:25 187:2,3,8,9 Grapple 18:13,14 18:16,21 19:17 20:2 23:11 118:16 119:1 126:13,18 126:21 128:2,7 133:22 135:19 136:12 140:8,9 177:16 178:11 187:24 188:4 grasp 118:25 grateful 18:13 168:12 gravity 25:13 gray 3:10,11 164:13,15,17,21 grays 3:2 great 43:6 78:23,25 87:13 107:4 109:13 greater 4:23 10:17 11:21 19:8 22:18 44:17 87:15 99:22 109:17 160:18 greatest 130:3 135:19 greatly 68:25 grid 182:23	ground 60:5,10,12 88:2 122:22 124:1 128:18,22 142:3 142:13,15 149:8 185:6 grounds 128:9 131:13 groups 126:17 170:18 guess 58:8 66:18 GY 148:14 GZI 148:14
G				H
gamma 28:10 29:8 31:11 74:6,6,11 76:1 77:10 98:24 100:15,22 102:1,8 103:22 104:2 122:21 143:9 144:24 146:1 147:23 148:24,25 149:1,3,7,15 150:6,8 157:4 158:7 159:7,8,12 159:16,24 160:1,8 160:15,23 178:16 gamma-emitting 62:25 Geiger 30:16 31:5 31:21 93:5 129:20 141:1,2,7,12 145:6 146:21 147:25 Geiger-Muller 27:11,22 28:5 30:2,6 145:3,13				h 55:21,22 118:14 118:14 120:17 Haar 1:4,16 33:6 56:15 70:8 130:3 150:12 half 20:9 30:14 110:8,11 143:16 143:17 160:7 179:4 181:9 183:14 halfway 144:18 150:16 165:15 Hallard 1:3,5 36:20 38:14 71:13 91:2 115:6,8 124:24 148:5 167:12 178:6 187:16 189:3 190:2 hand 124:19,22 133:25 Handed 2:7,10 78:9 124:22 138:22 175:8 handheld 135:23 136:4 142:6,12 handing 175:6 handle 146:11,18 handled 127:11 handwritten 126:7 handy 139:2 hang 145:15 happen 24:1 58:4

85:19	67:2 91:15 119:16	128:7 135:23	102:12	Imperial 125:13
happening 170:10	121:12 140:14	136:4 149:4,23	Howard's 97:13	180:13
happens 95:1 98:25	helped 1:7	151:16 155:14	hu 14:5	implication 109:15
happily 159:21	helpful 20:21,22	177:11	huge 23:4 86:25	importance 89:12
hard 59:7 137:16	51:20 64:23 81:19	higher 9:13 26:13	90:5	important 69:24
Harden 127:21	107:9 117:16	26:16,21 33:21	humans 86:1 179:1	80:10 104:20
Harrison 5:13 34:5	121:11	37:10 43:8 45:21	hundreds 157:24	106:21 108:7
34:11 35:13 40:14	helpfully 106:3	64:22 74:10,23,25	hypothesis 16:23	109:1 164:8
41:2,6,15,20 45:2	116:22	76:7 80:5,9 98:7	118:11,12 183:23	improve 2:14
47:17 49:13	helps 51:12 54:5	104:2 105:17	hypothetical	inadvertent 92:7,8
161:21 162:3	166:23	149:9 155:8	100:20	92:11,12,19
166:15,19 174:15	Heppinstall 16:10	highest 25:25 26:5		inappropriate 74:2
Harwell 78:16	16:16,20 62:7,8	35:18 36:25 43:12	I	inch 30:14
Haylock 38:25	78:1 91:2 116:7,9	54:10 57:23 64:25	i.e 38:8	include 5:8 37:20
152:5 189:17	116:13 124:12,13	182:24	IAEA 188:12	77:7,9 107:2
Haylock's 152:14	125:20,22,25	highly 57:25 59:21	ICRP 4:1 5:7,12,20	included 5:7 11:14
hazard 79:10,11	126:3 129:23	128:8 162:22,24	5:21 6:1,6,13 7:15	52:6 57:2 86:11
108:7 128:11	130:7 133:19	163:1	8:19,25 10:17,20	92:16 112:16
159:11 160:23	134:24 137:7,10	highly-absorbing	10:20,24 11:17	180:12 185:19
head 19:22 182:10	137:12,14,18,20	101:10	36:8 38:7 42:23	includes 106:14
headed 33:18	138:10,15,19,24	Hiroshima 66:22	44:8,13,22 46:16	151:7
heading 130:12	139:1,4,20 140:4	67:6,7	47:6,8,17 48:3,5	including 34:15
134:25 181:5	141:12 144:3,5,13	historical 130:5	53:21 54:7 69:20	56:24 89:9 174:3
health 5:14 11:18	144:16,18 147:5	hits 98:24	101:8 104:11	inconsistency
34:20 35:16 41:22	148:4 149:11	HMS 95:10	106:10,12 167:17	136:2
45:21 58:25 59:1	153:8,10 154:6,22	hold 71:13 185:16	168:14,19,20	incorporate 51:14
59:2 68:2,5 71:15	155:1,4,7 156:10	holding 182:9	170:12 171:6	incorporated 50:21
71:20,22 78:19,22	156:15,19 158:15	homework 152:14	173:4,7,8,13	incorrect 16:5
84:10 104:16	161:20,25 162:3	honest 14:24 35:24	188:9,24	170:10 171:4
124:17 125:4,15	162:19 164:24	46:25 86:16	idea 20:14 48:23	176:3
hear 20:4	166:1,15 167:25	honestly 15:1	122:3 157:3	increase 46:2 91:20
heard 26:7 78:19	168:2,5,8,12	hope 54:4,23	158:21	102:2 150:6,7
78:23,24 84:24	171:11 173:16	189:13	Identical 99:17	increasing 76:13
101:14	175:12,14,20	hopefully 133:12	identified 29:1	indicate 44:14
hearing 1:6 17:25	176:14,16,19,21	139:9 177:18	113:8	106:20 120:3
28:22,23	176:24 177:4,13	hot 161:20 162:20	identifying 188:2	135:22 143:10
heat 155:10	177:22,24 178:1,3	162:25 164:25	ignored 37:6,8	148:13 170:16
heavy 21:16,17,18	178:5 181:1	hour 68:24 130:22	illness 9:24	indicated 1:7 2:8
26:15	184:11 185:13,16	153:13 164:13	image 98:13 99:19	2:21 127:14
height 74:7	186:13 187:14,16	hours 68:24,25	images 125:7,12	132:12,14 138:1
held 26:23 78:15	189:2,7,17,19	118:14,15 120:5	imagine 28:3	indicates 26:25
helicopter 129:6,8	190:4	120:18,19,21,25	imitate 146:16	135:3 145:2
181:21 182:2,20	high 22:2 34:13	121:3 153:13	immediate 68:23	indication 69:14
182:22	37:3,5 43:16	166:12 181:9	immediately 181:6	indicator 29:9
help 10:12 11:1	60:18 79:24 87:19	183:15	181:16	indistinguishable
12:20 26:6 33:5	89:18 98:6 107:15	Howard 97:21	impact 104:5	99:12

individual 34:19 35:16 69:16 73:10 76:3,22	instrument 129:20 140:24 141:4 143:11,15 144:21 145:12 146:13 148:13 149:2,6	introduces 8:25	68:9 140:11	June 1:1 177:14 189:24
individuals 38:16	instruments 26:23 27:1 128:19 135:23 136:4 147:3 149:5 181:13	introduction 128:5 140:4	isotope 66:4	jurisdiction 126:8
inferred 170:20	integrations 76:9	invalid 32:9	isotopes 9:7,8 14:16 56:18 69:17 70:11,14 75:3	Justice 1:15,17,22 2:2,5,7,9,11,17,25 3:17 6:19 7:13 8:14,18 10:13,22 11:1,9 12:6,13,17 12:22 13:1 14:21 14:23 15:3,6,10 15:12,15,18 16:15 16:17,18,22 17:1 17:6 19:2,7,9,12 19:16,21,24 20:16 21:1,12 23:15 27:17,20,24 28:3 28:21,24 29:4,13 29:16,20,24 30:15 30:20 31:3,5,12 31:20,25 32:21 33:2,5,20 34:1 35:2,4,10,12 37:25 38:4,6,10 38:13 40:4,7,9,11 40:15,17,21 43:20 43:23 44:2,6,12 44:16,20,24 45:11 45:15,23 46:1,4 46:10,12,15 47:2 47:8,13,19,25 48:17,23 49:5,16 49:19 50:13,15 51:9 52:1,3,12,15 52:19,25 53:3,6,9 53:12,17,19,25 54:15,18 55:11,15 55:17 58:9,13,17 58:21,24 59:3 61:9,19,25 62:4,7 62:10,12,17,20,22 63:2,4,20,23 64:1 64:5,7 65:10,20 67:1,14,20 70:3,7 71:7 72:19 73:1 73:12,17,20,25 74:5,13 75:6,15
inform 36:21	intend 83:13	invalidates 107:23 109:5	issued 6:12 127:11 127:15	
information 13:10 17:3 28:5 36:23 44:17,18 57:2,4 59:9 68:17 70:23 72:16 83:18 91:25 97:2,8 107:8,10 107:19 108:3,10 108:16 110:6 117:1,15 118:5 119:20 131:1,1 133:6 136:9 141:8 145:16 147:7 149:13 156:3,5 162:8 177:8,8 186:19	intended 35:23 38:8 42:22 54:16 167:17 168:14	investigated 118:13	issues 19:3 76:25 111:15 114:22	
informative 125:14	intents 99:2	involved 84:9,13,14 102:23	item 11:16 13:5 52:23 53:15,16,20 99:19	
informed 17:24 133:13 169:18 177:2	intercept 98:7,12	involvement 16:12	items 99:20	
ingestion 6:14 33:10 92:7,8,11 92:12,19 161:1 170:17 179:23	interested 29:13 46:7 183:10	involves 43:10	iv 117:24	
inhabited 27:9 50:4	interim 133:22	ionising 173:2	J	
inhalation 6:13 54:11 57:10 85:14 85:25 88:1,17 161:1,10 170:17	intermediate 177:7 177:10	ions 188:16	job 36:21	
initial 90:7 155:10	internal 4:4 5:5,10 5:22,24 7:8 10:16 11:5 36:1,14 69:18,22,24 70:9 101:13,18 104:10 135:17 167:19 168:16 169:17 170:2 174:6	Irish 85:4	Johnson 176:14,19	
initially 161:3	internally 161:4	irrelevant 112:9	Johnston 13:6,24 15:24 16:5,12 17:5 28:9 56:6 92:7 110:21 111:18 154:1 156:3 157:9 165:11 177:14	
inputs 72:10,11,12	international 6:7,7 6:9 7:11 8:19 188:9,10,11	island 14:14,18 15:16 21:1,2,4,19 21:24 22:3,8,18 23:3,6,10,17,22 24:7 25:7,9 26:14 27:2,3,22 37:3 50:5 61:15,17,18 61:21 62:5 63:1 63:15,18 64:3 65:8,15 67:13 69:11 84:3 87:16 87:18 89:13 90:3 91:1 119:11 124:15 126:12 128:16,18 130:9 130:21 132:3 135:3,4 137:3,8 140:5 143:10 146:25 147:20 150:4 154:3 175:18,21 176:1,4 176:11,14,15,19 176:22 177:1 180:4,11,22 181:22 182:6 185:10	Johnston's 55:1 56:3 63:15 96:20	
inquiry 112:9 164:11	internationally 188:14	island-specific 139:25	joining 189:10	
inside 98:11,11,25 99:19 100:18,21 100:24,24,25 101:1 102:3 146:21	interpret 50:25 162:12	Islanders 92:6	Joint 182:7	
insignificant 42:20 128:11	interpretation 43:10 75:21,22	islands 14:21,22 20:15 63:16 68:5	Jones 117:19 118:7 127:24 141:19 142:1	
	interpreted 164:4		journal 174:25	
	interrupt 7:13		judgment 7:7,7,10 7:10 9:25 38:12 46:23 54:4 61:3,4 169:18	
	intolerable 59:15 60:19 61:2,5		judgments 36:24 54:20,23	
	introduced 3:2 53:6		July 175:25 176:10 176:20,21	
			jump 16:20	

76:24 77:2,8,13	138:2,5,13,16,23	82:6	lagoons 180:4,6,7	legible 1:20 138:3
77:21,24 78:2,8	138:25 139:3,21	kilograms 4:2	180:10,21,22	legitimate 17:14
78:10,12,14 79:2	140:2 141:1,11	18:17 20:19 81:16	182:11 185:19,20	length 10:5 70:17
79:4,6 82:11,14	144:2,4,12,14	81:20,23,24,25	185:22,24,25	lengthy 173:6
82:19,22,25 83:2	145:5,15,22,24	157:24 187:11,12	186:3,9	189:2
83:6,9,12,16,21	146:1,4,6 147:5,9	kilometres 22:10	laid 135:8	lens 184:16,19,25
83:25 84:24 85:20	147:12,15,18	22:15,17,21,24	lake 185:7	Lesvos 12:7,15
86:5,7,15,19	148:3,18,20,22	27:9 85:15,16	lakes 182:12,15,17	37:9 41:9
88:12,15 90:18,22	153:7,9 154:4,20	90:3 133:9	185:8	let's 17:16 30:15
91:4,7,10,14,22	154:23 155:3,25	kind 11:1,2 27:6	Lally 85:9	34:1 40:22 42:9,9
92:3,11 94:5,9,12	156:4,8,11,18,20	60:21 84:20 87:3	land 65:14 85:25	67:1 100:1 102:23
94:16,22 95:4,11	160:7,11,20	102:22 108:4	86:2 87:10 88:16	114:21 117:10,11
95:13,16,21 96:1	161:11,14,19,23	125:16 164:23	90:16 178:24	117:21 157:1,11
96:5,7,9,15,18,22	162:1,11,18,25	kinds 54:21 59:13	lands 65:14	157:12 162:19
97:1,5,8,11,15,18	163:3,6,10,18,21	knew 36:14 58:18	language 164:10	167:15 171:9
97:23,25 98:17	163:25 164:9,19	99:8	large 38:15 39:8	letters 165:11
101:17 102:10	165:5,17,20,22,25	know 8:5 15:1,3,6,8	68:6 89:15,20	leukaemia 91:20
103:5,13,21,25	166:7,11,14	16:7,24 17:3	98:18 99:18 127:9	level 14:5 22:2,2
104:5,8,13,21	167:24 168:1,3,7	18:16 21:5 22:7	155:10	25:19 37:3 50:17
105:12,20 106:16	168:10 171:10,17	36:18,18 37:19,19	largely 69:22	57:23 64:16 87:15
106:19,22 107:6	172:2,6,13,19,22	38:19 39:18 42:3	158:14	87:17,19 130:22
107:10,12,20,23	173:1,3,5,10,15	46:5 47:3 48:13	larger 24:3 176:8	130:23 143:6
108:5,15,21,24	175:10,13,19	51:11 58:9,13	latitude 133:3,9	149:17,22 150:23
109:3,10,21 111:2	176:13,15,18,20	59:6 65:4,5,16,19	law 43:10	150:25 160:3,15
111:4,6,11,14,18	176:22 177:2,12	68:8 77:6 78:23	Lawrence 76:5	160:17,18 162:15
111:21,24 112:2,4	177:20,23,25	78:24 80:24 88:12	layer 31:9	164:1,5,5 173:7
112:8,13,23 113:1	178:2,4 180:3,6,8	89:24 90:10,17	layers 89:18	182:24 184:5,6
113:7,12,15,22,24	180:25 182:9	91:6,22,24 92:10	leaching 154:10	levels 14:14 25:8,24
114:5,7,11,13,17	183:9,16,19,22	102:21 123:1	lead 75:1 98:8,11	25:24,25 26:12
114:19,23 115:7	184:9 185:9 186:8	124:20 125:23,24	98:24 99:19 100:4	52:9,9,12 59:15
115:10,13,18,22	186:12 187:7,9,11	126:9 128:9	100:11,21 101:1,9	64:2,10,13,15,19
115:24 116:1,5,8	187:13,15 188:15	142:13 152:2	104:3 175:16	64:21,25 74:6,7
116:11,14,19,22	188:19,22 189:1,8	158:7 186:18	leads 11:18	76:1 77:11 100:7
117:1,4,6,9,16,19	189:13,18,20	189:9	learn 39:18	107:16 128:10
117:24 118:4,7,10	justified 10:19	knowledge 6:9	learned 130:3	135:8 149:4,24
118:20,22,24	131:13	known 18:23	leave 1:16 54:19	153:2 157:21,24
119:5,14,17,20		103:17 135:9	62:10 67:9,11	161:3 166:17
120:9,16,20,24	K	157:22 159:4,11	88:10 91:8,11,17	171:1,14,22
121:2,5,7,10	Karl 78:17	160:22	92:21 113:4,24	library 124:20
122:8 125:19,21	keep 19:22 21:12		lecture 111:12	138:21 175:12,15
125:23 126:1	127:5 139:2	L	led 147:12	life 110:8,11 160:7
129:19 132:7,10	keeping 125:19	L-E 111:4	left 26:10 39:3	179:4 181:9
132:13,15,23	Ken 13:6 157:9	lack 109:14 110:14	102:17 109:24	183:14
133:4,13,18	kept 166:18	lagoon 179:24	132:25 138:6	lifted 155:13
134:16,19 137:6,9	key 2:21 137:4,24	180:1,3,4,14	legal 188:22,23	light 74:15 90:2
137:11,19,21,24	kilogram 80:5,6,9	185:7,9	legibility 138:17	103:14 119:25

120:15 127:8 135:11 lighter 80:20 likelihood 157:16 157:25 limit 25:8 52:10 81:21 111:25 112:2 123:5 141:10 171:2 172:24 173:8 limited 32:12 limits 18:25 56:18 169:11 173:13 Lindsey 151:17,21 151:23 152:3,10 line 16:20 27:20 48:14,21 112:9 113:6 122:18 141:18 156:25 158:3 163:10 link 47:18 149:25 lips 92:13 list 8:8 9:3,3,8 18:1 128:14 166:11 176:9 listed 9:7 lists 63:6 litres 179:25 180:8 little 1:13 2:13 13:25 30:12 49:8 64:9 145:4,6 162:12 172:4 174:14 live 85:15 Livermore 76:5 lives 20:9 living 100:21 local 4:1 136:12 localised 26:20 locate 181:14 located 129:8 logic 29:22 logical 140:1 logically 28:3 London 27:4,6,10 138:14	long 82:24 85:10 110:8,10 114:10 long-lived 161:7 long-term 153:2 longer 29:12 34:11 160:19 161:14 look 2:12 6:9 8:21 23:19 24:8 32:21 39:15 46:6 49:6 52:22,23 53:15 55:10 63:9 64:24 66:17,18 73:6,12 75:23 76:17 81:10 86:13,16 93:1 102:11 111:11 121:7,16 129:23 134:7 135:14 137:4 138:20 139:11 140:4 141:17 142:19 143:8 146:17,18 146:20 152:1 154:8 156:24 159:3 167:15 176:24 looked 5:15 8:3 25:6 41:3,10 56:23 63:19,20,22 64:9,10 67:23 74:3,6 75:4 78:13 87:13 107:14,17 136:5 139:21 161:2 174:23 182:22 185:4 186:2 looking 3:22 34:21 37:5 49:12,13 56:23 76:24 104:16 117:6 122:7,17,18 125:3 137:2 163:3 166:16,24 167:1 175:20 177:23 185:12 looks 138:2 145:4 147:18	Lord 1:4,7,18 2:16 7:16 8:17 10:25 11:6,10 12:20 14:22 15:17 16:10 16:25 19:6,15,18 19:23 27:19,23 28:1,7 29:3 31:15 33:4 35:9 38:3,5 40:6 44:23 45:5 48:13 50:14 52:18 53:1,7,15 54:4,17 58:11,16 62:1,18 64:6 65:22 70:8 72:25 73:16,19,23 74:3,19 78:11 82:21 85:1 86:3 86:16 88:14 91:23 95:3 96:6,19,25 97:22,24 101:19 103:7 104:7 107:8 107:22 111:13,25 112:6,12 113:5,23 114:9,16,25 115:4 115:23 117:14 118:3 119:12,23 120:14 121:4 129:22 132:12 138:1 140:1,15 145:9,25 146:3 147:14 156:2,9,10 158:15 160:14 161:25 167:25 180:5 183:21 184:11 189:7,11 Lorna 185:21 losing 113:15 loss 37:19 lost 70:4 100:2 153:7 lot 4:7 26:3 28:7 30:4 57:13 68:9 81:8,12 84:2,10 84:11 87:1 89:16 105:5,9,18 110:17 111:9 112:5,7 146:8 156:5 185:7	185:20 lots 99:20 low 22:6 39:1 80:8 151:15 177:7,7,10 177:17 181:13 lower 42:13 161:13 Lucky 78:14 lunch 113:12,14 114:21,23 115:4 lung 174:2,8	M	M-O-L-E 111:3 M-O-L-L 111:2 MacDougall 139:6 139:22 magnitude 22:17 87:8 165:8 169:4 main 27:8,8 60:8 93:17 122:12,21 123:6 140:24 Majesty's 181:23 Major 139:6,22 making 13:16 60:21 120:1 122:9 169:18 Maldives 15:3 man 78:22,25 manage 17:6,8 manuscript 174:17 map 185:12,14 Maralinga 57:18 margin 23:22 margins 44:18 maritime 118:17 mark 119:5 187:23 marked 95:2 132:5 132:19 140:2 marry 172:2 Marshall 68:5,9 92:6 mass 17:12 18:7,12 18:20 20:6,11,16 20:18 60:24,25 61:1 80:4,16,17 87:21 104:24	Master 135:4 136:20 137:13,22 138:4,11 match 130:8 material 21:23 25:12 32:6 80:1 88:16 90:15,25 92:9,15 99:23 101:11 150:22,24 163:11 184:1 materially 189:4 materials 28:16,18 28:20 30:9 87:24 127:12 157:25 159:5 163:15 165:4 maths 105:11 matter 5:17 130:5 maximum 129:8 130:15,23 131:24 149:19 184:6 McEwan 16:1 63:7 mean 5:7 18:7 21:25 24:15 25:24 33:25 40:4,11 44:6 45:25 46:6 47:11,19 48:14 55:13 58:5 65:14 65:16,21 66:23 68:8 72:3 73:11 76:2,8 81:12 82:4 84:17,17 89:14 94:3 96:19 98:21 101:5,7 108:8 112:8 114:19 118:20 120:12 143:4 161:1 163:17 188:15 meaning 164:4 meaningful 3:24,25 means 14:18 19:14 90:12 102:7 104:1 107:25 163:24 164:14 179:3 meant 19:21 measured 66:3
---	---	---	---	----------	---	--

128:10 134:12,17 135:20 159:10 160:6 184:6	mention 19:2 48:15 134:21 142:22 148:4,7	millilitre 21:6 millimetre 31:10 millimetres 31:10 million 154:13,14 milliR 2:20 millisievert 45:3 171:24 millisieverts 42:7 42:10,10,14 51:23 123:7	122:23 mobile 149:16 model 5:20 6:4,6 7:15,15,18 8:19 8:25 9:20 11:17 12:1,3 34:15 45:8 48:4,5,9,10 101:8 106:11,12 174:11	months 119:1 Morgan 77:18 78:17,20 79:8 81:6 morning 3:19,20 Mosaic 187:18 motion 178:19 179:11 move 83:2 91:15 95:11,13 157:1,12 moved 157:7 movement 143:18 moves 90:12 moving 54:18 88:5 MTR 163:7,8,11,15 mullet 65:2,3 multi-numbered 158:24 multiplied 35:25 40:24 47:11 123:8 124:7 multiplies 51:17 Museum 125:13 180:13
measurement 142:7 158:5 160:2 160:4 186:15	mentioned 17:19 35:6 107:21 108:9 124:14 133:11 134:23 135:14 139:6 152:17 162:16 172:19 186:9,14,21	mind 1:14 53:4 83:21 90:6 136:18 136:24 139:16 140:21 185:11 186:24	modelling 5:5 models 53:22 174:10,10 moderately 128:7 modern 2:23 3:7 27:14 modification 8:24 74:14	multiplier 65:2,3
measurements 28:11 29:9 57:24 66:4 85:2 120:1 127:25 130:19 133:23 181:23 182:21	mentioning 108:8 166:18	Mine 158:25 minimum 11:19 minus 43:2 55:23 55:25 56:6,11,12 56:13,20 57:6,16 57:19,21,21,22 58:2,15 69:8 110:24 111:21 130:17 151:12 152:22 153:1,3,4	modifications 75:11,15,16 modified 68:15 70:20 73:17 77:2 modify 54:2 modifying 74:2 mole 110:25 111:21 moles 110:24 112:1 187:4,7	multiplier 65:2,3
measures 12:19 128:14	mentions 63:7 164:2 181:2	minute 75:23 122:13	modification 8:24 74:14	multiplier 65:2,3
measuring 66:21 120:7	meter 140:20 146:10 152:22	minutes 48:18 78:15 89:7 93:17 94:15 154:24 165:7	modifications 75:11,15,16 modified 68:15 70:20 73:17 77:2 modify 54:2 modifying 74:2 mole 110:25 111:21 moles 110:24 112:1 187:4,7	multiplier 65:2,3
mechanism 88:21 160:13	method 45:18 129:25 139:12 140:17	misleading 22:19 51:21 66:25	modifications 75:11,15,16 modified 68:15 70:20 73:17 77:2 modify 54:2 modifying 74:2 mole 110:25 111:21 moles 110:24 112:1 187:4,7	multiplier 65:2,3
mechanisms 84:6 88:11	methods 140:19 181:12	misremembered 145:5	modifications 75:11,15,16 modified 68:15 70:20 73:17 77:2 modify 54:2 modifying 74:2 mole 110:25 111:21 moles 110:24 112:1 187:4,7	multiplier 65:2,3
medical 166:1	metre 74:7 82:6 87:18 130:17 142:19 151:5,13 151:14 153:3 154:12	missing 83:14,15 83:23 182:4	modifications 75:11,15,16 modified 68:15 70:20 73:17 77:2 modify 54:2 modifying 74:2 mole 110:25 111:21 moles 110:24 112:1 187:4,7	multiplier 65:2,3
meeting 78:15 79:21	metres 22:20 60:25 135:21	mix 28:17 69:3,15 69:16,17,22 70:13 71:16 74:18 80:19 112:16,17 153:15 153:19	modifications 75:11,15,16 modified 68:15 70:20 73:17 77:2 modify 54:2 modifying 74:2 mole 110:25 111:21 moles 110:24 112:1 187:4,7	multiplier 65:2,3
megabecquerels 87:18	microcurie 142:19 microcuries 130:17 135:20	mixture 28:15 Mm-hm 111:7	modifications 75:11,15,16 modified 68:15 70:20 73:17 77:2 modify 54:2 modifying 74:2 mole 110:25 111:21 moles 110:24 112:1 187:4,7	multiplier 65:2,3
megaton 77:9 177:7,16,17	micrometres 165:21		modifications 75:11,15,16 modified 68:15 70:20 73:17 77:2 modify 54:2 modifying 74:2 mole 110:25 111:21 moles 110:24 112:1 187:4,7	multiplier 65:2,3
member 47:17 166:1 172:24 173:8	micron 100:7 165:13,19,20 166:4		modifications 75:11,15,16 modified 68:15 70:20 73:17 77:2 modify 54:2 modifying 74:2 mole 110:25 111:21 moles 110:24 112:1 187:4,7	multiplier 65:2,3
members 10:15 32:24 34:21 165:24 171:3 172:16	micronised 21:18 microphone 145:4 microR 2:20,22 microsievert 2:23 microsieverts 122:11 171:3,24 172:23,24		modifications 75:11,15,16 modified 68:15 70:20 73:17 77:2 modify 54:2 modifying 74:2 mole 110:25 111:21 moles 110:24 112:1 187:4,7	multiplier 65:2,3
memorandum 26:8 26:8 77:19	middle 16:20 102:18 136:24		modifications 75:11,15,16 modified 68:15 70:20 73:17 77:2 modify 54:2 modifying 74:2 mole 110:25 111:21 moles 110:24 112:1 187:4,7	multiplier 65:2,3
memories 92:1	Milkfish 65:3		modifications 75:11,15,16 modified 68:15 70:20 73:17 77:2 modify 54:2 modifying 74:2 mole 110:25 111:21 moles 110:24 112:1 187:4,7	multiplier 65:2,3
memory 3:3 18:21 19:17 34:9 39:12 58:22 64:4,6,13 64:15 108:12 109:13 112:1 119:23 133:8 143:12 151:22 165:12,15 182:16 189:6			modifications 75:11,15,16 modified 68:15 70:20 73:17 77:2 modify 54:2 modifying 74:2 mole 110:25 111:21 moles 110:24 112:1 187:4,7	multiplier 65:2,3

N

N 190:1
name 156:23
naming 11:7
nanoparticles
21:19 59:23
National 41:21
56:16
natural 14:14,15
14:18 15:15 65:22
65:23,25 66:2
80:15 100:15
154:11 178:19
179:11
naturally 65:21
154:2
nature 32:6 125:7
125:12 142:8
177:3
near 91:20 180:11
nearly 108:8

114:16 necessarily 19:9 necessary 117:9 140:12 need 4:6,8 9:6 11:5 13:4 17:7 19:19 23:19 26:7 64:8 64:14 66:4 76:8 76:17,19 77:14 82:24 85:21 88:10 95:17 105:5 106:23 108:18 112:6,7,11 117:23 119:18 123:1 125:23,24 143:20 143:24 145:15 162:10,12 needle 143:18 146:12 negligible 140:12 neptunium-240 70:22 153:17 nervous 30:3 neutron 178:12 179:5 183:6 neutrons 181:7,7 183:2 never 17:5 30:7 53:4 84:14,14 159:21 185:11 nevertheless 128:8 155:18 172:16 new 14:11 16:2 94:18 185:25 nice 18:15 116:5 Nicholson 24:20,24 Nicholson's 24:21 60:7 night 6:6,11 10:2 47:16 77:22 78:5 nine 119:1 Nodded 65:6 126:23 nominal 153:18 non-Christmas 176:15	normal 32:13 64:2 147:25 149:9 172:24 normally 46:14 54:6 123:11 north 138:15 note 13:25 29:4 129:1 134:7 143:9 187:16 noted 29:5 177:1 notes 19:18,19,24 notice 167:11 NRL 14:12 NRPB 58:1,13,24 151:23 152:2,10 NRPB/75 152:11 NRPB/W1 152:11 nuclear 13:12 22:13 28:14 55:6 55:7 66:5 69:12 69:13 71:15,21 72:1,5,14 73:17 79:19,21 140:6 144:8 155:8,11,12 156:7 157:5 159:6 159:18,18 175:25 181:6 nuclei 178:13 nucleus 99:7 103:19,20 nuclide 4:22,24 74:18 107:25 109:8 110:1 183:8 183:11,13,14 nuclides 4:7 5:8,10 18:25 20:7,8 31:1 41:7 43:3,5 69:3 69:15,19,21 70:21 70:25 109:25 112:17 115:15 159:15 161:9 number 9:9 11:12 11:12 18:25 24:11 34:13 35:22 41:18 43:5 50:3 51:4 54:20 62:17,18	96:3 97:19 98:6 101:4 102:25 103:18,18,19,20 103:23 105:6,9 111:10,10 114:6 127:9 128:15 129:17 137:5,13 138:12,14 161:2 180:21 numbering 126:9 numbers 35:23,24 36:19 37:15,18,19 38:22 42:22 43:7 50:24 51:1 63:8 74:8,9 133:24 137:12 138:11 158:25 159:2 numeral 138:6,17 <hr/> O <hr/> o'clock 112:23 113:25 189:17,18 189:21 Oakridge 78:18 observations 12:4 observer 35:6 obsolete 174:1,9 obtain 43:12 obtained 61:13 128:20 135:21 obvious 133:16 149:20,23 obviously 10:4 20:7 32:12 42:13 47:17 87:2 105:3 172:2 183:4,5 occasional 57:20 occupy 178:25 occur 99:20,22 occurred 68:13 153:2 occurring 65:21 154:2 occurs 25:10 163:4 Ocean 90:9 96:12 oft 139:5	Oh 18:14 21:6 30:8 58:12 66:15 92:17 92:19 111:4 113:13 115:7 okay 5:19 6:24 7:6 8:2,18 10:8 12:25 17:16 24:2,10 30:20 33:19 35:11 40:21 64:4,7 66:19 71:6 75:6 79:1 83:24 92:4 92:20 93:3,6 97:10 99:11 105:12 106:19 107:1 111:17 114:21 117:24 119:19 121:15,22 122:5 148:24 157:20 166:7 183:16 186:8,12 old 59:2 110:1 132:24 Oldbury 124:20 older 34:15 one-page 18:24 ones 9:4 20:5 27:14 33:10 70:15 open 72:20 125:19 146:19,20 178:17 186:20 opened 166:3 operation 125:16 126:18,21 127:5 133:22 135:19 136:12 175:9,16 175:19 operations 118:18 126:22 131:15 175:17 182:7 opinion 17:14 89:3 89:4,6,8,13 opinion-based 17:15 opposed 7:15 32:1 111:6 144:9 opposite 126:10,22	optimism 36:10 orbiting 103:19 order 5:22 7:9 19:20 22:17 30:24 31:1,16 46:21 66:5 87:11 129:7 140:20 143:17 147:6 165:8,14 170:11 171:23 orders 87:8 orientate 162:19 original 1:20 2:1,15 3:14 11:8 32:19 45:13 118:16 132:18,19 133:2 originally 28:19 originals 132:6 outer 99:3 outside 16:8 34:17 43:1 63:17 107:4 107:6 108:25 110:5 overall 5:23 18:19 18:20 86:23 173:12 overcomplicate 134:22 overestimate 50:2 50:18 Overspeaking 43:19 overwhelmingly 159:13 160:24 oxide 21:5,9 oxygen 103:11,14 103:15 104:4 105:8,16,19 <hr/> P <hr/> Pacific 90:9,17 96:12 129:13,17 139:18,24 140:11 page 7:22,25 8:1 10:12 11:11,16 14:1 32:22 33:2,3 33:16,17,18 40:4
--	--	---	--	---

40:20 49:10,20 52:13,24 53:4,18 55:9,15,16,21,21 56:4 61:18,20,20 61:23 62:15,17,18 62:21 72:21 83:17 95:1,25 96:1,2,3 97:21,22,23 117:20,21,21 121:17 122:6,8,13 124:25 125:1,2,3 125:6 126:5,9,10 126:22 128:2,3,4 130:1,8,11 131:4 131:5,5 133:24 135:17,18 136:11 137:3,6,7 141:13 141:17,20,23 142:16 144:11,17 148:7,8,10 149:11 150:1,14,15,16,16 152:19,19 153:6 154:7,8 155:7 156:17,21,22,25 157:11 158:2 159:1 162:9 163:14,14 166:23 167:13,13,24,25 168:8 169:15 173:21 175:22,23 178:3 181:4,4 182:18 page-numbered 158:24 pages 38:15 39:8 53:24 126:20 134:24 135:18 152:4 pamphlet 139:13 Pandora's 166:3 paper 34:10,12,14 34:21,23 35:14 38:14,15 39:8 40:12,13,19 41:14 41:15 47:21,21 61:13 62:1 66:9	66:10 67:3,22 68:6,8,10 71:9 77:16 85:8 104:9 104:15 117:20 127:24 128:15,20 129:25 130:8 135:2 139:9,10,13 140:16 141:19 152:10 153:6 161:21 162:4,7,8 162:20 166:18,21 166:22 167:1,2,3 167:6,16 173:20 174:13,20,21,22 174:23 182:21 papers 5:13 17:13 17:18 34:4,5,7,9 48:11 64:11 66:11 69:11 84:11 104:15 106:20 129:12 136:22 139:5 151:23,23 178:9,10 paragraph 79:2,6 93:15 94:25 130:11,18 131:10 131:20 134:5 135:1,18 150:1 154:8 155:7 157:15,18 158:25 160:22 163:14 169:25 170:1,3,5 171:12 173:22,23 178:3 181:5 186:23 187:17 paragraphs 152:16 158:25 159:3 paraphrase 24:23 pardon 111:13 168:5 parentage 188:23 Parker 18:24 71:2 81:10,11,21 part 27:2,3 133:22 144:9 152:19 180:11	partial 31:18 participants 144:8 particle 4:1 21:16 21:17 59:16,18,19 60:24 61:2,5 99:1 99:2,5,6,9,12,15 99:16 100:8 102:18 162:20,22 162:24 163:8,9 164:16 165:13,19 165:20,21 166:4 particles 8:6 21:4 21:18 59:22,25 60:2,7,9,16 85:19 89:10 99:7,24 100:2,5,11,12,16 100:17,24,25 101:1,4,9,23 102:2 103:2,3 105:6,9 161:20 162:14,25 163:1 163:13 164:16 165:1,8,16 particular 27:14 47:20 68:8,10 83:15 90:22 96:16 130:20 169:19 particularly 13:12 19:1,25 24:20 28:9 29:5 30:21 36:17 43:2 44:4 55:6 60:2,8 64:21 77:10 80:2 87:6 96:20 111:11 143:22 147:2 161:5,9 162:9 182:17,18 183:9 185:15,17 particulate 14:6 parts 89:20 128:18 154:11,13,14 pass 2:6 passage 139:16 150:17 passing 185:22,24 paste 167:10	pasted 49:16 pathway 83:23 86:3,5,13 90:8 91:13,16,19 92:5 169:10,17,20 pathways 83:9,11 83:17,19 119:11 161:2 170:9 180:1 patience 116:2,4 pattern 182:23 patterns 181:14 pause 2:18 20:16 32:20 35:2,2,2 61:24 66:18 75:6 93:3 97:18 114:20 122:5 141:22 169:23,25 177:22 pavement 32:2 peak 153:4 pears 184:10 penetrate 30:13 penultimate 113:9 people 11:2,15 26:23 27:1 30:5 32:15,16 57:8 60:21 66:20,20 68:7 70:1 85:14 92:9 180:8 perform 82:20 performed 40:18 period 21:19 189:3 periods 87:8 110:10,11 152:25 161:5 permanently 143:16 permissible 130:23 person 92:25 100:20 personal 96:23 personnel 127:11 pessimism 36:10 75:2 pessimistic 45:7 74:21 phenomenon 84:15	84:22,24 85:12 104:5 photocopied 138:19 photocopy 132:24 photoelectric 5:16 98:4,5 102:7 103:23 photoelectron 97:25 99:10,11 102:17 106:10 photoelectrons 97:13 100:2,16,24 101:24 103:8,10 106:24 photograph 116:6 photographs 125:7 physicist 68:2 78:19 98:2 101:20 106:4 physicists 34:20 35:17 physics 68:5 71:15 71:20,23 78:22 84:10 102:6 pick 27:25 28:1 30:17 31:5,21,24 32:3 93:20 160:11 181:4 picked 158:22 167:9 picocuries 63:11 picture 102:11,14 102:16 piece 98:19,24 99:23 100:4,4 136:9 pieces 100:20 pin 99:18 pivotal 13:14 place 185:23 places 26:13,14 61:15 185:21 186:2 plan 132:16 137:3 137:7,9
--	---	--	--	---

planes 184:22	47:5 48:1 54:8	184:16	previously 131:9	94:2 99:7 104:15
planned 128:7	72:19 75:8 77:4	possibly 37:9	142:22 172:9	107:13,15 110:17
171:2 172:16	91:17 94:5,17	109:25	principal 4:14,15	110:22 113:3
planning 127:4	95:8,24 96:4,10	potential 49:24	4:20 66:1 123:3	produces 68:20
plant 180:19	105:1 110:3 125:9	52:4 86:20 179:23	134:15 181:18	88:4
plants 14:6	125:10,15 129:8,9	184:24	principally 70:18	product 22:2 23:21
plasma 59:24	131:19 132:4,5,11	potentially 85:17	112:20 129:5	161:3
platinum 101:10	132:12 135:4	110:4 114:7	principle 86:4	products 14:7 23:4
plausibility 4:11	137:25 139:23	184:21	89:22	23:10,17,25 28:17
plausible 85:18	149:3 155:2 161:7	power 30:11 69:8	prior 3:4 71:11	29:11 68:21,21
please 21:13 43:20	161:24 169:2	103:24 105:10	118:12	87:7 155:13 160:6
56:2 64:14 114:1	179:13	106:1,2 130:16	probabilistic 174:2	160:15 161:6,8
124:25 125:18	pointing 50:9 156:8	152:22 165:2,6	probabilities-type	179:6
126:1 127:23	pointless 160:9	166:8	51:3	profession 148:2
130:18 131:4,5,11	points 7:6 17:9	ppm 14:5	probability 54:13	Professor 28:9
131:21 133:20	72:24 96:3 132:5	pre-existing 119:9	103:22	38:25 66:12,16
134:25 135:16	policy 127:4,18	precautionary	probable 24:25	72:14 97:13,21
136:11 141:12	political 128:9	11:25 12:1 54:1	probably 20:3	102:12 110:21
144:1 148:16	pool 30:11,21 31:2	preceding 120:11	28:24 30:24 31:7	141:16,19 144:20
149:25 150:14	31:6,7,7,22 32:1,9	precipitation 24:13	34:18 39:4 48:23	154:16 155:4
154:6,17 155:7	pop 158:22	precise 69:15 70:13	58:19 79:18 80:7	156:16 157:8
156:15 161:22	populated 22:14	71:16 79:16	80:10 81:17 87:12	158:17 165:11
167:16 169:23	population 140:13	precisely 104:16	94:20 132:21	178:1,7 181:2
177:19 178:3	port 27:4,6,10	predict 11:18	143:16 164:23	promised 79:9
181:3 185:13	93:22 138:14	prefer 48:18	165:3 168:5 170:1	150:11
189:21	portable 130:20	116:11 185:7	182:4,5 184:3,7	prompt 62:7
pleased 189:9	141:4 145:18	preliminary 67:25	probe 144:25 145:3	proportion 22:4,5
pleasure 189:11	pose 70:4 117:12	premise 91:5	145:3,9,11,13	74:23 75:1 79:24
ploughing 56:21	117:17	prerequisite	146:2,16,16,17,22	80:8 81:14 105:16
plus 43:2 110:24	posed 6:20 43:21	169:17	147:10,13 149:15	105:17 123:15
111:21 118:14,15	136:7 159:13	presence 29:9	149:16,16	proportionately
120:18 150:8	position 25:3 29:2	67:12 79:12 132:1	probes 141:5	149:10
187:5,7	84:7	present 14:4 60:17	145:22 147:22	proportions 79:16
plutonium 19:1	positive 17:10	78:17 80:14	150:5,9	propose 158:18
29:10 56:19 74:23	possibilities 16:4	149:24 152:5	problem 4:5 8:6,7	proposition 85:24
75:1 85:3 157:17	possibility 15:19	159:6,16 160:19	procedure 130:9	protect 32:24
159:5,18 161:9	91:1 131:15	165:4 181:15	proceedings 16:17	protection 33:22
plutonium-240	134:11	presumably 14:18	process 7:20 17:8	37:11 41:12,21,22
70:22 153:17	possible 1:12,15	24:4 30:2 131:25	87:24 88:4 105:24	41:24 42:2 43:15
pm 115:1,3 156:12	9:16,17,20,21,24	presume 89:23	106:1,4 168:21	45:21 56:17 59:1
156:14 189:22	21:23 25:23,23	pretty 58:22 60:6	processed 127:16	167:19 168:16
point 1:12 6:5,18	26:12,19 37:6	143:23	produce 8:13	169:6,6 170:22
6:18,22 9:11	43:12 50:10 54:10	previous 28:8,22	107:17	172:1 173:18
14:16 16:13 29:11	54:13 81:6 82:2	28:23 40:20 119:1	produced 1:18 5:24	protons 103:18
31:12 38:8 39:17	82:23 90:24 91:21	119:3,4 120:21	24:13 39:8 42:6	provided 44:17
39:17 42:4 46:19	139:14 152:25	163:13	70:15 74:15 93:24	102:12 116:24

<p>providing 174:16 provisional 12:2 provisions 188:19 public 5:14 32:24 34:22 41:22 58:25 59:2 104:16 171:3 172:17,25 173:9 177:7 publication 174:25 published 43:14 177:4 puddle 32:10 Puncher 34:6,6 35:14 40:14 41:3 41:6,15,20 45:1 49:14 166:19 174:14 purpose 47:22 purposes 20:2 99:2 169:6 172:1 181:19 pursue 67:14 pursuing 112:10,14 184:11 put 2:15 8:7 10:9 17:10,21 27:24 35:7,15 41:20 44:18,24 53:14 62:4,12 72:22 77:19 90:23,23 95:19 100:1 109:25 116:12 120:16 125:20 132:18 136:22 139:3 140:14 141:5 142:16 144:2 148:5 149:17 154:1 155:20 162:1 175:3 177:20 183:2 putting 16:23 127:6</p> <hr/> <p style="text-align: center;">Q</p> <hr/> <p>qualification 45:5 68:18</p>	<p>qualifications 158:12 qualify 98:18 qualitative 14:17 102:23 104:22 qualitatively 102:24 quantify 14:15 25:4 45:17 87:14 102:5 quantitative 24:14 65:18 86:22 quantities 63:13 167:18 168:15,23 170:22 185:18 quantity 80:13,13 111:22,23,24 question 1:5 4:21 6:1,20 7:17 9:12 9:15,20 12:18 15:13 17:2,11 18:11 21:12 23:14 23:15,16,21 24:17 26:12 28:4 30:15 30:16,18,20 33:20 33:21 35:4 37:17 38:22 43:20,21 44:7,24 45:16,19 46:10,11 47:4 49:19 51:10 53:23 60:13,13 64:1 67:1,4,5 70:3,7 71:7 72:22 73:2 79:10 81:18 87:4 88:2 90:23 91:3 92:22 94:6 96:9 96:10,15 97:3,6 100:19 101:19 104:14 106:3,13 112:9,15,24 113:4 113:7,8,9,18,19 117:12,17 119:5,7 119:12,17,21 120:10 124:10 139:2 141:23 142:9,16,25</p>	<p>147:20 156:25 166:3 171:8 178:7 178:22 184:12 187:23 questioned 38:23 questioning 16:21 27:20 48:14,21 questions 13:2 16:23 17:25 18:1 22:9 38:20 39:3,5 44:16 47:14 54:21 70:4 73:1 85:21 109:4,22 114:20 115:5 116:9,18 120:11 126:5 131:8 140:15,22 144:20 150:12 155:20 172:11 178:5 186:21 189:7 190:3 quick 114:1 quickly 87:6,11 160:2,16 178:18 179:10 quite 4:6 9:9,16 22:1,2 28:7 30:3 41:8,10 56:5 59:2 62:16 67:24 69:10 80:8 81:14 84:22 85:18,18 87:10 88:9 108:13 146:8 156:5 158:1 178:18 179:10 180:8 185:20 187:22 quote 37:11 51:19 quoted 12:8 22:9 34:3,14 69:10,10 69:11 quotes 18:24 164:1 quoting 162:13</p> <hr/> <p style="text-align: center;">R</p> <hr/> <p>R 3:6,16 R3 177:15 rad 3:6,10,11</p>	<p>radiating 188:16 radiation 6:3 11:13 11:18 28:6 30:5 30:17 31:6,13,21 32:4 98:7,13 100:15,22,23 102:1 120:1,6,7 122:22 126:6 127:24 129:8 134:12,17,20 140:20 142:8 145:24 148:18 149:1 159:5,8,9 160:25 167:19 168:16 172:1 173:2 182:21,24 radiation-blocking 101:10 radiation-detecti... 128:19 129:20 radioactive 79:11 81:8 127:11 129:16 150:22,24 157:24 181:9 183:1,6,8,13,25 184:4 radioactively 150:18 radioactivity 62:24 89:9 159:4 179:15 181:15,24 radiological 41:21 41:25 56:16 108:7 109:1 128:11 129:2 133:23 134:4 radionuclide 4:4 5:10 radionuclides 37:8 62:25 68:12 69:1 70:10 71:4 73:20 74:8 85:13,24 158:6 159:12 160:23 170:24 171:13 178:6 radium 56:19</p>	<p>radius 22:14 rain 24:10,12 25:10 25:22 26:11,15 30:1 31:8,9 60:10 66:12,21,22 67:5 67:6,7 90:2 93:23 94:1,4,8,9,21 119:25 120:15 139:13,14 rainfall 26:20 27:7 60:3 95:20,23 raining 189:14 rainout 92:22 135:10 rainwater 25:2 97:6 129:13 139:19 182:13 raise 1:5 187:22 raised 59:14 103:24 150:22 range 30:22,23 42:1 43:1,3,5 44:25 57:20 151:11 175:25 ranges 50:11 rapid 86:25 87:9 187:1 rapidly 87:7 153:23 rate 69:3,16 74:3 87:9 131:17 143:10 146:10 148:16 149:2,3,6 149:7,10,18 164:12 rates 74:4 77:10 131:22,24 150:13 153:5,10,23 162:10,12 ratio 80:24 150:23 151:15,16 164:2 ray 98:24 103:22 178:16 RAYNER 121:11 121:16,20,22 122:3,13,17,20,23 123:1,16,19,22</p>
--	---	--	--	--

124:2,4,6,9,11 Re-examination 124:12 190:4 re-examine 116:10 re-features 166:16 re-suspended 87:25 re-suspension 49:7 55:18,20,23 56:6 57:14,16 88:3,4 150:13,23 151:2,6 151:11 152:21 153:1 reaches 88:16 reaction 87:4 89:14 90:7 155:13 reactions 164:22 reactor 163:11,12 163:15,16 read 5:12 7:19,19 8:17 12:15 14:3 15:13 34:23 66:9 66:11,12,13,15,23 67:3 73:25 74:16 81:16 93:7,13 96:5,19 104:9,15 104:17 108:13 118:11 130:18 131:1,10 137:16 141:25 157:10,18 158:16 167:1 169:22,23,24 173:22 reader 133:13 177:2 reading 42:23,23 44:8 60:7 94:25 108:15 142:23 151:15 159:19 167:24 169:25 170:14 172:21 182:9 real 135:3 realised 34:19 142:3 realistic 51:2	really 6:18,22 45:17 67:8,9 82:16 94:23 110:6 110:13 121:11 164:8 reason 35:19 37:22 61:6 97:19 106:7 106:8 136:10 159:23 180:12 183:1 185:19 reasonable 9:18 16:7 23:24 29:10 29:22 36:4 43:10 45:23 46:12,22 59:5,12 72:9 74:21 85:18 143:2 143:5,7 158:10 159:25 171:16 reasoning 26:5 28:12,13 29:20 reasons 34:14 41:18 54:6 188:8 reassure 140:13 recalculate 74:17 recall 3:21 8:24 39:7 42:7 93:12 118:16 119:15 188:3 receive 111:12 127:7 received 37:1 38:14 38:18 42:19 67:24 receiving 100:14 124:24 recognise 66:11 recognised 168:20 recollecting 173:23 recollection 29:6 95:1 120:14 121:4 157:10 166:7 recommend 47:6 recommendations 173:4 recommended 173:7,8 182:14 reconnaissance	118:18 record 130:5 186:19 recorded 31:20 records 128:6 135:22 red 96:11 reduce 179:4 reef 185:10 refer 3:16 14:13 19:18,19,24 34:8 139:17 146:14 182:12,13 186:3 reference 2:1 10:12 15:13 34:8 51:11 78:1 117:1,7,14 117:19,22 118:5 118:11 119:15 127:25 153:7 167:18 168:15 177:14 185:22,24 referenced 57:3 references 3:14 66:13 145:12 151:17,19,24 152:1 referred 1:24 5:15 10:8 17:23 18:22 29:1 57:1 124:16 128:22 129:3,10 129:15 130:25 152:10 161:21 179:7 180:10,13 185:21 referring 28:21,23 36:17 53:2,3,8 80:7 88:8,20 125:4 131:2 134:8 135:6,25 139:9 145:10 151:19 153:11 158:13 162:4 166:22 174:5 178:10 185:4 187:23 refers 14:15 40:12 40:13 45:1 103:9	146:10 147:16 163:15 185:23,25 reflected 12:3 reflects 17:13 refractory 28:16 Regan 28:9 110:21 111:19 141:16,19 144:20 156:16 157:8 158:17 165:11 178:2,7 181:2 Regan's 154:16 155:4 178:1 regard 89:12 106:3 regardless 69:14 region 154:11 178:15 regulations 173:2 188:17,20 regulators 169:3 relate 9:24 related 79:12 149:14 176:11 relates 80:2 111:15 relating 11:20 42:1 71:20 101:9 relation 59:18 relationship 45:12 51:13 52:16,20,22 53:15 69:6,6,8,9 103:17 105:10 106:1,2 172:14 relative 159:8 relatively 71:10 160:2 178:14 Released 112:4 releases 34:22 relevance 107:12 107:13 169:3 172:22 relevant 6:19 11:3 17:18 20:10 24:18 34:25 56:24 109:4 111:15 114:8 119:7 131:18 161:17 164:10	188:4 reliability 169:18 170:6,7,12,21 reliable 26:21 44:14 155:25 169:5,10 171:7 relied 13:13 38:11 55:7 57:2 rely 13:7 17:11 27:21 54:25 69:18 155:23,25 relying 110:6 rem 3:6,12,13 remain 25:5,6 46:22 remained 38:23 114:7 remarks 63:15 remember 3:3 12:9 30:22 59:6 85:10 91:21 117:7,8 132:22 133:1 140:2 141:3 160:16 163:8 184:2 remembered 186:25 187:21 remove 178:23 removed 180:20 repeat 100:19 171:8 repeating 10:2 replaced 10:24 replies 40:1 reply 79:9 report 1:21 2:15 3:22 5:20,25 7:5 7:19 8:3,15,16 9:8 12:14 13:7,24 16:2,2 17:20 19:3 25:9,18 32:17,19 36:6,7 37:7,24,25 42:18 45:13 49:11 49:11 50:25 54:24 55:9,9,11,15 56:3 56:4,10,16,22
--	---	---	---	--

57:3,5,14 58:5,7 58:14,16,18,20 59:2,9,10 60:8,8 60:11 61:8 62:2,2 62:14,16 63:7,20 63:22 67:13 68:14 68:15,16,19 69:23 70:17,20 71:24 72:8 73:4,6,9,14 74:1,3,11,15 75:5 75:13,17,21 83:16 83:20 86:9,11 94:9,10,14,16,19 94:22,24 95:6 97:14 107:21,23 108:11,12 109:5,7 109:23,24 111:15 117:11,12 121:18 124:20 128:4 133:11,22 135:14 136:8,11 139:21 140:18 144:1,9 147:18 148:4,6,7 149:18 151:22 153:16,22 155:5 157:15,19 158:22 158:24,24 160:21 161:3 167:4,13 169:1 170:23 175:14,15 177:4 178:1 179:22 180:2,17 181:3 182:11,16 185:22 186:10 187:22 189:5 Reported 151:11 reports 7:1 44:21 55:1 56:25 57:8 63:5 76:3 92:8 96:21 108:16 142:22 154:17 156:6 178:9 184:15 represent 4:5 representation 174:1,8	represented 81:13 reproduced 136:13 require 74:16 required 159:21 requirement 188:22,23 research 78:16 102:13 146:9 residual 127:24 182:21 residue 74:24 residues 68:21 81:13 resolve 8:6 respect 107:24 109:6 130:3 140:16 184:19 respond 148:24 responded 27:19 47:9,13 response 10:3,11 10:14 18:10 44:6 47:20 53:23 89:2 89:2 responsible 11:23 11:24 12:18,23 103:16 responsive 27:13 27:15 rest 24:8 176:22 restrict 127:5 restricted 126:17 result 23:21 39:5 76:6,7 85:25 95:20 108:15 115:9 135:10 136:21 149:4 resulted 96:17 results 34:4,13 54:21 70:8 74:14 102:21 116:20 117:2 130:12 136:12 148:12 166:4 176:4 resume 189:16 return 139:3,4	189:13 returned 93:17 127:10,16 132:2 reverse 126:10 review 7:2 170:11 reviewing 174:16 revised 47:23 121:16,18 RICHARD 1:3 190:2 right 2:2,4,11,12,17 2:25 3:17 4:6 5:19 7:24 9:3,15 13:3 14:2 15:10 15:24 17:17 18:3 20:21 21:10,10 24:6 28:3 33:2,7 35:10,11,12 39:9 40:10,15,17,22 42:11 44:3 47:25 48:24 49:6,22 51:25 53:5,9,11 54:4,12,15 55:9 55:19 56:2 62:4,6 62:12,13 63:4 64:7 67:14 76:12 77:13 78:3,12,14 80:12 81:6 83:12 83:16,21,25 84:1 84:12 86:7,19 89:5 91:7 92:25 93:3,9 95:4,11 96:22 97:1,3,7,23 102:10 105:12 106:22,23 108:5 109:21 113:1,5,13 114:13 115:7,13 115:14 116:1,8 117:22 118:20 119:14 120:9,16 120:24 121:5,10 121:21 123:2,18 124:2,13 125:3 126:13 128:1 129:13,19 132:15 133:4,10,13,18,21	134:1 137:14,18 137:21 138:20 139:3 141:11 145:1,15 146:6 147:15 148:3,17 150:2 152:12 153:14 154:9,16 155:3,6 156:4,20 161:19 162:3 165:22,25 166:14 166:15 168:1 172:5,13 173:5,10 173:15 174:24 177:19 182:11 183:18 184:22 186:8,12 187:22 right-hand 63:9 64:24 102:18 rightly 30:16 35:19 rise 16:10 149:7 178:13 181:8 189:15 rising 134:19 risk 5:20 6:4 8:8,25 10:16,17 11:17 12:1,2 41:9 46:1 47:10 48:3,4,9,10 69:20 71:20 101:8 140:10 161:25 168:21 169:16 174:1 risks 12:3 roentgen 3:6,7,8 Ross 93:2,25 95:18 95:21 rough 18:19 roughly 21:10 22:8 69:17 164:4 165:16 rounded 124:3 route 173:7 routes 38:18 39:7 83:5 row 53:20 Royal 139:6 Rs 2:25	rules 7:1 running 30:5 93:4 <hr/> S <hr/> safe 178:25 safety 6:10,15 7:14 99:18 173:12 188:12,13 sailed 181:24 sailing 47:15 salt 183:25 185:24 186:1 saltwater 180:7,23 185:8,23 sample 129:7,9 182:25 samplers 129:12 samples 62:25 129:1 181:20 182:6,19 sampling 127:12 135:2 139:19,24 139:25 140:16,17 140:22 180:21 samplings 139:10 San 176:12 sat 185:13 satisfactory 124:16 save 169:25 saw 93:25 185:17 186:6 Sawada 66:12,14 66:16 saying 21:25 23:18 23:20 32:6,8 37:12 47:13 48:5 50:16,21,23 51:8 70:6 142:16 153:20,21 171:12 171:17,19 172:15 173:11 188:5 says 11:16 14:3 16:6 26:9 33:15 36:8 37:7,9 39:20 46:17 47:6 48:6 49:23 50:3,6
--	---	--	--	---

53:20 56:7 61:21 93:16 96:10 122:18 127:3 130:14 132:24 135:18 136:3 142:21 143:3 151:10 152:24 154:9,15 155:7 158:9 159:3 160:21 163:23 167:5 173:24 176:25 178:8 179:9 SB1 97:17,18,18 SB1/2.4 97:14,15 SB10 144:1,6,7 148:5 SB10/161 150:11 SB10/163 7:21 SB11 154:19 155:4 SB11/2 154:17 177:19 SB13 61:9 186:16 186:18 SB13/24 13:18,20 SB13/36 56:3 SB13/38 154:6 SB14 141:13,15 144:4 156:15 SB17 125:18 126:2 126:3 138:23,25 181:2 SB17/8 158:23 SB2 97:17 SB2/2.12 55:10 SB2/2.14 148:7 SB2/2.17 32:18 SB2/2.4 97:16 SB22 77:24,25 78:6 125:21,22 138:24 SB22/14 175:12 SB3 161:22 SB3/10 166:18 SB6/77 62:11,14 SB6/79 61:8,12 SB7 67:17	SB7/110 66:8 SB7/96 67:16 SB9 97:11 SB9/140 93:2 scale 132:16,17,19 132:19,25 176:7 scaled 132:22 scavenging 25:1,21 scenario 24:8 159:15 scene 117:17 sceptical 157:14 Schedule 1:8 scientific 128:9 158:10 scintillation 145:9 145:11,22 146:2,4 146:24 147:13,22 scope 170:22 Scott 1:8 sea 15:11 24:4,9 84:4,5,8 85:4,6,13 85:15,24 86:24,25 87:24 89:11,24 90:15,25 129:7 134:13,16,19,20 178:6,25 179:10 179:11 181:15 182:24 183:1,4 sea-to-land 84:12 84:22,25 87:23 88:9,15 search 64:11 Seattle 17:21 seawater 24:12 65:12,13,16,17,20 65:22 84:19 87:6 87:21 92:23 96:17 129:1,7,9 178:13 178:17,19 180:9 181:1,5,6,12,20 182:6,19 183:4,10 183:19 184:5 second 49:11 95:25 122:14 128:3 131:10 134:25	136:9 140:16 142:18 143:1,4,12 143:14,14,17,23 143:24 146:12 149:19 163:10 177:21 185:3 186:7 Secondly 181:20 Secretary 84:7 158:4 178:10 section 134:4 139:11 140:18 148:8 168:13,18 168:19 secure 17:4 security 118:18 sediment 179:16 see 2:12 8:8 30:4 50:6 51:6 52:7 55:4,21 58:19 64:16 66:5,17 67:1 73:6 78:17 94:18 98:13,19,20 103:8,9 111:14 113:13 114:19,21 114:24 119:18 126:16,20 128:2,5 128:12 129:10,25 130:12 132:8 133:2 136:11,20 138:5 140:4 141:18 144:24 146:20 150:20 153:13,23 157:11 164:16,22 167:8 170:15 175:24 184:14 189:20 seen 12:7 26:24 30:7 54:9 56:22 57:23 58:3,5,5,16 58:17 61:16 66:9 67:22 71:10 73:23 78:10 79:25 85:8 93:7,8,10,10,11 93:13 96:22 97:8 102:14 107:19	125:11 136:15,21 145:11,13 146:5 selected 62:25 126:17 selective 158:16 Sellafield 84:9,10 91:21 send 79:9 sense 9:23 28:24 85:1 113:15 170:4 sensible 113:16 sensitive 128:19 129:20 142:18 148:25 181:13 sensitivity 143:1,6 sent 18:1 40:1 sentence 131:10,21 152:24 167:23 168:12 179:21 182:1,2,19 186:23 186:25 separate 80:16,19 129:11 158:5 series 175:17 187:24 188:4 serious 110:4 serves 29:6 34:10 64:13 108:12 109:13 119:23 133:8 set 8:13 172:9 173:1 189:5 setting 117:16 seven 120:5,19,20 120:25 121:3 Shackleton 1:19 89:25 116:20 117:2 129:5 131:6 131:9 133:19 181:19 shallow 186:3,8 shellfish 179:18 shells 99:4 shield 98:8,10 shielding 98:9 ship 27:4 96:8	127:16 ships 47:15 127:13 127:14 181:23 short 20:9 49:3 62:16 75:19 82:22 110:11 115:2 152:25 156:13 short-lived 75:3 178:14 short-term 109:16 159:13 160:24 shortly 181:21 shorts 93:20 shots 187:3,19,20 show 175:5 showed 180:14 shower 135:11 showing 51:25 52:4 shown 52:6,8 shows 102:16,22 125:15,16 146:11 side 63:9 64:24 102:19 105:23 125:20 148:5 sideways 146:7 sievert 3:9,12,13 sieverts 3:2 23:12 significant 22:1 25:11,20 42:16 63:13 73:24 81:14 84:5 86:12 87:11 87:22 90:4,8 104:2 110:19 135:20 150:7,10 164:22 170:9 significantly 26:13 39:12,13 57:9,11 81:15 103:10 149:4,7,9 silt 84:18 similar 4:5,18 34:5 54:9 74:4,9 93:10 119:24 120:15 140:25 148:1 156:2 162:15 165:5 179:13
--	---	--	---	---

similarly 27:7	smaller 99:23	38:16 68:20	standard 6:7 7:11	128:15,20 129:12
Simon 68:6 72:14	100:7,20	sought 39:25 56:23	71:3 188:9	129:25 130:8
92:6	Smith 20:13	56:24	standards 6:10,15	135:2 136:22
simple 18:9 61:4	so-called 69:7	source 13:10 49:23	188:12,13	139:10 142:4
146:12 164:9	111:10 146:10	99:8 119:6,9,24	standing 100:14	stop 6:17,21 98:20
simplest 81:17 82:9	Society 68:6	121:5 134:15	stands 163:11	114:13
111:8	sodium 178:12	163:9	Starfish 176:16,18	stopping 30:11
simplify 4:21	181:8 183:4,5,5	sources 64:12	start 48:15 95:9	stork 96:12
simply 28:2 29:4	183:12,13 184:4	83:18 155:23	156:25 163:14	storms 87:2
31:2,8 32:2 35:25	sodium-23 183:12	south 27:3 135:4	182:4	straight 35:13
36:2 40:19 43:24	sodium-24 181:8	176:11	started 148:1	straightforward
46:19 57:1 59:19	183:13 184:4	southern 27:2	starting 77:4 94:17	35:25
65:19 66:2 75:3	soil 14:25 64:16,17	180:11	131:22 168:3	stratosphere 89:17
93:14 179:3 184:7	64:17 65:10,23	space 89:6	starts 126:22	stress 4:6,8
single 162:22,24	92:14,16	span 22:13	131:11 150:17	stressing 24:23
163:1	soils 14:4	spare 78:9	state 160:20	Stretch 24:21
site 130:16 135:4	somebody 71:24	speaking 1:10	State's 84:7 158:4	Stretch's 60:8
135:21 136:20	75:20 100:14	specialist 11:5	178:10	94:10,14
137:4,13,22 138:4	179:25	specialists 11:6	statement 10:2	strictly 99:6
138:11	somewhat 90:19	specific 36:16	11:12 14:17 18:4	strong 155:11
sites 61:21 128:16	166:3	69:19 74:18 76:25	30:7 36:15 38:11	strontium 5:9
129:17	soon 151:24	76:25 80:3 84:22	40:6 59:17 66:3	161:8 162:15
situation 23:20	sophisticated	88:20 101:19	70:3 88:19,23,25	164:3,5
24:1 29:25 127:8	174:11	103:17 104:14	89:1 93:2 95:10	struggling 122:6
size 59:16,18,19	sorry 7:13,25 12:9	110:15 118:19	95:18 104:23	studied 67:23 73:9
60:24 61:2,6	13:19 23:15 31:3	155:17 177:12	127:22 155:16,21	74:18
99:23 100:8	33:16 35:3 40:6	specifically 71:22	158:10 170:3	studies 11:20 68:4
165:12	43:22 46:24 52:12	86:14,18 87:14	statements 24:11	170:20
sizes 157:23	53:1,7 58:11,12	88:3 120:6,7	24:20 30:4 85:20	study 33:13 37:13
skills 11:3	62:9 73:12 92:20	specified 169:20	states 41:11,24	39:22 40:4,9,11
skin 122:13 123:6,9	97:4 100:19	spectra 70:9	64:20 126:16	40:12,13,17 45:1
123:10,14,15,23	113:15 116:3	spectrum 69:1	135:1 173:18	73:24 92:6 167:4
163:4 164:15,22	122:6 126:6	75:12	177:5,9	167:5
164:23,25	128:24 137:19	speculate 91:4	stationary 163:7	stuff 24:15 61:24
SL 68:6	139:1 141:21	106:15	staying 141:12	76:14 84:2
Slave 137:10,11,21	142:11 153:18	speculation 84:2	stenographers	sub-question 44:3
slight 45:5	156:18,19 161:12	split 141:21	154:24	subheading 40:9
slightly 12:21 41:2	162:10,18,24	square 22:9,16,20	step 23:23 146:7	163:4
45:21 74:10 76:7	163:9 167:9,21,25	22:21,24 135:20	179:3	subject 113:11
98:18 104:1	169:22 171:8	142:19 152:22	steps 5:23 146:6	173:17
slowly 160:3	172:7	squared 82:6 87:18	178:23	subjective 36:24
small 60:6,9,16	sort 4:21 18:19	130:17	stick 177:10	37:4,20 54:20
76:16,21 85:19	62:19 77:8 84:21	stable 183:12	stickers 127:6	59:17
99:20,24 104:3	85:16 86:21 109:3	stages 127:5	sticking 60:20	subjects 79:4,5,8
134:21 158:1	174:4 180:19	stakeholders 169:4	105:2 133:19	subscript 13:25
180:21 185:18	sorts 36:25 37:4	stand 36:9	sticky 26:1,9	subsequent 135:22

136:3	surprised 87:21	table 6:14 9:2	185:1 188:9	150:12
subsequently 68:15	surrounded 15:11	32:22 33:7,18	takes 51:16 88:15	term 85:1 110:25
substances 69:25	surrounding	34:7,24,25 35:13	101:8	111:1 146:13
substantive 128:3	155:12	40:5,12 41:16	talk 13:4 17:22	161:14
successor 152:6	survey 1:19 14:10	44:18 46:5 48:9	92:25 121:22	terms 18:17,17
suck 92:13	14:12,12,13,17,20	49:10,13,20 51:7	talking 5:18 40:1	36:17,18 55:6
sucked 180:14	17:20 61:14	51:12,13,13,14,19	43:17 79:18,18,22	63:17 72:11 75:3
sucking 96:12	118:19 128:18,22	52:1,2,3,12,23	79:23 81:7 84:1	76:1,13,23 77:10
suffers 132:24	129:2,3,5,6	53:1,2,3,4,6,13,14	90:4 99:24 102:23	80:10 81:14,15
sufficient 12:24	131:14 134:4	53:14,17,18,25	102:25 105:4	82:3,9 84:20
20:2 35:20,21	135:5,6,25 136:3	54:2 61:17,23	139:18 143:2	86:10 88:6 104:10
36:3,13,13 108:2	142:3,13,15 175:3	62:6,14,24 63:4	144:21 160:25	105:15 125:9
108:3 170:2	175:21 181:19	64:24 65:24	161:9 165:9 167:5	128:11 166:17
sufficiently 12:1	185:25	112:16 144:18,19	171:22,23 182:17	172:14
suggest 11:21 59:4	surveyed 142:14,14	145:18 153:6	184:4	terribly 51:20
suggested 10:15	surveys 14:11	162:9 163:3,21	talks 61:20	terrifying 96:13
83:22 91:19	15:15,21 26:25	164:10 166:24	Tanner 5:13	test 68:13 126:12
suggests 74:1	130:19 135:22	167:5 168:8,10	106:20	160:20 163:11,15
suits 30:5	136:12 176:4	172:10,14 174:18	target 4:12,13,14	176:8 177:15
summarise 28:25	suspect 29:13 182:4	174:19	4:15,20	178:11
summary 167:15	suspended 84:19	tables 52:17,20	targeted 127:13	tested 184:13
167:22 174:22	88:16	tabs 97:19	targets 4:16	testing 15:22 140:6
sums 20:3	SVs 3:1	take 7:21 11:11	task 77:4 140:6	140:19
supplement 128:19	swallow 92:14	13:18,24 24:2	team 38:21	tests 72:14 124:8
supplementary	Swordfish 176:14	29:25 35:24 41:11	teaspoons 92:13	127:18 144:8
68:15,16 70:20	176:15	48:14,18,20,21,24	technical 7:7,9	175:25 176:6,6,7
75:13,17 153:16	sympathise 93:15	49:10 61:7,17	tell 18:6 19:13	176:10
153:22		70:21 75:18 81:4	37:14 39:23 65:24	text 9:5 137:24
support 23:8	T	82:24 83:13 90:16	66:23 71:24 78:8	174:15,18,18
suppose 16:6	T 69:8	92:22 95:17 114:9	81:4 82:1 95:22	176:24
sure 1:9,10 6:17	tab 11:11 13:19	114:23 119:10	101:7 115:8 117:9	thank 1:22 2:5 3:17
16:19 17:13 31:15	32:22 49:17,20	125:18 129:7	117:10,24 142:7	5:3 13:4 16:18
32:18 35:22 41:4	61:11 62:22,23	133:4 141:13	145:5 166:21	19:23 48:12 51:6
58:23 66:13 76:19	67:19 77:24,25	164:14,20,24	177:13	51:9 64:23 65:11
88:14 89:21 92:24	78:4,6,7 95:11,14	176:5 184:20	telling 44:22 146:1	66:6 95:3 97:12
106:7,8,14 122:9	95:16 97:19	take-off 118:2	tells 145:17	106:6 113:24
123:5,11 158:16	125:18,22 126:3,4	taken 19:7,12	tend 2:3 34:19 37:4	114:11 115:24,25
158:20 174:8	127:23 128:3	25:19 26:9 35:13	70:12 105:19	116:2,4 124:6,9
surely 15:25	133:20 135:15	40:13 43:3 59:11	157:16 161:12	124:23 156:11
surface 22:7,13	138:24 141:14,15	60:3,10 72:15	tended 64:21	166:25 175:2
31:2,8,24,25 32:2	144:1,7,15 155:4	123:6 127:4	tendency 85:20	186:12 188:2
32:8,12,13 84:20	156:18,19,19	128:14 129:2	Tennessee 78:18	189:8,10,15,20
150:18,24,25	161:22 168:2,3	136:22 139:14	tens 23:12 90:3	thanks 174:16
160:18 181:21	174:13 177:21,23	163:6 178:23	tenterhooks 132:25	thermonuclear
182:22 184:17	178:1 181:2	179:21 182:7	ter 1:4,16 33:6	69:5 70:15 71:5
surfaces 60:20	186:16,17,18	183:25 184:24	56:15 70:8 130:3	73:5,7 77:7 89:16

<p>113:3 153:19 they'd 34:15 thick 28:2 31:10 thickness 27:16 31:12 thin 31:9 thing 29:10 51:18 82:9 83:4 84:20 84:21 85:16,19 87:3 102:22 104:22 122:17 133:7 146:10 158:23 164:23 165:5 things 46:5 60:20 75:24 82:7 96:13 101:21 125:24 144:2 158:18,19 think 1:19 2:3,19 4:3 5:2,5,13,15 6:6,10,12 7:6 9:12 9:16 10:1,5,23 11:7 12:7,8,15,16 13:17 14:11,15 18:15,18 21:23 24:10,22 25:23 27:5 28:12 29:1,7 30:3 31:13 32:11 32:13,21 34:6,14 34:20 36:6,8,12 37:1,5 39:4,10,14 39:25 41:1,22 42:21 45:17,18,23 46:23 47:21 54:25 55:6 56:15 57:2,7 59:14 60:13 62:1 71:18 72:6,7,10 72:15 74:9,16 76:10 77:4,14,24 80:2,6 81:17 83:17,22 85:23 86:17,17 88:8,19 90:3 91:23,24 92:2,7,23 94:3,5,9 94:12,20,23,25 95:21 97:1 100:8</p>	<p>101:15,16 103:14 104:14,17,22 106:12,23 107:23 108:12 109:11 110:3,23 111:8 112:6,11,20 114:2 114:7 115:8,10 116:5 117:8,14 118:24 119:23 120:16 121:24 124:16,19 128:24 129:3,10 131:18 131:18 132:18 133:1,11 134:10 136:7 137:3,16 138:10 139:5 140:2,8 141:2,6 142:1,10,17,18 143:11 146:4,9,13 147:2,14,16,25 148:4,22 151:21 152:1,13,16 155:20 156:23 157:2,13,20,22,25 158:1,2 159:25 162:22 166:9,15 166:18,21,23 167:12 171:16,17 171:19 174:25 175:16 177:7,9,10 179:3,7 180:7 181:18 182:5,14 184:2,7,11,20 185:20,23 186:18 186:20 187:19 188:8 189:6 thinking 129:19 168:18 182:11 third 63:9 79:2 95:24 96:4 131:10 134:5 157:14 Thirdly 181:23 Thomas 38:25 thought 1:9 20:4 53:1,7 59:18 61:3 61:5 70:8 86:23</p>	<p>87:20 89:13 90:7 90:19 106:8 108:9 113:7,17 137:13 139:23 140:1 147:19 157:7 185:9 186:14 thoughts 87:12 three 3:5 6:12 11:7 20:6 33:10 35:7,8 37:13 62:24 64:17 65:3 70:21,25 102:16 115:14 118:14 126:22 151:17 170:18 181:12 189:10 threshold 127:8,10 164:14 Tier 28:8 165:10,24 time 7:18 8:14,16 12:13,16 17:7 21:20 23:6 27:17 27:18 28:25 41:23 48:14 69:8 72:21 73:23 82:12 117:2 127:18 136:8 145:6 146:23 156:16 159:4 160:4 161:5,6 163:6 164:14,17 164:20 168:6 177:4 179:6 189:3 times 10:17 37:13 37:13,23 57:12,13 80:5 81:3 115:16 115:19,20,22 130:16 135:15 136:21 138:19 139:7 155:20 160:17 165:3,14 166:9 timesed 123:1,19 123:23 timing 114:1 tissue 4:1,2 99:14 99:15 123:8,19,23 title 72:21</p>	<p>today 145:6 togglng 52:15 told 45:16 75:16,23 94:24 153:5 189:1 tolerability 60:14 tomorrow 189:16 189:21 tonnes 18:18,21 20:20,21 21:3,18 89:9,10 top 2:21 78:17 128:5 135:17 148:10 158:3 159:1 173:21 top-right 133:25 topic 47:3 67:2 83:2 91:15 94:17 95:1 97:2,9 108:21 109:22 112:24 113:12,17 113:19 116:16 117:25 133:19 143:25 181:1 topography 15:7 torrential 30:1 93:23 94:1,4,21 total 18:11,20 20:6 20:11,15,16,18 81:15,20 82:3,9 82:16,18 114:6 115:14,15,16 121:23 122:4,13 122:19 165:3 touch 24:19 touched 79:8 toxic 79:12 trace 130:2 tracing 188:23 track 58:14 tracking 127:14 tracks 97:25 trained 98:2 trajectory 2:13 transcript 24:21 transfer 84:12,23 84:25 87:23 88:10</p>	<p>88:15 transferred 85:25 86:1 89:17 179:17 transport 93:21 treated 180:15 trench 94:13 trials 127:9 Tribunal 1:6,11 9:17 16:12 28:8 36:21 37:16 43:9 116:9,18 125:8 126:13 130:5 131:11 134:7 148:15 153:5 157:8 158:16 165:10,24 190:3 Tribunal's 162:7 tried 25:4,5 34:18 40:19 41:3 87:14 109:3 147:4 152:13 tritium 107:15 109:17 112:22 113:2,2,22 troposphere 89:18 trouble 32:3 177:18 true 5:2,6,12 6:17 29:15 39:4 42:21 42:25 100:6 182:3 try 17:13 19:18 30:15 59:7 82:25 146:9 172:2 trying 2:14 20:13 45:11 46:24,25 52:15 54:3 60:15 86:20 99:25 111:14 112:13 117:7 133:5,14 162:18 163:8 172:13 183:16 tube 28:2 146:20 146:21 Tuesday 1:1 turbulence 87:1 turn 117:10,11 124:25 125:6</p>
---	---	---	---	---

126:5,20,25	171:12	127:17 132:11	189:4	106:9 112:19,20
127:23 128:4	UK 187:3,18	146:9 147:9	uranium 14:4,7,14	112:22 113:1,2
133:20,24 134:24	188:16	157:13 173:11	14:18 15:16,24,25	146:16 147:25
135:17 143:25	Ulster 102:14	understanding	16:13 17:17 18:6	148:14 158:23
144:11,17 150:14	ultimately 9:24	44:2 48:8 130:8	18:19,21 19:1	167:17,19 168:14
154:3,6 161:22	173:13	135:12 142:6,12	20:11,14,16,18,24	168:16 174:2,10
166:17,23 167:12	ultra-fine 59:22	160:21 167:20	21:3,5,9 22:4 23:3	178:25 179:4
175:21 178:3	unavailable 136:9	181:17,25	23:17,24 29:14,15	185:13 188:17
186:16	uncertain 33:8	understood 36:13	33:9 46:7 55:5	useful 2:17 28:24
turned 21:3 183:7	uncertainties 32:20	36:21 111:1	56:18 61:7,24	77:4 94:17 124:6
Turner 151:17,21	34:21 37:17 38:22	123:16 155:19	62:3 63:6,10,14	125:17 162:8
152:15	39:6,20 43:2,13	undertaken 186:19	63:16,18 64:3,10	USEPA 34:8,13
turning 16:15	43:14 44:1 45:17	underwater 176:16	64:20 65:7,12,16	35:5,8 40:24 45:2
156:24	48:11 49:9 50:11	undue 12:2	65:17,19,20,22,23	45:22 48:4
twice 162:16	52:5 53:13 54:3	unfair 82:13	65:25 66:1,2,3,4	uses 7:14 8:24 56:5
two 5:13 6:12 7:6	54:11 168:21	unfortunately 1:25	66:21 67:7,12	56:5 92:8 153:15
8:25 11:6 14:13	170:11 174:3	3:5 58:7	79:11,16,18,19,23	UT-38 18:17
14:15 16:4 17:18	uncertainty 32:23	uniform 28:17	79:23 80:15 81:9	
23:18 34:5,9,11	33:22 35:7 37:12	105:4 149:5	89:10 98:9,10,11	V
45:1 52:17,20	37:21 38:1,2,3,4	uninhabited	98:24 100:4 101:3	v 150:1
56:25 64:17	39:24 40:7,23	135:21	101:9 102:18	valuable 13:11
104:14,15 108:11	44:20,25 45:15,20	Union 6:15	103:10 104:3,12	value 19:13 35:18
109:12 110:7	47:10 48:2 49:24	unit 3:10,12 80:4	104:19,24 105:1,4	35:18,19 38:3
113:25 136:2,24	51:14,22 53:21	151:5	105:6,7,18,18	42:25 43:8 45:22
139:5 140:24	54:14 76:14	United 41:11,24	114:5,6 154:2,11	46:19 54:8 56:11
146:6 152:13	107:16 166:16	64:20 173:18	161:11,12	58:6 133:10
153:14 160:16	167:19 168:16	177:5,9	uranium-234 81:24	135:20 153:4
164:24 166:11	169:4,16 171:20	units 2:19,20,24 3:5	115:20	164:21
176:10 180:10	171:25 172:8,8,15	3:14 82:6	uranium-235 81:23	values 10:21 34:8
184:18 185:21	172:19 173:11	universally 6:8	115:19	36:1 37:21 38:1,4
type 140:19 147:3	unclassified 177:5	University 17:20	uranium-238 81:22	38:8 45:21,22
163:8	uncomfortable	61:14 102:13	115:15	46:19 47:5,11
types 11:20 69:7	110:14	unknown 91:5	uranium-240 70:22	52:8,10 54:14
102:16 140:24	uncontrolled	unpleasant 59:21	153:17	57:20 64:16,17
141:6 146:24	130:24 135:9	unreliability 171:5	Urge 11:23	148:12 170:16,17
typical 64:10,19	underestimate 52:4	UNSCEAR 108:11	use 3:15 5:20 6:1	170:19,24 171:12
	52:7	108:11 109:11	7:4 13:8 26:23	vaporised 21:21
U	Underneath 137:10	110:7 156:6	28:5,25 29:8	vapour 157:24
U-234 79:13,16,25	understand 19:2	unstable 162:2	33:21 35:4,8,19	variation 157:23
80:5,8,9,14,22,24	27:21 29:23 30:16	up-to-date 41:17	38:2,2 39:23 41:5	variations 73:10
81:3,13	31:3 35:21 43:25	upper 16:12 18:25	43:12,16 44:20	76:2,2,21 131:17
U-235 79:24 80:6,9	44:12 46:10,11	19:4,7,12 25:8	45:12,22,25,25	varies 104:1
80:15,19,25 81:3	50:8 64:14 98:4,5	50:17,24 52:8,9	46:18,18,19,20	various 5:23 26:1
U-238 80:19	98:6 111:24	52:10,12 81:21	48:4 50:8,20	33:10 59:13 61:15
UCPA 173:25	116:23 118:10	111:25 112:2	54:14 55:25 56:12	68:6 82:6 83:5,18
UF 170:16,17,19,24	120:9 121:13	123:5 155:9 187:4	56:19 74:21 92:13	83:19 84:6 96:13

vary 70:12	17:21 61:8,14	we've 6:20 17:21	whatnot 68:22	wouldn't 26:10
Vaskess 27:3	67:13 175:3	48:17 49:11 54:9	whichever 46:8	27:14 28:1 31:8
130:16,22 135:21	wasn't 6:22 8:16	61:9 72:20 97:12	whilst 124:24 182:9	36:15 59:18 82:24
136:21 137:2,4,11	10:7 18:1 23:14	112:11 115:4	wide 42:1	90:6 100:3 138:7
137:15 138:6,12	41:4 71:9,11	136:5 141:24	widespread 22:3	184:1
verified 177:9	75:25 91:16	147:6 157:21	25:8 150:3	wound 44:5 45:6,8
Verma 185:16	112:18 118:14	173:6 175:19	wind 87:2	wounds 44:3
version 1:18,20	water 30:9,10,11	182:14	window 27:16	write 8:10 33:12
vicinity 181:21	30:12,13,14,17,21	weakens 109:5,7,23	146:19,20	37:13
video 125:12,14,17	30:23 31:6,13,22	109:24	wish 6:21 117:15	writing 12:14
180:12 185:17	32:1,4,9 87:1,2	weapon 22:14 69:7	122:24 158:15	written 33:7,14
186:6	90:5,12 102:17	71:21 72:14 74:22	187:17	47:21 71:24 136:8
view 9:11 14:16	103:15 139:10	74:25 76:23,23	withdrew 114:12	163:12
131:15 159:7	179:25,25 180:4	131:16 153:18	189:12	wrong 16:15 47:14
161:15	180:14 181:8	157:5	witness 17:2,9,10	62:9 74:2 172:6
views 10:19	182:14 183:17,19	weapon's 155:9	24:11,20 30:4,7	184:15
visible 98:21	184:6,12,16,19,25	weapons 20:18	58:12 67:2 73:2	wrongly 35:20
volcanic 15:7	184:25 185:18	55:6,7 69:4,4,5,12	82:14 86:22 89:6	wrote 7:19 8:15,16
volume 144:7,9,10	186:5,7	69:13 71:16 72:1	94:24 95:10 97:2	86:8
	waters 181:24	72:5 73:10 74:22	114:4,6,9,12	
	wave 178:19	74:24 76:3,22,25	125:25 130:6	X
W	way 4:2 5:8 9:23	77:5,7,9 79:21	154:21 189:11,12	X 126:13 140:9
wait 141:21	17:7 35:23 41:2,2	81:20 110:23	witness' 55:11	190:1
Walsh 151:18,23	42:22 46:17,17	140:7 156:7	witnesses' 94:11	x-ray 98:19,23
152:1,6,9,11	51:1,2,3,4 54:16	weapons' 81:13	wonder 1:12	X-rayed 98:12
want 6:21,22 13:24	60:6,9 65:23,24	weapons-type	wondered 51:7	X-rays 98:20
20:11 32:25 46:6	81:17 90:18	79:19	58:18	
48:13 61:17 70:4	110:12 111:8	website 78:13	wondering 88:20	Y
72:19 73:2 75:7	124:21 132:22	125:13	Woodville 127:21	Y 18:13,14,16,21
77:16 82:8,16	138:21 156:8	websites 56:24	word 81:4 182:4	19:17 20:2 23:11
83:4,14 91:14	159:1 172:10	Wednesday 189:24	words 44:8 75:25	118:17 128:2,7
92:3 95:23,24	we'll 5:17 17:21	week 4:8	127:6 139:11	133:22 135:19
96:4 106:25	22:23 48:24 49:1	weeks 87:8 164:24	142:23 151:16	136:13 177:16
109:21 111:11	67:9,11 68:17	166:12	157:18 159:19	yardstick 42:5
122:25 128:24	91:8 92:21 97:13	weight 19:14	167:22	year 12:14 119:3,4
133:4 134:22	113:24 114:23	weighting 9:1,4	work 26:10 30:23	years 3:3 6:12
142:20 162:6	119:18 133:12	123:8,20,23	45:11 68:9 71:4	10:20 92:1 110:9
169:22,24 172:2	148:5 189:20	went 10:19 93:20	84:9 121:25 143:7	110:9 174:11
175:4,4	we're 46:6 52:23	94:12 103:1	145:7 152:21	Yeso 177:13
wanted 6:25 54:10	54:18 60:22 72:22	122:10 133:15	160:12	yesterday 3:21 22:1
105:24 114:2	76:24 90:4 102:22	weren't 8:14 118:8	workable 12:1	24:19 26:18,19,24
123:4,11 167:2	102:25 104:9	176:11	worked 177:15	57:15 116:19
wants 13:1 147:6	113:16 120:20	west 90:12 135:4	workhorse 142:10	121:24 126:6
158:19	143:2 144:21	176:11	142:17 144:19	141:9
War 125:13 180:13	161:9 167:5,6	western 27:3	working 10:21	yield 177:6
wash 26:11	171:22,23	wet 31:2,8,24,25	worth 108:8	yttrium 162:15
Washington 14:13		32:2,8,13		

164:3,5	130:16 151:11	130 32:22 33:2,3,16	1958 143:2	2016 1:1 189:24
<hr/> Z <hr/>	152:21 153:1,3,4	33:17 40:4 49:10	1962 175:24,25	21 1:1
Z 78:17	153:14 154:24	52:16,18,21 53:4	176:5	22 123:7 175:11
Zealand 14:11 16:2	157:15,18 164:21	131 142:16,25	1970s 15:23	189:24
185:25	165:1,3,6,7,14,15	132 53:24	1975 61:22 175:3	23 178:12
zero 22:13 181:21	165:16 166:7,9	1320 130:20 140:25	175:21	235 80:20
182:23	168:2 177:14	141:4 142:17	1980s 15:23	238 20:11,17,18,24
<hr/> 0 <hr/>	189:17,18,21	143:7 144:19	1990s 15:23	21:3 33:10 46:7
0.01 123:9	10-year-olds	145:14,18 146:8	<hr/> 2 <hr/>	63:10,14 66:1
0.9 164:2	170:19	146:13 148:7	2 11:16 30:22,25	238-uranium 64:25
<hr/> 1 <hr/>	10.00 1:2 189:16,24	137 163:24 164:3	31:10,16,17,22	24 13:21
1 2:23 3:10,11,13	10.30 189:16	165:1	33:15 39:23 41:5	244 7:22 8:1
16:5 30:21 31:16	100 2:22 3:8,11,13	137CS 163:24	48:7 74:10,11	247 11:11,16
31:22 39:21 62:14	10:16 90:3	139 95:10,12,13,16	75:25 76:11 85:16	25 49:1 156:11
62:24 74:7 77:9	103 168:19	95:23	96:1,3 109:17	175:24
85:15 92:9 97:20	106 49:20 52:13,16	14 94:25 117:1,7	115:20,22 120:18	250 38:15
97:25 102:11	52:18	118:5 177:21	130:11,17 133:2,9	28 187:12,13
115:16 120:18	109 53:18,19	140 93:6 95:11	143:13,14,22	28,000 187:2,3,8,9
128:4 130:8	11 21:6,8,10,14,15	15 3:3 48:18 68:25	144:10 148:8	187:14
132:25 133:2,8	56:4 77:24,25	155:7 181:9	154:11,13,14	280 117:20
142:19 143:12,13	78:4,6,7 109:12	183:15	155:4 158:8	285 55:17 117:21
143:17,23 144:7,9	115:17 133:24	150 135:20	162:17 164:6,15	124:5
162:9 165:13,19	134:2,24 175:25	1500 110:24 111:21	164:17 165:3	29 95:1
165:20,21 166:4	176:10	151 32:22	170:16,17 171:6,6	<hr/> 3 <hr/>
178:2 183:6,11	11.12 49:2	16 83:17 87:18	175:23 177:24,25	3 1:25 2:4 14:1
190:2	11.17 126:25	127:23	178:1	33:14,15,15,15
1-year-olds 170:19	11.25 49:4	160 144:15	2,000 112:1 187:4	39:22,22,22,22,23
1,00 149:19	110 122:15 133:9	161 144:1,7,16,17	2,700 172:23	39:23 40:15 41:5
1,000 171:3,24	116 190:3	150:14	2.00 115:3	42:13,14 45:20
172:22,24	117 52:24,25	17 161:23	2.12 55:13,14	46:3,4,7 48:7
1,500 187:5,7	12 115:21,22	176 126:22	2.14 32:19 55:13,17	49:20 51:12,13,17
1.05 115:1	125:22 153:13	177 126:5,7,7,10,25	2.17 32:20,22 49:11	51:19 52:12 53:13
1.2 69:9	158:25 159:3	178 126:10	2.2 44:7 53:23	53:18,25 56:6,12
1.5 130:16	160:22	18 17:24	129:24	56:13,20 57:6
10 11:19 19:8 36:2	120 42:14 45:4	180 144:12	2.3 130:12	58:2,15 61:23
37:8,12 40:25	124 190:4	182 144:11,13,14	2.4 97:18,19	109:17 115:19
42:5,6,12 46:3	1257 140:19,24	144:18	2.8 134:4 187:11	120:18 139:11
55:23,25 56:6,11	141:3	183 144:17	20 3:3 50:6,8,9,19	140:8 163:14
56:12,13,20 57:6	129 53:24 141:13	185 39:8	50:20,21 51:5	170:5,16 171:6
57:12,13,16,18,21	141:17,20,21,23	188 153:6,8,9	81:2 93:17 94:15	186:23 190:3
57:21,22 58:2,15	167:13	189 156:17,22,25	141:18 187:7	3,000 80:5
68:24 81:25	13 53:16,20 133:20	157:11 178:3	2000 108:12	3.08 156:12
109:12 115:16,19	138:24 158:25	19 156:25	2002 59:4	3.2 139:11
115:19,20,22	159:3	191 158:2	2003 12:2	3.25 156:14
	13.1 126:10	193 178:22	2013 141:17	3.3 18:21 19:16,17
	13.4 126:16	1953 78:16 79:17		

3.4 134:25	51:17 56:11 57:16	137:13,17,25		
3.9 154:8	57:19 120:18	138:7,11,12		
30 39:14 124:25	124:7 149:1	151:12 154:7,8		
125:1,2,3	152:22 160:17	165:6 176:10,20		
33 166:12	161:22 162:9	176:21 181:2		
34 181:5	165:14,16 166:9	8,000 20:19 81:23		
388 22:9,20	167:22 168:13	80 55:15		
	170:15	81 55:9,16,17,17,21		
<hr/> 4 <hr/>	5,000 22:16,21,24	82 55:21		
4 33:14,15 50:3	5,700 110:9	<hr/> 9 <hr/>		
51:13 52:2,3,23	5.1 141:13,15	9 93:15 125:18		
53:1,6,17 55:24	156:16,19	126:3,4 131:4,5,5		
55:25 57:21,22	50 26:4 148:7,8	138:2,14		
103:24 105:10	500 10:17 110:24	90 5:9 162:15		
106:1,2 120:18	187:5,7	95 54:12		
133:24 134:2	51 148:10	96 67:20,21 136:11		
137:5 141:17	52(f) 149:11	138:10		
143:1,4,4 148:14	56 150:1	99 137:3,6,7		
153:1,4 159:1	<hr/> 6 <hr/>			
165:2,4,14,15	6 1:22,24 2:4 46:7			
166:9 179:25	57:21 97:22,23			
180:8	120:18 134:24			
4.1 32:22 33:18	153:3 158:3			
40:5 44:18 49:10	170:17 171:6,12			
51:15 53:4,14	173:10 174:19			
54:2 166:24 167:5	6,000 110:9			
168:8 172:10,20	67 121:17 122:13			
174:19	<hr/> 7 <hr/>			
4.15 114:14 189:15	7 52:23 53:15 61:18			
189:22	61:19,20 133:22			
4.30 189:20	181:4 182:18			
40 22:15 42:7,10	7.1 163:4			
45:4	70 150:14,15,16			
400 42:10 45:4	152:19			
81:24 122:11	71 152:19			
124:3,5	72 44:8 117:21,21			
42 173:21	75 159:1			
43 166:23 167:25	77 62:8,9,12			
168:8 186:16,17	78 135:17			
186:18	79 62:10,11,12			
44 178:3	<hr/> 8 <hr/>			
45 125:6	8 20:20,21 21:3,18			
46 155:7	48:7 61:20 89:9			
<hr/> 5 <hr/>	89:10 135:15			
5 11:22 46:7 48:7				