

<p>1 Monday, 20 June 2016 2 (10.30 am) 3 MR RICHARD HALLARD (continued) 4 Cross-examination by MR TER HAAR (continued) 5 MR JUSTICE BLAKE: Yes. Good morning. 6 MR TER HAAR: My Lord, I'm not aware of any housekeeping 7 matters this morning unless there is something the 8 Tribunal wants to raise with us or anybody else. 9 MR JUSTICE BLAKE: Yes. 10 MR TER HAAR: Mr Hallard, you have some housekeeping. You 11 have something in your hand. 12 A. I was just wondering if I may. 13 My Lord, I have the summary of the evidence which 14 I considered which we were discussing on Friday. 15 Q. Is this something you prepared over the weekend? 16 A. This is something I prepared over the weekend. 17 MR JUSTICE BLAKE: Ah yes, this was the list of documents 18 that you consulted. 19 A. I did, yes. 20 MR JUSTICE BLAKE: Do you have copies -- lots of copies? 21 A. I have 15, I think. But they are not hole-punched, 22 I just realised. 23 MR JUSTICE BLAKE: If you pass them all up to me. (Handed) 24 A. Some of the items on this list have had to be included 25 from memory because all the paper files, of course, that</p> <p style="text-align: center;">Page 1</p>	<p>1 A. Yes, I've certainly only seen one of Mr Large's reports. 2 Q. Well, if you are going -- 3 A. I think it is the first under tab 12. I would need to 4 read it properly to be clear, but the thing I remember 5 most about it was the discussion about the detonation 6 height for Grapple Y. That appears to be discussed 7 here. 8 Q. Your recollection is good because that starts at page 4 9 and goes through to page 6. 10 A. Yes. 11 Q. Now, just to test that as a matter of your approach: 12 your speciality, as we discussed on Friday, is I think 13 one could call it in broad terms radiological 14 protection? 15 A. Yes, that's correct. 16 Q. What is being discussed here are to a very large extent 17 meteorological considerations which is outside your 18 expertise? 19 A. It is outside my expertise, yes. 20 Q. Whilst there is plenty of other evidence to which this 21 Tribunal and the previous Tribunal turn, you are reliant 22 on other people's views in relation to whether the 23 height recorded for the Grapple Y is correct or not? 24 A. That's correct. There was obviously this report by 25 Mr Large and then I think there was quite a lot -- or</p> <p style="text-align: center;">Page 3</p>
<p>1 I received are in Cumbria at the moment. So they are 2 not available. But I think the list is accurate. 3 MR JUSTICE BLAKE: Thank you anyway. 4 Right, thank you for that. 5 MR TER HAAR: Mr Hallard, would you give me just a moment 6 while I look through this. (Pause) 7 I'm sorry you had to spend so much of your weekend 8 doing this but it's very helpful. Thank you very much. 9 I am going to carry on going through the reports 10 just to clarify -- I was trying to do two things on 11 Friday. One was to identify what you'd looked at and 12 that has now much helped, and the other is to work out 13 the boundaries of your expertise with other experts' 14 expertise. 15 A. I understand. 16 Q. So could we now take up bundle 12, SB12. We had got, 17 before we came to a bit of a grinding halt, to tab 12, 18 and the evidence of Mr Large. 19 Now, when we were discussing it on Friday, if 20 I remember rightly, you had -- sorry, that's at tab 12 21 of this bundle. 22 A. Yes. 23 Q. You remembered having seen one of the two statements. 24 There's one at tab 12 and one at tab 13. I think you 25 thought you had seen the one at tab 12?</p> <p style="text-align: center;">Page 2</p>	<p>1 there was some discussion about this issue in one of the 2 expert reports from Mr Johnston. 3 Q. Yes. There is indeed. 4 Would it be fair to say that -- I'll come back to 5 your report itself your approach was broadly in this 6 regard to accept Mr Johnson's analysis of the height of 7 this explosion rather than Mr Large's? 8 A. Well, the report didn't actually -- my report did not 9 actually make any assumptions about the detonation 10 height for Grapple Y. The approach that I took in the 11 report, and undoubtedly we'll discuss this later in more 12 detail when we go through the report, the approach that 13 I took was I read all of the expert evidence that I was 14 aware of which was relevant, the two reports we've just 15 discussed by Mr Large and Mr Johnston, and also the 16 meteorological reports by Mr Strange -- 17 Q. Stretch. 18 A. -- Stretch, beg your pardon -- and Dr Nicholson and 19 those four overlap. There is a degree of overlap 20 between those, and I concluded from that that there was 21 considerable uncertainty about how much fallout there 22 would have been from Grapple Y if you were looking at 23 the cloud and trying to work out how much fallout could 24 have come from the cloud onto the Island. 25 So instead, what I've relied on is the information,</p> <p style="text-align: center;">Page 4</p>

<p>1 particularly the monitoring information, which again we 2 can discuss later, I'm sure, the monitoring information 3 on the Island and the levels of contamination that 4 I believe the management of the Island, if I can put it 5 like that, the AWE and the military management of the 6 Island, would have considered significant to the point 7 that they would have had to have taken action had those 8 levels been exceeded.</p> <p>9 Q. So if I can summarise your evidence I hope accurately, 10 you were aware that there was meteorological debate --</p> <p>11 A. Yes.</p> <p>12 Q. -- which took place which depended in part upon the 13 historical investigation as to exactly how high the 14 Grapple Y bomb was when it went off?</p> <p>15 A. Yes, that would have been one of the issues.</p> <p>16 Q. And one of the significant features of that debate is 17 that the lower that the bomb was when it was detonated 18 the more likely it was to suck up material from the 19 ground, and what goes up has to come down, so the 20 consideration there between meteorologists led to the 21 consideration of how much of the ground material was 22 sucked up into the radioactive explosion -- perhaps 23 that's not the right expression -- into the radioactive 24 cloud, and then fell back to earth.</p> <p>25 But your approach was not to involve yourself in</p> <p style="text-align: center;">Page 5</p>	<p>1 Q. I think it would be fair to say that you needed to rely 2 upon a very large amount of material from people with 3 different expertise from yourself.</p> <p>4 A. That's correct.</p> <p>5 Q. We'll come to some other examples of that in a moment.</p> <p>6 So moving on from Mr Large's first report, he then 7 has a second report at tab 13. As you say, you hadn't 8 seen this before so you didn't take this into account?</p> <p>9 A. I don't believe so. I don't remember it.</p> <p>10 Q. We then have at tab 14 a supplementary report from 11 Professor Regan.</p> <p>12 Now we know from questions on Friday that you looked 13 certainly at his principal report. It's not quite clear 14 from the note you produced today -- and that's not a 15 criticism, you were doing the best you could over the 16 weekend -- whether you saw all the supplementals.</p> <p>17 I don't know whether you can remember at this distance 18 from doing your report whether you would have seen all 19 the supplementals.</p> <p>20 A. I've seen this one -- well, I've seen a report by 21 Professor Regan dated 16 September 2011, which is the 22 date on this supplemental report, so I think this would 23 be the report that I have seen.</p> <p>24 Q. Can we just at page 7, while we have it open, page 7 of 25 that report, paragraph 55 -- we did actually stop at</p> <p style="text-align: center;">Page 7</p>
<p>1 that debate but to say, "I will look at the records on 2 the Island and see what they show me"?</p> <p>3 A. Yes. Essentially I felt that I didn't have any 4 expertise, any competence to be able to make a judgment 5 as to the precise height. Perhaps as an aside I did 6 note that -- no.</p> <p>7 Yes, I think that's fine.</p> <p>8 So -- but I felt I'd no expertise or no competence 9 to be able to make a specific judgment on that. I felt 10 that my expertise was more to do with monitoring and the 11 levels of contamination that may have existed on the 12 Island.</p> <p>13 Q. I think again just if you like to clear some of the 14 ground between us, we do not in any way challenge the 15 mathematics of your report where you carry out 16 calculations as to dosimetry and if you assume there is 17 this much radioactivity in the air how much will be 18 breathed in. That area, my head got lost in the maths 19 very quickly.</p> <p>20 A. I'm sorry.</p> <p>21 Q. But we bow to your special knowledge in that regard. 22 What I am trying to see is what information you had 23 to take into account in order to carry out that 24 calculation.</p> <p>25 A. Right.</p> <p style="text-align: center;">Page 6</p>	<p>1 this point on Friday. He is giving some evidence there 2 about personal dosimeters and this is in your territory 3 very much, isn't it?</p> <p>4 A. It is, yes.</p> <p>5 Q. Is it common ground that personal dosimeters do not give 6 any measurement for internal ingestion or inhalation of 7 radiation, in particular for alpha emitting 8 radioisotopes such as 239 Pu and 210 Po?</p> <p>9 A. Yes, that's certainly true. The film badges they use 10 certainly would not give any direct measurement. You 11 can infer certain results from that but I think in the 12 way that this is meant I agree with it.</p> <p>13 Q. Would you also agree, if we go a little bit higher on 14 the same page with what he says at paragraph 51: 15 "A simple measure of how much activity arises from 16 a certain type of radiation, such as gamma emission, can 17 be determined by using a simple gas-filled Geiger-Muller 18 counter or handheld scintillation counter. These types 19 of device give a gross value of the number of 20 radioactive decays per second to be measured at a given 21 time. They measure the number of counts of a given type 22 of radiation (gammas or betas usually) in a fixed time 23 period."</p> <p>24 Just stopping at that paragraph is that something 25 with which you'd agree?</p> <p style="text-align: center;">Page 8</p>

1 **A. Yes.**
 2 Q. Again paragraph 52:
 3 "These types of detectors do not give spectroscopic
 4 information and therefore cannot be used to determine
 5 the nature of the radionuclei which are present and
 6 giving rise to the measured radiation. They cannot be
 7 used to tell if the gamma rays being measured are from,
 8 for example, decay of 137Cs, 131I or activation products
 9 such as 60Co."
 10 Would you agree with all that?
 11 **A. In the way that he -- yes, I might qualify that slightly**
 12 **later but yes, I agree with what he said.**
 13 Q. Again, just 53 I think reflects something you said on
 14 Friday, and 54:
 15 "Personal dosimeters usually measure an integrated
 16 dose. This corresponds to the total dose to which the
 17 individual was exposed over a defined period of time.
 18 Such devices are usually only useful for gross
 19 measurements of radiation exposure from sources external
 20 to the individual who is being exposed. For the
 21 radiation workers and personnel in the tests, they would
 22 be useful in identifying examples where individuals
 23 would be exposed to external gamma radiation, for
 24 example from short-lived fission fragments and some
 25 activation products in any deposited fallout."

Page 9

1 **A. I would largely agree with that. Again, sometimes it's**
 2 **difficult to know whether to go into any detail or not.**
 3 **From the film badges that were being worn you can**
 4 **get an approximate -- at least with modern film badges**
 5 **and I think with these as well, you can get**
 6 **an approximate indication of the types of a broad range**
 7 **of gamma energies and discrimination between beta and**
 8 **gamma, in a fairly crude way. So it might tell you low**
 9 **energy gamma, high energy gamma and beta. So that's**
 10 **a slight qualification on what Professor Regan is saying**
 11 **but in broad terms I agree with it.**
 12 MR JUSTICE BLAKE: Was that the qualification you also
 13 indicated you might have to 52? That's your comment on
 14 54, as I understand it.
 15 **A. What I meant by that, my Lord -- again I may be trying**
 16 **to read too much into this; I have a habit of doing that**
 17 **--**
 18 MR JUSTICE BLAKE: Well --
 19 **A. -- you can infer what an isotope is from an estimate of**
 20 **its half life. Now with these isotopes it would be**
 21 **difficult, with the possible exception of iodine-131**
 22 **which has a half life of eight days. The others have**
 23 **very long half lives, but on at least two occasions it**
 24 **was concluded that the isotope present was likely to be**
 25 **a certain isotope called sodium-24, based on the fact**

Page 10

1 **that its half life was approximately 14 hours.**
 2 **So it's not quite what Professor Regan is talking**
 3 **about here. It's perhaps taking it one stage further to**
 4 **say that if you do a series of measurements to measure**
 5 **the rate that the isotope is decaying, particularly for**
 6 **an isotope with a short half life, a few hours or even**
 7 **a few minutes, you can then compare that with a database**
 8 **of isotope half lives and make a judgment as to the**
 9 **possible isotopes that may have been involved. But that**
 10 **would be purely a judgment.**
 11 MR JUSTICE BLAKE: Okay, thank you.
 12 MR TER HAAR: Could I ask you please to turn on to page 13
 13 in this report, please. Paragraph 112 at the bottom of
 14 that page:
 15 "As far as I have noted in my reading of the
 16 documentation to which I have had access thus far,
 17 I cannot find a single case of monitoring for internal
 18 ingestion/inhalation of alpha emitters in the veterans
 19 who served at either Maralinga or Christmas Island."
 20 I will come to his comments on that in a moment, but
 21 would you agree that so far as your reference to the
 22 documents shows there's not a single case of monitoring
 23 for internal ingestion or inhalation of alpha emitters?
 24 **A. Amongst the veterans I believe that's true.**
 25 Q. He says he finds that puzzling, and this is where the

Page 11

1 overlap with your radiological protection world may be
 2 important.
 3 **A. Yes.**
 4 Q. He says this:
 5 "The risks of hazards from this pathway of radiation
 6 were clearly identified and the procedures known for how
 7 to make at least rudimentary sampling measurements of
 8 the men's urine, for example. However, in particular
 9 for the Grapple tests, the majority of the veterans were
 10 not even issued with external gamma/beta dosimeters and
 11 thus I've not seen empirical measurements of doses which
 12 they might or might not have received:
 13 My question to you is not necessarily whether you
 14 agree with that but do you agree that that is a view
 15 which an experienced person in this field might hold?
 16 **A. Yes, I do. Clearly the Island management again, if**
 17 **I can use that term, have made a judgment that the**
 18 **majority of people, particularly the majority of**
 19 **veterans, are very unlikely to have received either**
 20 **an internal or an external exposure based on their**
 21 **prognosis if you like of what was expected from the**
 22 **detonation.**
 23 **Frankly, I find the absence of film badges**
 24 **surprising. I don't really understand why film badges**
 25 **were not more widely used on the Island.**

Page 12

<p>1 In terms of internal dosimetry monitoring, I suspect 2 that that as a process would have been relatively 3 unusual. I think I said on Friday that I believe that 4 some of the -- that some of the Aldermaston staff, 5 perhaps a small number were undergoing internal 6 monitoring. 7 It's perhaps questionable whether you would expect 8 that internal monitoring to include the veterans on the 9 basis of the fact that no fallout was anticipated. But 10 I think particularly the -- the absence of film badges 11 I do find surprising. 12 Q. It may well be that the answer you have just given leads 13 to your agreeing with the next couple of paragraphs. 14 I am going to take you through the next couple of 15 paragraphs as well. 16 A. Right. 17 Q. Paragraph 113: 18 "I note again here, as in my original report, that 19 the majority of those personnel who were provided with 20 dosimeters for the Grapple trials received measurable, 21 above background gamma-ray doses. Assuming these 22 readings arose from exposure to the fallout/residues 23 [produced] from the tests and knowing the large fraction 24 of 239 Pu in the fallout material, it would seem 25 reasonable to me to then at least check/monitor those</p> <p style="text-align: center;">Page 13</p>	<p>1 wouldn't it? 2 A. That would be fair comment. 3 Q. So that failure to carry out what we would now recognise 4 as standard, produces a difficulty for someone in your 5 position of trying to assess the dose that may have been 6 suffered? 7 A. That's correct. I would agree with that. 8 Q. Again just to complete it, because I think it's along 9 the same lines, if we go to 114: 10 "For the Grapple Y test only 3 per cent, 114 out of 11 3,722, of the veterans present were provided with 12 dosimeters, yet of these 114 individuals 96 recorded 13 a non-zero external gamma/beta dose. It follows that if 14 these individuals were exposed to gamma-ray radiation 15 they might well also have been exposed to alpha emitting 16 radiation. Again not even these 3 per cent of Grapple Y 17 veterans who were provided with dosimeters and 18 registered non-zero doses were screened post-detonation 19 for internal alpha radiation exposure." 20 Again, by modern standards that's a fair comment, 21 isn't it? 22 A. By modern standards that's a fair comment, and of course 23 I have estimated in my report, I have included 24 a component for internal exposure which would support 25 that.</p> <p style="text-align: center;">Page 15</p>
<p>1 veterans who registered non-zero measured doses for the 2 possibility of internal alpha contamination. This does 3 not appear to have been carried out in any cases that I 4 am aware of." 5 Again I think you would agree that that's a fair 6 comment, wouldn't you? 7 A. I think judged against modern standards, certainly 8 nowadays we would initiate some internal monitoring 9 I think in a situation like this. In terms of whether 10 the judgment that they made at the time was reasonable 11 it would really have to be made in the context of the 12 culture and the knowledge at the time, and therefore 13 perhaps to criticise that decision based on modern 14 standards would not be fair. But I think by modern 15 standards, in a situation such as this that it would be 16 highly likely, it would be normal, I think, that some 17 internal monitoring would be done. 18 Q. Mr Hallard, the legal landscape for this is that there 19 have been separately claims for negligence against the 20 Government in relation to the testing. That's not what 21 we are concerned with here. The reason I draw attention 22 to this is that one of the problems that you and others 23 have with measuring dose is that what would now be 24 regarded as perhaps standard practice was not carried 25 out at the time. And that would be fair comment,</p> <p style="text-align: center;">Page 14</p>	<p>1 Q. But the problem you are faced with, and perhaps more 2 acutely the Tribunal is faced with, is that because of 3 the methods adopted, the procedures adopted at 4 Christmas Island 50-plus years ago, to ask of anybody 5 assessing what the dose actually was made very much 6 more difficult? 7 A. It certainly is much more difficult. Had we had urine 8 sample results, for example, then that assessment would 9 have been much easier. 10 Perhaps I could just make one -- or just a couple of 11 qualifications. The numbers that Professor Regan 12 quotes, I can't remember if those are the correct 13 numbers or not, but I don't think you are asking that 14 question. I just qualify that slightly because we may 15 need to go there later. 16 But the people who were issued with film badges, of 17 course, were people who the Island management considered 18 were likely or had the potential to receive radiation. 19 And therefore, given that situation it's perhaps not 20 surprising that the majority of people who were issued 21 with film badges did record a measurable dose. That 22 does not correlate in the other direction to 23 say: therefore this proportion of the population of the 24 Island would also have received a non-measurable dose. 25 If the judgment on who should wear film badges was</p> <p style="text-align: center;">Page 16</p>

<p>1 correct you would expect that quite small population to 2 see significant doses. Perhaps from -- ah, that is 3 specifically the veterans, yes, so I'll stop there. 4 Q. Again, I think we are at common ground on this. If you 5 apply modern standards of how to carry out tests, you 6 have to work out not only what you think the likelihood 7 is but also identify the areas where you don't know what 8 the problems may be? 9 A. Yes, that's true. 10 Q. So again applying modern standards of protecting workers 11 and anybody else who might be near any form of nuclear 12 event, you actually do not in modern terms pre-select 13 who is going to be measured because you are actually -- 14 you may be missing some of the most important evidence? 15 A. You may still make a judgment as to the level of 16 monitoring and who you might choose to monitor. I think 17 I said on Friday that people working in a plutonium 18 plant, for example, would experience -- or would be 19 asked to provide urine samples. Some others might also 20 be as well. You would make a judgment on that but then 21 you would test the judgment. 22 I think I also mentioned on Friday that if you had 23 made a judgment that, for example, people working on 24 a certain plant would not need a certain type of 25 monitoring you would still organise what are called</p> <p style="text-align: center;">Page 17</p>	<p>1 emitters, by modern standards this is woefully 2 inaccurate? 3 A. I think by modern standards we would certainly want to 4 take urine samples at the very least from a proportion 5 of the veterans to establish whether there was any 6 indication and any evidence of internal exposure and 7 then we would use that to inform further judgment. 8 Q. Of course we are going to hear more and more about 9 control groups when we get to the epidemiology, but as 10 a matter again of safety procedures you would be taking 11 urine samples not only from those who you suspected 12 might have been exposed but from those who you hoped 13 would not have been exposed so you would have the best 14 control samples you could on the Island? 15 A. Yes. You would probably take urine samples from 16 a proportion of those, which is quite similar to the 17 campaigns we were talking about, the same principle. 18 MR JUSTICE BLAKE: Can I just clarify that if -- I know it 19 didn't happen, but if urine samples had been taken from 20 any of these people, would the testing process of the 21 sample have been able to carried out on the Island or 22 would it have to be sent back to more sophisticated 23 testing in London or somewhere else? 24 A. I think, my Lord, it would have had to have gone back to 25 Aldermaston for the samples to be tested.</p> <p style="text-align: center;">Page 19</p>
<p>1 campaigns, so that for perhaps a month or two months in 2 a period of several years you would actually monitor 3 those people for, for example, internal activity to 4 demonstrate or to confirm that your judgment was 5 correct. So you would test the judgment. You wouldn't 6 simply make a judgment and then assume that it was 7 correct. 8 Q. Of course, if we just think about the historical context 9 of these tests. There was an imminent atmospheric test 10 ban treaty. There was a limited time within which the 11 Government could carry out these tests, I think you're 12 aware of that. 13 A. Yes. 14 Q. So carrying out the campaigns of the sort that you are 15 talking about was wholly unrealistic in the context of 16 what was regarded as being in the highest level of 17 national interest in a relatively short period of time. 18 A. Yes, I would agree with that. 19 Q. And I emphasise I'm not here conducting a case examining 20 negligence on the part of the Government. I am just 21 highlighting by modern standards the absence of evidence 22 that certainly today you would regard as being the 23 minimum that would be available in a properly conducted 24 test. I think you would agree that certainly when we 25 are dealing with the internal consumption of alpha</p> <p style="text-align: center;">Page 18</p>	<p>1 MR JUSTICE BLAKE: So it's not a quick: here's a urine 2 sample, take it round to a machine, yes, no, maybe, do 3 it again? 4 A. The levels of plutonium, and it's principally plutonium 5 that you would be looking for, although urine sampling 6 is also done for uranium, but the levels of plutonium 7 you are looking for in particular are small and 8 therefore you would need quite sophisticated machines to 9 do it. 10 MR JUSTICE BLAKE: Spectrometry? 11 A. Yes, I think they would have used alpha spectrometry. 12 Nowadays they use what is called a mass spectrometer. 13 They actually measure the mass of the plutonium rather 14 than the activity because the modern instruments are 15 more sensitive. 16 MR JUSTICE BLAKE: But that kind of machine is not available 17 on the Island so it would have to have gone back? 18 A. No, I'm not aware of that kind of machine on the Island. 19 If there was, I'm not aware of it. 20 MR TER HAAR: It would seem unlikely there was because they 21 weren't carrying out a programme of testing urine 22 samples, but if they'd thought about it in advance is it 23 the sort of machinery that you could carry with you to 24 the laboratories that were on the Island? 25 A. I don't think so. I've never actually seen the kind of</p> <p style="text-align: center;">Page 20</p>

<p>1 instrument that is used, but my assumption is that they 2 would be quite large, particularly in the 1950s. 3 I think there was some sophisticated measuring equipment 4 on the Island used for the initial management of the 5 samples which were taken from the cloud sampling 6 Canberras. If I understand correctly, the initial 7 sampling was done on the Island and then the samples 8 were dispatched to Aldermaston for more detailed 9 analysis. So there were some sophisticated machines on 10 the Island but I don't think they would have been 11 suitable for this purpose.</p> <p>12 Q. At any rate, it appears so far as one can tell that this 13 was not something which was thought about at the time as 14 a form of checking and control.</p> <p>15 A. No. I have seen a letter from a senior manager at 16 Aldermaston indicating that he believed that some form 17 of urine sampling should have been taken. But I'm not 18 aware that any further action was taken as a result of 19 that letter and I'm afraid I couldn't point you either 20 to the person who wrote it or to the letter itself.</p> <p>21 Q. I'm sure if we need to we can trace it. 22 Could we go on in this bundle to the next tab which 23 should be I hope 14A.</p> <p>24 A. Yes.</p> <p>25 Q. Just for completeness, another report from</p> <p style="text-align: center;">Page 21</p>	<p>1 MR TER HAAR: Hold on a moment. Well, it's in the original 2 bundles. 3 MR JUSTICE BLAKE: 24 is the first tab of the next volume. 4 So do not despair. 5 MR TER HAAR: Right. In my Lord's copy is tab 24 6 Mr Johnston's report? Otherwise I may despair. 7 MR JUSTICE BLAKE: Well, it's a report by Mr Johnston: 8 "I, Kenneth Johnston, have been instructed by ..." 9 MR TER HAAR: That's right. Could you go to bundle SB13 10 where I hope -- 11 A. I've just done that. Tab 24. 12 Q. Good. Now this -- 13 MR JUSTICE BLAKE: If you put your tab 24 from 12 to 13 we 14 might still be talking the same language. 15 MR TER HAAR: We might be. At least we haven't got quite 16 the problems of bundling as we had on Friday even if the 17 order is not as smooth as it might be. 18 Anyway, this is one of the reports that I am sure 19 you have seen. This is from Mr Johnston on behalf of 20 the Secretary of State. 21 A. Yes, I believe this is one of the ones I've seen. I'm 22 just noting the date. I've got 4 May and this says 23 3 May. But I think it must be the same report. 24 Q. All right. Now -- 25 A. And I do recognise some features of this.</p> <p style="text-align: center;">Page 23</p>
<p>1 Professor Regan, headed at the top of the first page 2 "20 September 2012". 3 A. Yes, I will have seen that. 4 Q. Right. I'm not going to take you to any details of that 5 at this stage. 6 Then 14B, another report from Professor Regan, 7 concentrating on Maralinga. 8 A. Yes, I've seen this. 9 Q. Then I would be surprised if you saw any of the next 10 run. 15 is Dr Lindahl, so is 16, then 17 is again 11 Dr Lindahl. These are dealing with medical issues, not 12 your territory. 13 A. No, I've not seen that one. 14 Q. Then 18 is the start of a -- that's a report from 15 Dr Darroudi. Again on the medical side, not your 16 territory? 17 A. No. 18 Q. Rather than taking you through them one by one, if we go 19 on through, please, to tab 24, here is a report which 20 I am absolutely certain you've seen from Mr Johnston. 21 A. Tab 24? 22 Q. Yes. I hope we sorted out any bundling problems. It 23 should start "I, Kenneth Johnston ..." 24 DR RAYNER: We don't have 24. We stop at 23. 25 A. Yes, that's where I got to.</p> <p style="text-align: center;">Page 22</p>	<p>1 Q. Now, his speciality is that he is part of a team of 2 radiochemists. 3 A. Yes. 4 Q. One would call you a radiophysicist. 5 A. Yes. 6 Q. Radiochemistry, so he has a focus which is different 7 from yours and he had been very much involved with the 8 nuclear test programme himself as we see? 9 A. Yes. 10 Q. Can I just pick up one comment he makes at page 3, 11 paragraph 7. He says this under the heading "Alpha 12 monitoring in the field": 13 "It should be noted here that these 'Noble 14 gas-filled proportional counters' for alpha counting 15 were used by both AWRE and AERE radiochemists, but 16 require stable laboratory conditions and careful sample 17 preparation. They were totally unsuited [this is his 18 underlying, as I understand it] to area monitoring of 19 alpha contamination in the field. The use of simple 20 gamma-sensitive probes to detect and map any areas of 21 local fallout provided a practical and effective 22 solution, given the known association of plutonium and 23 uranium with beta/gamma active debris." 24 Certainly so far as using these rather more 25 sophisticated pieces of machinery you'd agree with his</p> <p style="text-align: center;">Page 24</p>

6 (Pages 21 to 24)

<p>1 comment?</p> <p>2 A. Yes, I would. Noble gas, if people are not familiar</p> <p>3 with the term, is also called an inert gas, so that</p> <p>4 might argon or krypton for example. And proportional</p> <p>5 counters are still used. They tend to be large, they</p> <p>6 can measure alpha and beta contamination. They can be</p> <p>7 used, the modern ones can be used in the field but even</p> <p>8 so it's relatively unusual to use proportional counters</p> <p>9 in the field because they're quite fragile. So in the</p> <p>10 late 1950s I think that would be an entirely accurate</p> <p>11 statement.</p> <p>12 The use of simple gamma-sensitive probes. Yes,</p> <p>13 I also believe that that is a reasonable statement, that</p> <p>14 if you assume a certain composition of the</p> <p>15 radionuclides, as I have done and I know that</p> <p>16 Mr Johnston did and I believe Professor Regan did too,</p> <p>17 if you assume a certain composition of the radionuclides</p> <p>18 then you can use the gamma emitters as a way of</p> <p>19 detecting the alpha emitters that you know must be there</p> <p>20 given that proportion.</p> <p>21 Q. Well, can we go on again to the process of identifying</p> <p>22 what you've seen. I'm a bit worried that it may not be</p> <p>23 in this one. I have it in bundle SB13 at tab 45 and 46.</p> <p>24 But I'm a bit worried that we may not all be singing off</p> <p>25 the same hymn sheet.</p> <p style="text-align: center;">Page 25</p>	<p>1 pathways" or "environmental pathways" is extremely</p> <p>2 important in the context of this case, isn't it?</p> <p>3 A. Yes.</p> <p>4 Q. What you are doing is you are looking at the ways in</p> <p>5 which radioactivity can come in contact with human</p> <p>6 beings and human beings can come in contact with</p> <p>7 radioactivity by looking at the circumstances in which</p> <p>8 radioactive material falls, is deposited, may be</p> <p>9 re-suspended, may still be in the air without having</p> <p>10 fallen?</p> <p>11 A. Yes, that's correct.</p> <p>12 Q. And we'll come on to a bit more of his speciality, but</p> <p>13 you are not a specialist in those highly technical</p> <p>14 areas, are you?</p> <p>15 A. No, I'm not.</p> <p>16 Q. So again you would bow to his expertise in that area?</p> <p>17 A. Yes.</p> <p>18 Q. If we go on in that paragraph 2:</p> <p>19 "I have a degree in environmental physical science</p> <p>20 from the University of Kent (1977). I was awarded a PhD</p> <p>21 by the University of Est Anglia for study into the</p> <p>22 deposition of atmospheric particles and gases (1985).</p> <p>23 In addition to post-doctoral work into the</p> <p>24 light-scattering properties of particulate materials,</p> <p>25 I worked for over 16 years (from 1986) at the</p> <p style="text-align: center;">Page 27</p>
<p>1 MR JUSTICE BLAKE: 45 and 46 looks like it's in this bundle.</p> <p>2 So, so far, so good.</p> <p>3 MR TER HAAR: 45 should be Mr Stretch's report.</p> <p>4 MR JUSTICE BLAKE: Yes.</p> <p>5 MR TER HAAR: And 46 should be Dr Nicholson's report.</p> <p>6 MR JUSTICE BLAKE: Yes.</p> <p>7 MR TER HAAR: We've taken tab 45 first of all. We discussed</p> <p>8 earlier that you bow his expertise insofar as he deals</p> <p>9 with meteorology?</p> <p>10 A. Yes.</p> <p>11 Q. Then 46 -- this may be important -- Dr Nicholson you</p> <p>12 describe in your references in your paper, report, as</p> <p>13 giving meteorological evidence, but were you aware that</p> <p>14 in fact his expertise is not simply meteorological but of</p> <p>15 a very specialised nature in relation to certain</p> <p>16 environmental factors?</p> <p>17 A. I picked up that he has expertise in particle deposition</p> <p>18 so -- but I'm not aware of anything beyond that.</p> <p>19 Q. If you go to tab 46, please, the second paragraph, he</p> <p>20 describes what he is now doing and as part of his</p> <p>21 history:</p> <p>22 "I am currently a private consultant specialising in</p> <p>23 atmospheric particles, environmental radionuclides and</p> <p>24 transfer pathways."</p> <p>25 Just stopping there, the expression "transfer</p> <p style="text-align: center;">Page 26</p>	<p>1 Harwell/Culham Laboratories for UKAEA/AEA Technology.</p> <p>2 My role there was to lead research and consultancy into</p> <p>3 the behaviour of environmental radio nuclides,</p> <p>4 specialising in atmospheric transfer processes and</p> <p>5 aerosols (i.e. airborne particles). Since 2002, I have</p> <p>6 operated as a private consultant (trading as Nicholson</p> <p>7 Environmental). My consultancy work has continued along</p> <p>8 the themes of environmental nuclides and atmospheric</p> <p>9 particles and I have undertaken projects for various</p> <p>10 governmental and non-governmental clients."</p> <p>11 Then paragraph 3, second sentence:</p> <p>12 "I have published approximately 50 papers on topics</p> <p>13 relating to environmental radioactivity, environmental</p> <p>14 transfer process and atmospheric particles and written</p> <p>15 around 70 reports in these areas."</p> <p>16 Just to give you an example of some of the papers he</p> <p>17 has written. In his references at the last pages of the</p> <p>18 tab, page 10, he refers to three papers of which he is</p> <p>19 the author. You see against the name "Nicholson, KW</p> <p>20 (1998a)", "The dry deposition of small particles:</p> <p>21 a review of experimental measurements". "Nicholson KW,</p> <p>22 (1998b)", "Review of particle resuspension". So very</p> <p>23 much right on one of the key areas in this case; would</p> <p>24 you agree?</p> <p>25 A. Yes, it is. Sorry, perhaps --</p> <p style="text-align: center;">Page 28</p>

7 (Pages 25 to 28)

<p>1 Q. No, do carry on.</p> <p>2 A. I was just going to say the information that I have used</p> <p>3 on resuspension was information that I took from what is</p> <p>4 known as the Carter report, which is a major dose</p> <p>5 reconstruction that was done for the Australian veterans</p> <p>6 in the -- I think it's 2006, from memory, following the</p> <p>7 atomic tests in Australia. And there was a great deal</p> <p>8 of information in that, including information on</p> <p>9 particle resuspension and that was the source that</p> <p>10 I used for that purpose.</p> <p>11 Q. I'll come back to that because I understand that's</p> <p>12 a very important part of your approach.</p> <p>13 A. Yes.</p> <p>14 Q. Then just to see the third paper Dr Nicholson refers to,</p> <p>15 the 1995 paper: "Physical aspects of bioaerosols,</p> <p>16 sampling and deposition", something called "The</p> <p>17 Bioaerosols Handbook".</p> <p>18 What is one area of concern when we are dealing with</p> <p>19 suspended materials, as in radioactive materials</p> <p>20 suspended in the air, is a consideration of what are</p> <p>21 called radioactive aerosols?</p> <p>22 A. Yes.</p> <p>23 Q. I'll come back to that in a moment but certainly from</p> <p>24 looking at this, Dr Nicholson's expertise in that area</p> <p>25 is way beyond yours?</p> <p style="text-align: center;">Page 29</p>	<p>1 A. Yes, that's correct. There was a witness bundle which</p> <p>2 I read.</p> <p>3 Q. And so, for example, the evidence of Mr Pascini, who was</p> <p>4 one of the airmen actually in the air and had the</p> <p>5 remarkable experience of flying through the nuclear</p> <p>6 cloud, you've seen that evidence?</p> <p>7 A. I've seen that, yes.</p> <p>8 Q. And so far as the witness evidence is concerned,</p> <p>9 I imagine you've taken that as being historically</p> <p>10 accurate?</p> <p>11 A. Oh yes.</p> <p>12 Q. One document you haven't referred to, I think, on my</p> <p>13 quick reading of the list you produced today, is this.</p> <p>14 In your original list of references you referred to the</p> <p>15 Secretary of State's closing submissions.</p> <p>16 A. Yes.</p> <p>17 Q. If you just take up bundle SB19, please, for a moment</p> <p>18 and just open it up at the first page, what you should</p> <p>19 find here is something which says in the middle of the</p> <p>20 page it's the closing submissions.</p> <p>21 A. Yes.</p> <p>22 Q. These are the closing submissions of those of the</p> <p>23 appellants who are represented by the law firm Hogan</p> <p>24 Lovells.</p> <p>25 A. Yes.</p> <p style="text-align: center;">Page 31</p>
<p>1 A. Yes, I think that's fair.</p> <p>2 Q. I will come back to some parts of those reports in</p> <p>3 a moment. But what I haven't seen in your list of</p> <p>4 references is any reference to the cross-examination</p> <p>5 which took place before the previous First Tier Tribunal</p> <p>6 of the various experts.</p> <p>7 A. The transcripts from the first -- from the previous --</p> <p>8 it is mentioned there.</p> <p>9 Q. You did see them?</p> <p>10 A. I have seen them, yes. Professor Regan, Mr Johnston,</p> <p>11 Mr Nicholson, and of course -- sorry, Dr Nicholson, of</p> <p>12 course -- Mr Stretch --</p> <p>13 Q. Sorry if I missed it.</p> <p>14 A. -- didn't actually give evidence in the end.</p> <p>15 Q. I think what happened was that, and it may be apparent</p> <p>16 to you, in the end between Mr Stretch and Dr Nicholson</p> <p>17 on meteorological areas there was a very, very</p> <p>18 substantial area of agreement.</p> <p>19 A. I think they just concluded that they agreed on the</p> <p>20 issues so there was no point.</p> <p>21 Q. Again, one thing which is now clear from the note which</p> <p>22 you produced is you saw the witness statements not only</p> <p>23 of the appellants but also the body of witness</p> <p>24 statements from other witnesses who are not appellants</p> <p>25 in these two cases.</p> <p style="text-align: center;">Page 30</p>	<p>1 Q. And the submissions take up the whole of this volume.</p> <p>2 Was this material which you looked at? There's no</p> <p>3 record of it in your report, I think. I may be wrong.</p> <p>4 A. I'm sorry, you were asking if I've seen all of them?</p> <p>5 Q. Mr Hallard, I am making a bad point because I missed the</p> <p>6 reference. It is actually referred to in your list of</p> <p>7 references.</p> <p>8 A. Right.</p> <p>9 Q. Can you go to divider D in that?</p> <p>10 A. In SB19? Yes.</p> <p>11 Q. So this should be a section starting at page 27, headed</p> <p>12 "Exposure Christmas Island".</p> <p>13 A. Yes.</p> <p>14 Q. As pointed out to me you do make reference to this, this</p> <p>15 document as a whole, and this is a careful analysis, we</p> <p>16 would say -- or you say -- running over some 60 pages of</p> <p>17 every detail of the evidence which had been called</p> <p>18 before the First Tier Tribunal the first time round,</p> <p>19 setting it in context, obviously putting the case for</p> <p>20 the appellants and then analysing it?</p> <p>21 A. Can I just be clear? Is this an extract from the</p> <p>22 closing, the Hogan Lovells' closing submissions?</p> <p>23 Q. It's not an extract; it is the closing submissions.</p> <p>24 A. I certainly read that.</p> <p>25 Q. One thing which this does do, if we just take</p> <p style="text-align: center;">Page 32</p>

<p>1 an example, go to page 28, section 10 --</p> <p>2 MR JUSTICE BLAKE: I've lost where we are.</p> <p>3 MR TER HAAR: Sorry.</p> <p>4 MR JUSTICE BLAKE: SB19.</p> <p>5 MR TER HAAR: SB19, divider D, for Desmond.</p> <p>6 MR JUSTICE BLAKE: Yes.</p> <p>7 MR TER HAAR: I was going within that to page 28.</p> <p>8 MR JUSTICE BLAKE: 28, thank you.</p> <p>9 MR TER HAAR: If everything is working it should be</p> <p>10 section 10 of those submissions.</p> <p>11 MR JUSTICE BLAKE: It is.</p> <p>12 MR TER HAAR: Heavens! For once it's working.</p> <p>13 Mr Hallard, if we just take this, what's been done</p> <p>14 here is a very careful analysis, we say, of every bit of</p> <p>15 the evidence in relation to the fallout. And if you had</p> <p>16 it in front of you, as your references show you did, one</p> <p>17 would have expected there to be discussion in your</p> <p>18 report of those parts of the points being made which you</p> <p>19 would take into account in accepting and those which you</p> <p>20 were rejecting. But I see nothing of that sort in your</p> <p>21 report.</p> <p>22 A. Okay. Perhaps it's the way that I've done it.</p> <p>23 I've not specifically commented on the expert</p> <p>24 reports or the references. I was asked to take them</p> <p>25 into account, to consider them, which I've done. From</p> <p style="text-align: center;">Page 33</p>	<p>1 questions and you'll find that at divider 2.17.</p> <p>2 A. Right.</p> <p>3 Q. That's what the structure is.</p> <p>4 Now, as you told the Tribunal a bit earlier this</p> <p>5 morning, you didn't involve yourself in meteorology.</p> <p>6 A. No.</p> <p>7 Q. But you did try to look at the evidence as to what the</p> <p>8 measurements were and whatever methods of measurements</p> <p>9 there were available to you --</p> <p>10 A. Yes.</p> <p>11 Q. -- from the hard data?</p> <p>12 A. Yes.</p> <p>13 Q. Now, you obviously did the best you could. But would</p> <p>14 you agree with me that whichever area of measurements</p> <p>15 you're looking, at the procedures adopted with the</p> <p>16 benefit of hindsight present real difficulties in every</p> <p>17 single part of the evidence?</p> <p>18 A. There's certainly a number of questions marks over the</p> <p>19 sticky paper samples. There were -- would it help if</p> <p>20 I just summarised from memory what were the key methods</p> <p>21 of sampling? Or would you rather go into that later?</p> <p>22 Q. If you can't accept my general proposition I will take</p> <p>23 them one by one. I think that's probably easiest.</p> <p>24 A. Okay.</p> <p>25 Q. Let's start with the sticky paper samples. That you</p> <p style="text-align: center;">Page 35</p>
<p>1 memory, and I'm afraid it is quite a long time since</p> <p>2 I read this, but from memory I took account of I think</p> <p>3 all, perhaps bar one area. I've just picked up the area</p> <p>4 of hot particles which I think there was some discussion</p> <p>5 on in a response recently but I think in all other areas</p> <p>6 I have taken account of all of the issues that were in</p> <p>7 this report.</p> <p>8 Q. Right. Because I draw attention to it for two</p> <p>9 reasons: firstly, to see how you've taken it into</p> <p>10 account; secondly, while we're going through a review of</p> <p>11 the documentation to draw the Tribunal's attention to it</p> <p>12 because we will be saying this is a very careful review</p> <p>13 of all the evidence and in a sense we say a good</p> <p>14 starting and ending point on the evidence. That's</p> <p>15 a matter for submission in due course.</p> <p>16 Okay, could you put that bundle away, please, and go</p> <p>17 at last to your own report.</p> <p>18 A. Which bundle is that in?</p> <p>19 Q. Sorry, bundle SB2. I do apologise. You'll find the</p> <p>20 first of your reports at divider 2.14.</p> <p>21 A. Right.</p> <p>22 Q. Just so you know what the structure is, you provided</p> <p>23 a couple of clarifying or amending reports. You'll find</p> <p>24 those at the two following tabs, and then you find</p> <p>25 a very lengthy and very helpful series of answers to</p> <p style="text-align: center;">Page 34</p>	<p>1 deal with to begin with at page 16 of your report at</p> <p>2 paragraph 5.</p> <p>3 A. Right.</p> <p>4 Q. You then also develop your comments further, so we have</p> <p>5 it in mind, at page 46 and following. Actually there's</p> <p>6 a reference to page 45(vi) and then you come back to the</p> <p>7 subject on page 46 and 47.</p> <p>8 A. Right.</p> <p>9 Q. Let's start at page 16 where you first deal with this</p> <p>10 issue.</p> <p>11 Now, we know first of all that what we're talking</p> <p>12 about, and you set this out at paragraph 5(a), are</p> <p>13 relatively small pieces of paper?</p> <p>14 A. Yes. I think at the time they were about a foot by</p> <p>15 6 inches. So they're small.</p> <p>16 Q. And as you say at the bottom of the page going over to</p> <p>17 the top of page 17, there were 10 samplers for the</p> <p>18 Grapple Y test.</p> <p>19 A. Yes.</p> <p>20 Q. To cover an Island which is roughly how long?</p> <p>21 A. Slightly over 40 kilometres.</p> <p>22 Q. And the sticky paper samples themselves, putting it</p> <p>23 shortly, are useless in rain, aren't they?</p> <p>24 A. There's been some debate about this, including debate</p> <p>25 about whether the samplers were actually exposed during</p> <p style="text-align: center;">Page 36</p>

<p>1 rain, and it may be worthwhile going into that in 2 a little while.</p> <p>3 MR JUSTICE BLAKE: Well, in order to track the question 4 down, if -- which may be an "if" -- there was rain 5 during the sampling process, does that affect the 6 ability of the samplers to retain the information?</p> <p>7 A. Yes, my Lord. I think there's no question about that. 8 The sticky paper samplers are described as a large piece 9 of sellotape. So I think intuitively we can see that if 10 sellotape gets wet that it loses a lot of its 11 functionality.</p> <p>12 The only reason I qualify the statement, because 13 I don't want to try and say that sticky paper samplers 14 were a particularly good way to sample the -- they were 15 sparsely distributed around the Island, they had 16 weaknesses in rain, considerable weaknesses in rain.</p> <p>17 Had the activity in the rain been very high I would 18 have still expected to see some activity on the sticky 19 paper sampler, in the same way that -- so had the 20 rainfall been particularly active, I wouldn't expect to 21 see particulate activity deposited on the sticky paper 22 sampler because it would have lost its stickiness but 23 I would have expected to have seen some residual 24 activity on it. But the other weakness --</p> <p>25 MR JUSTICE BLAKE: Even with a loss of stickiness some</p> <p style="text-align: center;">Page 37</p>	<p>1 say: so what level of activity was in the rain?</p> <p>2 Q. There are two problems, I suggest. The first is that 3 the sellotape loses its stick?</p> <p>4 A. Yes.</p> <p>5 Q. But the second is that you've got a tiny proportion of 6 the whole of the Island or the whole of the atoll being 7 considered?</p> <p>8 A. Yes.</p> <p>9 Q. And Dr Nicholson's evidence, which I think you accepted, 10 was that rain is -- I always have difficulty pronouncing 11 this -- inhomogeneous?</p> <p>12 A. Yes.</p> <p>13 Q. One example he gives, if it's pouring with rain, like 14 a recent event, you can sometimes be standing one side 15 of a bridge and getting soaked and your friend who is 16 the other side of the bridge can be totally dry?</p> <p>17 A. Rainfall certainly can be very patchy.</p> <p>18 Q. That is a factor you have to take into account in 19 assessing whether or not these sticky samplers would be 20 of use in determining whether there was wet deposition 21 of radioactive material.</p> <p>22 A. The fact that there was only 10 on an Island of some 23 400 square kilometres I think tells you that they will 24 not help you to detect an inhomogeneous distribution of 25 activity as you've described it.</p> <p style="text-align: center;">Page 39</p>
<p>1 information is retained?</p> <p>2 A. Yes, my Lord. I think had the rain been very active --</p> <p>3 MR JUSTICE BLAKE: Very radioactive --</p> <p>4 A. Very radioactive, I beg your pardon.</p> <p>5 MR JUSTICE BLAKE: -- as opposed to very strong rain?</p> <p>6 A. Very radioactive. Forgive me, my Lord, I just ...</p> <p>7 MR JUSTICE BLAKE: Yes.</p> <p>8 A. Had the rainfall been very radioactive I would have 9 expected to have seen some evidence of that on the 10 sticky paper. I don't think you would have been able to 11 then work backwards and say: what does that actually 12 mean in terms of activity? But I think if the sticky 13 paper sampler was showing a very low level of activity, 14 effectively at background, it would indicate that very 15 high levels of radioactivity in rainfall had not been 16 falling onto it.</p> <p>17 MR TER HAAR: Can we agree with this: that there is at least 18 a respectable view that the sticky paper samplers are 19 not an effective way of recording radiation from a wet 20 deposition?</p> <p>21 A. Yes, they are a poor way of doing it. The best you 22 could do is to infer, to say that if it's very low it's 23 an indication that it wasn't exposed to very high levels 24 of that radioactivity in the rain, as I said, but you 25 certainly would not be able to work backwards and</p> <p style="text-align: center;">Page 38</p>	<p>1 In producing the report I took it one stage further 2 than that, though. What I actually assumed, although 3 perhaps quite a lot of the -- there's at least some 4 evidence that this is highly conservative, but I assumed 5 that there was actually widespread, high level 6 contamination over the whole Island, effectively uniform 7 contamination over the whole Island. Given that 8 scenario, I would expect that the sticky paper samplers 9 would have shown had there been widespread uniform 10 contamination over the Island, but in terms of 11 inhomogeneous, patchy contamination, if you like, then, 12 yes, they are exceedingly limited.</p> <p>13 Q. There is some contemporaneous evidence, isn't there, of 14 concerns about whether or not these sticky papers were 15 being kept dry?</p> <p>16 A. Are you referring to the letter from Major MacDougall?</p> <p>17 Q. Well, I wasn't but there is that. I was actually 18 thinking -- well, let's turn it up. If you go to bundle 19 SB8. It's not one we've had out today.</p> <p>20 If you have bundle SB8 now, Mr Hallard. I think you 21 are making yourself a safe zone as well.</p> <p>22 A. I am, I think it's on silent. (Pause). Forgive me, 23 I should have done that.</p> <p>24 Q. In bundle SB8 could you go, please, to page 133. I 25 think this is actually the letter you have in mind.</p> <p style="text-align: center;">Page 40</p>

<p>1 Whether you'd call it a letter is another matter, this 2 is what you had in mind? 3 A. Yes. 4 Q. Good. The relevant passage, you are obviously ahead of 5 me, is paragraph 3.2, "Sticky papers"? 6 A. Yes. 7 Q. "As at present. Would you please continue to make every 8 effort to expose the sticky papers only when it is dry, 9 and the rainwater samples only when it rains. As before 10 this is of particular importance in the 14 day period 11 following any test firing." 12 So that appears to be a concern -- it's difficult to 13 read into it, but at least possibly a concern as to 14 whether or not people were keeping the sticky papers 15 dry? 16 A. Yes, I think there's also some doubt in my mind anyway 17 as to who this letter was actually addressed to. The 18 reason I say that is because the bottom of the first 19 page and the top of the second page says that the 20 samples will be forwarded to England, to Aldermaston in 21 England. 22 Now there were actually two sets of sticky paper 23 sampling. One was what was called the Pacific sampling 24 campaign and the other were the sticky papers which were 25 in use on the Island. These are described in a report</p> <p style="text-align: center;">Page 41</p>	<p>1 paper sampler and a rainwater sampler. And so there was 2 only as I recall one rainwater sampler on 3 Christmas Island at the Joint Operations Centre which is 4 perhaps 2 or 3 kilometres, something like that, from 5 Main Camp. 6 And given that, given that you've got a sticky paper 7 sampler and a rainwater sampler, the letter seems to 8 make complete sense: if it's raining, cover the sticky 9 paper sampler and rely on the rainwater sampler. 10 If you have no rainwater sampler, which was the 11 majority of the sticky paper samples on the Island, why 12 would you refer to the rainwater sample when there was 13 only one located at the Joint Operations Centre? 14 So I'm not saying that letter definitely does not 15 refer to the remaining sticky paper samplers but I do 16 have -- I do have that doubt, if I could express it. 17 MR JUSTICE BLAKE: At 3.2 he talks about sticky papers and 18 3.3 rainwater samples. 19 A. That's correct, my Lord. 20 MR JUSTICE BLAKE: Whoever he is writing it to and whatever 21 he is writing it about, he thought that the rainwater 22 samplings were satisfactory or very satisfactory? 23 A. Yes. What I read into it, my Lord, is that he was 24 effectively saying that these are two alternatives: you 25 either use the sticky paper or, for the reasons that</p> <p style="text-align: center;">Page 43</p>
<p>1 by Mrs Clare who worked at Aldermaston. 2 The Pacific samplers included several different 3 types of sampling. They included a sticky paper -- 4 these, sorry, were distributed lit on various islands 5 across the Pacific, and there was one location on 6 Christmas Island in the Joint Operations Centre which 7 included one of the Pacific Island samplers. The rest 8 of the samplers, the sticky paper samplers, on the 9 Island were not part of the Pacific sampling campaign. 10 The reason I make that comment is that I understand 11 it was only the Pacific samplers which were sent back to 12 England for analysis, that the sticky papers which were 13 used on the Island were actually counted -- or the 14 remainder, apart from the one that was in JOC was 15 actually counted on the Island. Therefore, the fact 16 that he refers as of present to returning the samples to 17 England makes me wonder whether he's actually referring 18 to the Pacific sampling campaign. And I know that some 19 of the reports that were written on the results of the 20 Pacific sampling campaign were written by 21 Major MacDougall. I think there was at least one 22 written by Major MacDougall. 23 The other reason I wonder about this -- and again I 24 may be reading too much into it -- is that it was only 25 the Pacific sampling campaign where there was a sticky</p> <p style="text-align: center;">Page 42</p>	<p>1 we've already discussed, if it's raining, cover it and 2 then use the rainwater sampler. 3 MR JUSTICE BLAKE: Have you seen any analysis of rainwater 4 samples? 5 A. There is an analysis of rainwater samples in what is 6 referred as to the Clare report which is one of my 7 references and we'll probably get on to that later. 8 MR JUSTICE BLAKE: Okay. What you are telling us is that as 9 far as you know there was only one rainwater sampling 10 centre on Christmas Island. 11 A. Yes. 12 MR JUSTICE BLAKE: I don't know if that's a convenient 13 moment. We have to find a break for the stenographers 14 so shall we choose this one? Right, we'll break for 15 10 minutes. 16 (11.45 am) 17 (A short break) 18 (11.55 am) 19 MR TER HAAR: Mr Hallard, can we perhaps conclude this 20 question of when -- you were on the question of when 21 these samples were taken back to the UK is one of the 22 matters you were dealing with. 23 A. Yes. 24 Q. Can we leave it in this way, perhaps: that the 25 historical record makes it impossible to be sure which</p> <p style="text-align: center;">Page 44</p>

<p>1 samples were a matter of checking and measuring on the 2 Island and which were carried back to the 3 United Kingdom?</p> <p>4 A. My understanding is that it was the Pacific samplers, 5 which I think included the one at Joint Operations 6 Centre, I'm relying on memory now, which went back to 7 England but the remaining samplers, so that would have 8 been the remaining nine samplers on the Island, were 9 counted on the Island.</p> <p>10 Also, the Clare report -- and this actually comes 11 from contemporary records -- the sticky paper samplers, 12 they showed the time on and the time off. That's the 13 time that the sample was started and the time that the 14 sample was finished and there's no indication on that 15 that the sample period was interrupted in any way. I'm 16 not going to suggest that that is a definitive statement 17 that therefore they must have operated continuously over 18 that period because I don't know. So I think what I'm 19 expressing is there is some doubt.</p> <p>20 Q. That's exactly -- one of the difficulties in this case 21 first of all is to get one's head around the fact that 22 we're looking at reasonable doubt, not balance of 23 probabilities?</p> <p>24 A. Indeed.</p> <p>25 Q. And secondly to remember that we're dealing with events</p> <p style="text-align: center;">Page 45</p>	<p>1 A. Right. SB11?</p> <p>2 Q. 11, yes. Could you please go to tab 2. This is 3 Professor Regan's first report. It is page 54, 4 paragraph 253.</p> <p>5 A. Right.</p> <p>6 Q. 253, at the bottom of that page. He says this: 7 "As I have mentioned previously, I'm not convinced 8 of the efficacy of the use of sticky tape ('sellotape') 9 for sample collection of airborne and settled fallout 10 and particularly with the use of sticky tape left 11 exposed for 24 hours at such a time in such a hot, humid 12 environment. This seems to be both a crude and 13 unreliable technique and contrasts with the previous 14 technique used in the earlier Mosaic tests of using 15 rotary collectors which could keep a time logged 16 measurement of when each sample was taken. The use of 17 such material in a tropical climate would I suspect 18 result in at least some of the adhesive evaporating 19 thereby removing at least some of the attached 20 particulates with it, resulting in a underestimate of 21 the actual dose present. The use of these sticky tape 22 types of measurements is even more surprising when one 23 considers that in the earlier tests a rotary sampling 24 made up of a radial tray of collected material which 25 turns and slots into position under an open aperture for</p> <p style="text-align: center;">Page 47</p>
<p>1 a long time ago --</p> <p>2 A. Yes.</p> <p>3 Q. -- where the contemporaneous records either are missing 4 or were not kept to the standards that you might hope?</p> <p>5 A. I think the records of the sticky paper samplers and the 6 other samplers were available. I'm not aware that the 7 record that particularly is summarised in the Clare 8 report is incomplete. As far as I know, the sticky 9 paper samplers and the rainwater samplers, et cetera, 10 the single air sampler from Christmas Island, as far as 11 I'm aware that record is complete. I'm not aware of any 12 significant gaps in it.</p> <p>13 Q. We don't know one way or the other, do we?</p> <p>14 A. You mean that if there were samples which weren't kept 15 then we wouldn't know about them?</p> <p>16 Q. Yes, because we haven't got the original records to 17 check?</p> <p>18 A. We have the summary of the original records in the 19 interim reports, for example, or the residual activity 20 report for Grapple Y, so they were records which were 21 made at the time, but they're not the raw data. So in 22 terms of: do we have raw data? No, we don't. But we 23 have contemporary summaries.</p> <p>24 Q. Could we go, please, to bundle SB11. You can put any 25 bundle apart from your own report away.</p> <p style="text-align: center;">Page 46</p>	<p>1 a given time period thereby enabling fallout dose 2 distributions to be determined in given discrete time 3 periods. These rotary-based measurement devices would 4 have been very useful as they would allow a real-time 5 breakdown of the changes in deposited activity and 6 effects such as radioactivity 'grown-in' as more and 7 more fallout material was deposited on the ground as the 8 radioactive fallout cloud passed over the contaminated 9 area."</p> <p>10 First of all, would you agree that this alternative 11 method of measurement to which Professor Regan refers 12 would have been a better system?</p> <p>13 A. It certainly sounds like it. I'm not familiar with it. 14 I've seen this -- I mean I have read this paragraph and 15 I haven't -- but I've seen no other information on the 16 rotary sampler. I know the principle of rotary 17 sampling. It sounds from what Professor Regan says as 18 if it would have been a better type of sampler.</p> <p>19 MR JUSTICE BLAKE: Do you know what it is, a rotary sampler?</p> <p>20 A. In principle, my Lord, well, it's as he describes. It's 21 something where the sample medium is effectively moved 22 in and out of use, if I can put it like that. So 23 an area of the sample medium would be in use for 24 a period, let's say half an hour, for want of anything 25 else, and then that would then move on and a fresh</p> <p style="text-align: center;">Page 48</p>

12 (Pages 45 to 48)

<p>1 sampling medium would then take over from it and that 2 would then sample for 30 minutes. I think that in 3 general terms that is what he is describing here. 4 MR JUSTICE BLAKE: So A different part of some round 5 container is opening up to the elements, is it? 6 A. Yes. 7 MR JUSTICE BLAKE: Is that done automatically or is some 8 human person going round moving it all on? 9 A. I think it would be done automatically. Certainly for 10 a modern system it would be done automatically and I 11 think it would be some kind of simple motor apparatus. 12 It certainly sounds better than the sticky papers. 13 MR TER HAAR: And would you agree with his point, it seems 14 to be perfectly good common sense if anybody has had 15 experience of sellotape, that it's likely to lose its 16 stick if left out for 24 hours at a time in a hot, humid 17 environment? The first sentence of that paragraph. 18 A. It seems like a reasonable statement but to be honest 19 I actually don't know. I've never really tried it but 20 I guess that's possible. Please don't misunderstand me. 21 I'm not trying to suggest that the sticky paper sampling 22 system was a particularly good system. It had many 23 flaws and I think I've actually identified quite 24 a number of those flaws in my report. So I'm not trying 25 to suggest that it was a good system but all I'm</p> <p style="text-align: center;">Page 49</p>	<p>1 First of all, as a statement of historical fact do 2 you agree with that? 3 A. Clare doesn't say it but one of Mr Johnston's reports 4 does go into the issue of particle size, and I think he 5 concludes that the largest particle that he would expect 6 to see for particularly the Grapple Y detonation would 7 be of the order of 1 micron, 1 micrometer. 8 Q. The point being made here by Professor Regan is he is 9 concerned about not so much the largest particles but 10 the smallest particles? 11 A. Right. 12 Q. Because he then goes on to say this: 13 "This is important as particles of this size are 14 those most likely to be inhaled giving rise to 15 significant ongoing internal doses." 16 Then he discusses particular isotopes and he says 17 they are particularly harmful taken internally. 18 So the point he is taking is that you can't see what 19 measurements there were of tiny particles. That's 20 a fair comment, isn't it? 21 A. Yes, the Clare report contains no information on 22 particle size. As you say, the comment I made about 23 Mr Johnston's report is the largest particle size and 24 you would expect there to be particles of a smaller 25 size.</p> <p style="text-align: center;">Page 51</p>
<p>1 pointing out perhaps is that it was -- despite its flaws 2 it still had some limited -- very limited -- usefulness. 3 Q. Right. I think I would probably go almost that far with 4 you, but would you agree with his description in the 5 next sentence that this is a crude and unreliable 6 technique? 7 A. Certainly it had many limitations. 8 Q. And you yourself -- we can go if necessary to page 47 of 9 your report -- say it was unlikely to pick up localised 10 fallout? 11 A. Very unlikely. 12 Q. Very unlikely? 13 A. Yes, very unlikely. That would be a straight matter of 14 probability. You have 10 samplers on an island of 400 15 square kilometres. 16 Q. Then going to the top of the next page, paragraph 254 17 deals with the question of delay in taking the samples 18 back to England. We discussed that. 19 A. Yes. 20 Q. Then 255: 21 "The AWE report on Christmas Island by Clare et al 22 provides no details on how the smaller sized, 23 sub-micrometer fallout particles were measured and/or 24 what the fallout particle size distribution was 25 following the Grapple tests."</p> <p style="text-align: center;">Page 50</p>	<p>1 Q. Then going on to paragraph 256: 2 "Following on from the point above, the absence of 3 radionuclide assay means that no accurate breakdown of 4 the exact radioisotopes present in the fallout was 5 made." 6 So that's also a sound point, isn't it? 7 A. The cloud sampling aircraft, of course, the Canberras 8 which flew through the cloud would have been able to 9 make those measurements. There is nothing in Clare, in 10 the Clare report, which gives an indication of the mix 11 of radionuclides. I think that's what he was saying. 12 Q. Yes, I think what he's saying is first of all at 255 he 13 is saying, well, you can't tell -- I call them "tiny" -- 14 small particles there were, and he also says you can't 15 tell what the mix was of whatever particles there were? 16 A. Certainly from the Clare report you can't. The Carter 17 report, which I referred to earlier, gives actually 18 quite a lot of detail on the nuclide mix which I've 19 largely used in my own report. There are issues about 20 the fact that the Carter report was written for atomic 21 weapons, that is fission weapons, and there may be some 22 differences with fusion weapons, that is thermonuclear 23 weapons which was obviously the majority of weapons on 24 the site. 25 I have used the Carter data, modified in my final</p> <p style="text-align: center;">Page 52</p>

<p>1 report, to take account of some additional isotopes,</p> <p>2 some additional nuclides which I identified. But the</p> <p>3 Carter report is the best source of that information.</p> <p>4 Q. Let's see whether you at least agree that the view</p> <p>5 expressed in the next paragraph, 257, is at least</p> <p>6 a legitimate view. Let's go through it together:</p> <p>7 "I am also somewhat surprised at the rather</p> <p>8 non-uniform distribution of dose measured for the</p> <p>9 fallout on Christmas Island, in particular, whereby in</p> <p>10 general the higher levels are measured in uninhabited</p> <p>11 areas but not in other inhabited areas. Such a</p> <p>12 distribution of dose from fallout while theoretically</p> <p>13 possible seems rather unlikely and possibly reveals</p> <p>14 a lack of sufficient counting stations as well as</p> <p>15 showing up the potential flaws in the sticky tape</p> <p>16 counting and collection system as discussed above."</p> <p>17 Stopping there, would you agree that the non-uniform</p> <p>18 distribution of those is somewhat surprising, as he</p> <p>19 says?</p> <p>20 A. You would expect, I think, some uniformity but that goes</p> <p>21 back to the expert report of Dr Nicholson where he</p> <p>22 comments that some inhomogeneity, some non-homogeneous</p> <p>23 distribution is also possible.</p> <p>24 Q. You see, what he is also drawing attention to in the</p> <p>25 second sentence is that remarkably you seem to have</p> <p style="text-align: center;">Page 53</p>	<p>1 see there's four pages to each page.</p> <p>2 A. Yes.</p> <p>3 Q. And the numbering I'm going to give you is the numbering</p> <p>4 of the internal pages, so I am going to ask you to go to</p> <p>5 page 21 in the top left-hand box.</p> <p>6 A. The one that starts "England because the highest rain</p> <p>7 fell"?</p> <p>8 Q. That's absolutely it.</p> <p>9 Could you go, please, to line 18, the start of the</p> <p>10 question there and second sentence of that question:</p> <p>11 "Can you help us as to whether you consider the</p> <p>12 monitoring which you understood to have been used</p> <p>13 provided a reliable measure of fallout over the Island</p> <p>14 generally?"</p> <p>15 The answer:</p> <p>16 "Oh no, no. I think there were 10 sticky papers."</p> <p>17 I should say this is Dr Nicholson's evidence so you</p> <p>18 know where you are.</p> <p>19 "If you put ten sticky papers out in your garden and</p> <p>20 measured lead deposition or something, you will get</p> <p>21 an order of magnitude difference in the measurements</p> <p>22 just because of the aerodynamics of the garden."</p> <p>23 I'll come on to a bit more of what he says there.</p> <p>24 We've spoken so far about the problems of the sticky</p> <p>25 samples when they come into rain?</p> <p style="text-align: center;">Page 55</p>
<p>1 higher levels being measured in uninhabited areas than</p> <p>2 in inhabited areas and that in itself seems rather</p> <p>3 improbable, doesn't it, that you would just by chance --</p> <p>4 A. Well, not really, I would suggest, because the</p> <p>5 detonations were all made about 40 kilometres from the</p> <p>6 inhabited areas. The air drops of the four</p> <p>7 thermonuclear weapons were all made off the south west</p> <p>8 tip of the Island, and the two atomic weapons, the two</p> <p>9 fission weapons, were all made just inland on the south</p> <p>10 west tip -- the bottom corner anyway of</p> <p>11 Christmas Island.</p> <p>12 All of those detonations were approximately</p> <p>13 40 kilometres from the inhabited areas, the Main Camp,</p> <p>14 Joint Operations Centre and Port London.</p> <p>15 So if there was to be local deposition around the</p> <p>16 point of detonation, it would have been some</p> <p>17 considerable distance from the areas of habitation.</p> <p>18 Q. Well, can we also look at the evidence given by</p> <p>19 Dr Nicholson from an environmental point of view? You</p> <p>20 can put that bundle that you have open away and could</p> <p>21 you take up bundle SB14, please, and if you could go</p> <p>22 within that to divider 5.8, please.</p> <p>23 A. 5.8.</p> <p>24 Q. And you should find yourself there looking at</p> <p>25 a transcript for Wednesday, 13 February 2013. You'll</p> <p style="text-align: center;">Page 54</p>	<p>1 A. Yes.</p> <p>2 Q. What Dr Nicholson is here pointing out with his</p> <p>3 expertise in relation to environmental pathways and the</p> <p>4 other specialties we looked at earlier is that even when</p> <p>5 you've got a dry deposition the aerodynamic effect is</p> <p>6 significant?</p> <p>7 A. Yes.</p> <p>8 Q. Let's go on and see what he says.</p> <p>9 A. Okay.</p> <p>10 Q. Just starting again:</p> <p>11 "If you put ten sticky papers out in your garden and</p> <p>12 measured lead deposition or something, you will get an</p> <p>13 order of magnitude difference in the measurements just</p> <p>14 because of the aerodynamics of the garden. Even though</p> <p>15 the overall aerial deposition would be the same, just</p> <p>16 the sampling kinetics would change.</p> <p>17 "Once you start talking about a whole Island then</p> <p>18 it's going to vary considerably. Exactly how many is</p> <p>19 a reasonable number is just debatable. For normal,</p> <p>20 smooth contour maps, I mean, ten is a bare minimum.</p> <p>21 When you know the source and you know the parameters</p> <p>22 around it then you can sometimes get away with it. When</p> <p>23 you don't know the meteorology and you are only taking</p> <p>24 one single measurement as opposed to a series of</p> <p>25 measurements then it's clearly insufficient by a long</p> <p style="text-align: center;">Page 56</p>

<p>1 way."</p> <p>2 Do you disagree with anything that Dr Nicholson said</p> <p>3 there about problems with sampling?</p> <p>4 A. No, I wouldn't, particularly from the dry sampling that</p> <p>5 he's talking about here. Although perhaps we might get</p> <p>6 on to the issue of dry sampling later because I think he</p> <p>7 also commented later that he thought it was highly</p> <p>8 improbable that there would be dry deposition from the</p> <p>9 anvil of the cloud.</p> <p>10 Q. We may or may not, let's see how we get on with other</p> <p>11 topics. Can we go on in his evidence:</p> <p>12 "You've spelt some of your points out, I think, in</p> <p>13 bullet points, the top two on page 9, some of your</p> <p>14 criticisms about the sampling programme and issue about</p> <p>15 the dose calculations?"</p> <p>16 Answer:</p> <p>17 "Yeah, I think, again, it comes back to it doesn't</p> <p>18 represent hot spots. You will get hot spots just</p> <p>19 because of the location of the samplers, the aerodynamic</p> <p>20 effects. The samples themselves are actually not</p> <p>21 efficient. The principle is that particles are</p> <p>22 sedimenting down and will land on the sticky surfaces,</p> <p>23 which is probably reasonable for very large particles,</p> <p>24 but when you come to smaller material then it doesn't</p> <p>25 work because of the aerodynamic effects. In fact, even</p> <p style="text-align: center;">Page 57</p>	<p>1 the example you've just taken of the highest sample</p> <p>2 which was measured during all the tests on the Island,</p> <p>3 multiply it by 5, that would be, what, a factor of 3 or</p> <p>4 4 higher than the uniform activity which I have assumed</p> <p>5 for the Island.</p> <p>6 So the activity that I have assumed was deposited</p> <p>7 across the whole Island, the uniform activity, is</p> <p>8 actually a high level of activity.</p> <p>9 Q. It may be a high level --</p> <p>10 A. We can perhaps come back to that later.</p> <p>11 Q. -- but, on this evidence, what you've taken as</p> <p>12 a uniform -- and we'll come back to lack of</p> <p>13 uniformity -- at uniform level might be a significant</p> <p>14 understatement, mightn't it, on this evidence?</p> <p>15 A. Well, this was a single sampler. If there was uniform</p> <p>16 activity across the Island, which is what I've assumed,</p> <p>17 you would expect all of the samplers to be showing that</p> <p>18 level of activity. The rainfall, as we've said before,</p> <p>19 would introduce an element of doubt. The particle size</p> <p>20 would introduce an element of doubt. So certainly there</p> <p>21 will be uncertainties in terms of the precise</p> <p>22 measurements, but the level that I've assumed is not</p> <p>23 based on the sticky paper result, I've simply compared</p> <p>24 that level with the sticky paper result. The level that</p> <p>25 I've assumed is far more based on monitoring by people,</p> <p style="text-align: center;">Page 59</p>
<p>1 for large particles, they aren't especially efficient.</p> <p>2 If you compare -- we call it deposition velocity, which</p> <p>3 is just the same as a deposition efficiency, if you</p> <p>4 like, if you look towards the measured values that are</p> <p>5 measured for rough surfaces, like grass, and for these</p> <p>6 types of sampler, these ones are several types less, so</p> <p>7 it may be a factor of 5 or something like that they tend</p> <p>8 to under-read. You under-read because particles blow</p> <p>9 around them."</p> <p>10 Now, this is -- first of all I think we have agreed</p> <p>11 this is very much more his expertise than your</p> <p>12 expertise?</p> <p>13 A. Yes, indeed.</p> <p>14 Q. What he is saying here is you may be under-reading by</p> <p>15 a factor of 5 or something like that. Now, that will</p> <p>16 be -- if we take the highest measurement on the samplers</p> <p>17 at 300 --</p> <p>18 A. Yes.</p> <p>19 Q. -- that's a massive under-reading, isn't it, of great</p> <p>20 significance?</p> <p>21 A. It would mean that the sample activity was about 1500,</p> <p>22 if you take that extreme case that he is quoting here.</p> <p>23 The level of activity that I assumed, the level of</p> <p>24 uniform activity that I assumed for the island, was</p> <p>25 equivalent to 430 microcurie. So if you were to take</p> <p style="text-align: center;">Page 58</p>	<p>1 human monitors, using radiation instruments, perhaps --</p> <p>2 well, we can perhaps come back to that later.</p> <p>3 Q. We will come back to that.</p> <p>4 A. Right.</p> <p>5 Q. But, so far as what's shown -- I'm taking this -- what</p> <p>6 I am trying to do is take each of the methods of</p> <p>7 measurement and, as I said earlier, show that there are</p> <p>8 real problems with each one.</p> <p>9 A. Okay.</p> <p>10 Q. But, insofar as uniformity is concerned you have ten</p> <p>11 samplers here, and because of aerodynamic effects, even</p> <p>12 if you had uniform radiation fallout, radioactive</p> <p>13 fallout, the likelihood, so says Dr Nicholson, is that</p> <p>14 you would actually see differing records on the ten</p> <p>15 sheets of paper?</p> <p>16 A. Yes, I understand that point. And, as you say, his</p> <p>17 expertise is far greater than mine, I wouldn't argue</p> <p>18 with that.</p> <p>19 Again, I'm not trying to suggest that sticky papers</p> <p>20 are a good type of sampler. I agree with quite a few of</p> <p>21 the things he said there, in fact some of my views</p> <p>22 actually come from reading this transcript, so I'm not</p> <p>23 trying to defend sticky paper samplers and say actually</p> <p>24 they're a lot better than people say. No. There were</p> <p>25 many deficiencies, but what I'm saying is that there was</p> <p style="text-align: center;">Page 60</p>

<p>1 still some value in the results, even if that was quite 2 limited, particularly in certain scenarios. 3 Q. The value you do get -- and I suggest only this -- is 4 that where you have a sample which records a particular 5 level you can take it that that at least is the minimum 6 level at that point. But you get no more than that. 7 A. Yes, I would agree with that. 8 Q. Then just to pick up the reference so that the Tribunal 9 has it in their notes and in the transcript. If we go 10 on at page 23 to line 20, this is where Dr Nicholson 11 deals with the concept of inhomogeneity. He says: 12 "The hot spot is inhomogeneity. The patchiness of 13 the deposition. So you'll get, for instance, in a room 14 of this size, you may get an area in the corner which is 15 of much higher deposition than the rest. That is a hot 16 spot. 17 "Now, it could be caused by aerodynamic effects, or 18 it could be because more rain fell in a certain area, 19 but you get various depositions according to location, 20 and that spatial inhomogeneity results in hot spots 21 which are areas where there are higher than average 22 deposition. Now, they could be on a small scale, 23 a medium scale or a large scale. 24 "Now, a hot particle is an individual particle which 25 has a disproportionate amount of radioactivity</p> <p style="text-align: center;">Page 61</p>	<p>1 A. Right. 2 Q. -- and this you deal with, again just to get a record, 3 in your report, you deal with it at paragraph 18, first 4 of all, in your reports, (b), and you also come back to 5 the subject at page 47 at subparagraph (xiv). 6 A. Yes. 7 Q. Now, the question that the Tribunal now faces in 8 assessing this part of the case is to try to work out 9 exactly what was done by way of ground surveys. 10 A. I agree. 11 Q. We don't have any direct evidence of what was actually 12 done, who went out to do what, how surveys were carried 13 out and somebody producing a documentary report or 14 anything of that sort. 15 A. Sorry, was that a question? 16 Q. That was a question. 17 A. There's no -- well, I've only ever seen one survey sheet 18 from Christmas Island and that was for the area around 19 probably Grapple Z1. It would have been either Grapple 20 Z1 or Grapple Z4, and I think the indications are it was 21 Grapple Z, 1 which are used in the dose assessment for 22 Mr Butler. That's only the physical survey sheet which 23 I can recall seeing. 24 The results, though, are summarised, I think 25 principally in the residual radiation measurements</p> <p style="text-align: center;">Page 63</p>
<p>1 associated with it. Definition of what they are vary, 2 and they are at various committees talking about this, 3 but I think one arbitrary definition is 100 becquerels. 4 The importance of hot particles is firstly it could lead 5 to hot spots, but I think more importantly it has a dose 6 implication as well." 7 Now, I think you accept what he says about the 8 possibility of hot spots because of varying levels of 9 deposition. 10 A. My expertise is -- I've no expertise in meteorology so 11 I would accept Dr Nicholson's statement on that. 12 Q. Thank you. 13 You've been very fair about this. If we take the 14 first set of measurements, that's to say the sticky 15 paper samples, those appear to have been the leading 16 contenders relied upon by the controls at the time for 17 measuring radioactivity fallout? 18 A. I'm not sure that's true. I think they were used as 19 indicators. So, where an unusually high sticky paper 20 result was identified, it was then followed up. But the 21 principal method of monitoring, I think, would have been 22 people using sensitive contamination monitors, Geiger 23 counters. 24 Q. So the question then is -- which leads us into ground 25 surveys --</p> <p style="text-align: center;">Page 62</p>	<p>1 report, I think that's the correct report, which 2 comments that for Grapple Y -- sorry, the residual 3 radiation measurements report for Grapple Y comments 4 that, having identified the high result which was in 5 an area called Vaskess Bay on the west coast of the 6 Island, that monitoring was then done in that area and 7 that fallout was detected using instruments, using 8 sensitive instruments. 9 But they then commented that radiation surveys, 10 contamination surveys, I beg your pardon, using 11 sensitive instrumentation was then done on other parts 12 of the Island and no other contamination was found. 13 The one difficulty that gives, if I can just move 14 one stage further, is that that comment, apart from the 15 comment about monitoring around Vaskess Bay, is 16 imprecise, clearly, it just says other parts of the 17 Island were surveyed. Therefore, it's difficult to read 18 anything specific into that. 19 But there are two witness statements from 20 Bernard Armer and Bernard Baker, which I don't refer to 21 in my report, which I think was an oversight, I should 22 have done. I think at the time I'd seen the witness 23 statements but then couldn't find them again, to be 24 honest. But I have found them recently, and those two 25 witness statements, both men were involved in</p> <p style="text-align: center;">Page 64</p>

<p>1 transferring I think the Island inhabitants onto a ship 2 offshore during the test, both men refer to monitoring 3 being done that they witnessed. One on the boat, the 4 ship that they went to -- I can't remember its name for 5 a moment -- and the other at Port London when one of the 6 two gentlemen arrived back.</p> <p>7 To be complete about that they do make the comment 8 that the people who were doing the monitoring appeared 9 very nervous, but the monitoring was done specifically 10 because there had been high levels of rain around Port 11 London which was also reported around Main Camp, that 12 there was high levels of rain which had been observed 13 and the men had been caught in high levels of rain while 14 this work was going on. It was for that reason that the 15 monitoring was done both on the ship and of the people 16 themselves when they arrived back in Port London.</p> <p>17 That seemed to me to be significant because we also 18 have -- I have eye witness evidence that not only was 19 the monitoring done at Vaskess Bay, it was also done on 20 the ship and it was also done of the people, and 21 presumably the ground in Port London. Again, it would 22 be an assumption, but my assumption would be that, if 23 they were monitoring in Port London and appeared to be 24 concerned about it, then they would also have been 25 monitoring at main camp and other areas where there was</p> <p style="text-align: center;">Page 65</p>	<p>1 Q. As far as we can tell from our review of the 2 documentation, the only records of any surveys are in 3 the Vaskess Bay area to which you referred and in the 4 forward area?</p> <p>5 A. Yes.</p> <p>6 Q. Which --</p> <p>7 A. The forward area around Grapple Z1.</p> <p>8 Q. Yes.</p> <p>9 A. Yes.</p> <p>10 Q. Which is a very small percentage of the 4,000 square 11 kilometres of the Island?</p> <p>12 A. Yes.</p> <p>13 Q. We are talking about less than 1 per cent of the Island?</p> <p>14 A. Well, including the area around Port London, which I've 15 just referred to --</p> <p>16 Q. Still less than 1 per cent.</p> <p>17 A. The crucial point about Port London and the assumption 18 that that would then include Main Camp is that these 19 were the main inhabited areas. Therefore, if the 20 evidence suggests that the main inhabited areas were 21 clear of contamination, then that is actually quite 22 an important -- an important piece of evidence.</p> <p>23 Q. It is, it is a very slim piece of evidence, at best, and 24 we don't know exactly what was done or how it was done, 25 do we?</p> <p style="text-align: center;">Page 67</p>
<p>1 heavy rainfall.</p> <p>2 I think the reason that that's significant is the 3 statement that's made in the residual radiation 4 measurements report, is that they had done surveys over 5 the Island using these instruments, these Geiger counter 6 contamination monitors, and no other contamination had 7 been detected.</p> <p>8 So I therefore put those two things together, that 9 the statement, summary statement, in the report says 10 that no other radiation was measured, but with no 11 international of location. That those two witness 12 statements, in particular, are very useful because they 13 now say that we know of at least the Port London and the 14 ship area where similar measurements were made and the 15 statement then says no other activity was found.</p> <p>16 Q. Well, we can agree with this, can't we, that records of 17 surveys were woefully inadequate?</p> <p>18 A. We have -- well, I've only seen one survey, so -- 19 I certainly have no other direct survey evidence.</p> <p>20 Q. In a properly run and scientifically informed system you 21 keep records of negative surveys as well as positive 22 surveys?</p> <p>23 A. Yes, I would have expected the records to be retained. 24 We can't say that they weren't, but we certainly don't 25 have the records.</p> <p style="text-align: center;">Page 66</p>	<p>1 A. No. Perhaps I'm making assumptions, but I think they 2 are reasonable assumptions. I've worked with monitors 3 for 35 years in terms of people monitoring areas and 4 monitoring people. I believe that the probes that they 5 were using on the Island -- sorry, probes, that's the 6 actual detector -- that the actual detector which was 7 being used on the Island was similar to a detector which 8 I first used when I started my professional life. They 9 are reasonably sensitive; they are quite a good 10 detector. They are old, they're not used any more, they 11 are obsolete now.</p> <p>12 But if you were going to monitor somebody you would 13 pass that detector -- it's effectively a tube, it 14 doesn't look hugely different to that microphone, it's 15 a little bit wider than that, you would hold it on 16 a handle at one end and it has an open window below it 17 which allows access from the beta radiation into the 18 actual Geiger tube which is inside the tube. You would 19 pass that over the individual, quite close to the 20 individual, so that if there was contamination on that 21 person it would be obvious, you would measure it. And, 22 similarly, for ground.</p> <p>23 Q. First of all, it wouldn't tell you anything about the 24 any internal emitters?</p> <p>25 A. No, it would tell you if there was external emitters,</p> <p style="text-align: center;">Page 68</p>

<p>1 but the external emitters would then be the source of 2 any internal activity. 3 Q. Well, they might or might not be. 4 First of all, let's see if we can agree this. The 5 if you were to carry out the sort of regime which would 6 now be regarded as standard you wouldn't be just by 7 chance having some people tested in Port London and the 8 forward area and the Vaskess Bay area survey, would you? 9 You would be carrying out something which was systematic 10 and recorded? 11 A. Yes, you would. 12 Q. There is no evidence to support a systematic and 13 recorded programme of surveying Christmas Island, is 14 there? 15 A. No, there's no evidence of that. I have looked for 16 evidence of surveys before, and I've seen passing 17 reference to it in reports written by Mr Albury(?). In 18 the laundry, for example, he's made passing reference to 19 surveys being done in the laundry on the Island, the 20 active laundry on the Island, but I haven't been able to 21 find any evidence, any records of systematic surveys, 22 apart from what we've discussed. 23 Q. There are two points. First of all, there is no 24 evidence whatsoever of any systematic programme of 25 surveys?</p> <p style="text-align: center;">Page 69</p>	<p>1 the rest of the Island, so therefore you wouldn't 2 actually have expected there to be controls during that 3 visit. 4 Q. With respect, Mr Hallard, aren't you, in giving that 5 answer, in danger of pulling yourself up by your own 6 bootstraps in this sense. That the testing and surveys 7 and all the controls appear to have been concentrated on 8 the area where it was expected that there would be 9 a risk of fallout. 10 A. They are the areas -- they're only the areas that we 11 have specific evidence for. 12 Q. It does appear that that's where the measurement, 13 et cetera, was concentrated on the controlled areas? 14 A. Certainly for Grapple Z1 and Grapple Z4, that's correct. 15 But, yes, in terms of what we know, that's what we know. 16 Q. If what was actually happening was significant 17 radioactivity fallout outside the controlled areas, the 18 method of testing and measurement was not such as to 19 pick that up? 20 A. If there had been systematic, significant and widespread 21 fallout, any instrument which is in use is likely to 22 have detected it because the background count rate on 23 the instrument would have gone up. So instruments in 24 use in the Joint Operations Centre, the background is 25 likely to have gone up; instruments in use for</p> <p style="text-align: center;">Page 71</p>
<p>1 A. I haven't found any. 2 Q. Secondly, there is no record of such surveys as were 3 carried out? Or minimal records, perhaps would be more 4 accurate. 5 A. Apart from the one that we discussed, I haven't found 6 that either. 7 Q. You note one of the concerns raised by my clients is 8 that they had access across really the whole of the 9 Island, including on some occasions into Ground Zero, 10 after the tests had taken place in an uncontrolled way. 11 You are aware of that witness evidence? 12 A. I am, but if I recall correctly -- if we're talking 13 about the same person, that visit to the Ground Zero, it 14 was the Ground Zero of Grapple Z1 and Grapple Z4, it was 15 the balloon area, took place several months after the 16 last of the detonations. Therefore you would expect 17 that any activity which had deposited in that area would 18 have decayed. In fact, there is a letter from the 19 Island -- from one of the senior health physicists on 20 the Island, pre-dating that visit, I think, saying that, 21 with the exception of a small number of areas, some 22 buildings in Joint Operations Centre, I think, that with 23 the exception of those that the levels on the rest of 24 the Island were then below the levels that would require 25 a controlled area. So there were no controlled areas on</p> <p style="text-align: center;">Page 70</p>	<p>1 monitoring people and equipment, I think, at the airport 2 would have gone up. Therefore, if there had been 3 significant and widespread contamination resulting from 4 these then you will have seen an increase in background 5 on those instruments. 6 People using the instruments at the boundaries of 7 these controlled areas would have seen significant 8 levels of contamination, very high levels of 9 contamination, had that contamination gone beyond the 10 boundary that they were dealing with. 11 So, again, I'm not trying to defend the regime that 12 they were using because on a modern site you would 13 expect the regime to be much more systematic and the 14 records to have been much more complete, but I think 15 there is ad hoc information, ad hoc evidence, that had 16 there been systematic and widespread contamination that 17 it's likely to have been detected. But, to be fair, 18 that is a judgment. 19 Q. And it's a judgment that you'd accept is open to 20 considerable doubt? 21 A. It's certainly open to doubt. It can be challenged, 22 I've challenged it myself, and of course my role is not 23 to defend it, it's to advise the Tribunal. 24 Q. That doubt is expressed -- put it this way -- 25 a perfectly reasonable body of opinion would be -- would</p> <p style="text-align: center;">Page 72</p>

<p>1 come to a different conclusion?</p> <p>2 A. You could certainly express doubt as to whether -- as to</p> <p>3 whether the surveys would have detected some localised</p> <p>4 contamination, for example. You would certainly -- it's</p> <p>5 certainly possible, perhaps even likely, that there was</p> <p>6 localised contamination in some areas. I'm not going to</p> <p>7 speculate how big that might have been, but there could</p> <p>8 have been localised contamination which was in excess of</p> <p>9 the levels which were recorded or measured.</p> <p>10 Q. Not only that, there's also the risk that those areas of</p> <p>11 localised contamination could have included the very</p> <p>12 dangerous alpha emitters?</p> <p>13 A. It's likely that they would because the constituents of</p> <p>14 the fallout would have included both beta gamma emitters</p> <p>15 and alpha emitters, particularly plutonium and -- well</p> <p>16 plutonium is the most active of the alpha emitters.</p> <p>17 It's very likely that those two would have been mixed</p> <p>18 together.</p> <p>19 Q. Let's move from ground surveys to air sampling. Once</p> <p>20 again there are considerable difficulties, aren't there,</p> <p>21 with the air sampling that was carried out.</p> <p>22 A. Yes.</p> <p>23 Q. Would you agree with that?</p> <p>24 A. Yes, I would. There was only one air sampler which, in</p> <p>25 my view, is completely inadequate.</p> <p style="text-align: center;">Page 73</p>	<p>1 I am going to come on to seafood and seawater</p> <p>2 sampling.</p> <p>3 A. I'm sorry?</p> <p>4 Q. Seafood and seawater sampling.</p> <p>5 A. Right.</p> <p>6 Q. The water itself and what swims around or crawls around</p> <p>7 inside it in the water.</p> <p>8 A. Yes.</p> <p>9 Q. Now, this may be one of the areas where -- it's the</p> <p>10 questions I asked you right at the beginning about</p> <p>11 interplay between epidemiology and the work you carried</p> <p>12 out may be the most important.</p> <p>13 A. Right.</p> <p>14 Q. Can I explain why and see if you have taken account of</p> <p>15 this.</p> <p>16 The Wahab and Rowlands survey.</p> <p>17 A. Yes, that's the survey of the --</p> <p>18 Q. The sailors, the people on -- they weren't all</p> <p>19 sailors -- but they people on board some New Zealand</p> <p>20 naval ships.</p> <p>21 A. Yes.</p> <p>22 Q. At least there is a view that show chromosomal</p> <p>23 abnormalities in the people surveyed which suggest that</p> <p>24 they were exposed to radiation. Now, there's a lot of</p> <p>25 argument about the science of that and I'm not going to</p> <p style="text-align: center;">Page 75</p>
<p>1 Q. Similarly, rainwater samples -- we already touched on</p> <p>2 this -- considerable difficulties with that?</p> <p>3 A. Yes. Again, there was only one rainwater sampler and,</p> <p>4 again, that's not adequate.</p> <p>5 Q. Then let's move on to dosimeters. As we discussed on</p> <p>6 Friday -- are you comfortable? Are you happy?</p> <p>7 A. I'm fine, yes, I'm fine. If you don't mind me just</p> <p>8 getting up and sitting down.</p> <p>9 Q. My concern is that you should be sufficiently</p> <p>10 comfortable you can give your evidence without</p> <p>11 discomfort interrupting you.</p> <p>12 A. I'm fine, thank you.</p> <p>13 Q. Dosimeters. Again, we did discuss this, there is</p> <p>14 considerable pre-selection of who would have dosimeters.</p> <p>15 Again, with the benefit of hindsight, we wouldn't have</p> <p>16 done it that way if we were going about it now, would</p> <p>17 we?</p> <p>18 A. I think not.</p> <p>19 Q. Can we also move on now to -- we're getting towards the</p> <p>20 end of the methods of measurement, there are a couple of</p> <p>21 other points I want to take up.</p> <p>22 MR JUSTICE BLAKE: Are we still going to need this one,</p> <p>23 SB14, the transcripts?</p> <p>24 MR TER HAAR: I think not. I think I've done the</p> <p>25 transcripts, thank you very much.</p> <p style="text-align: center;">Page 74</p>	<p>1 trouble you with.</p> <p>2 If that be right, for this group there are two</p> <p>3 possibilities of how they might have been exposed to</p> <p>4 radiation. One is that in some way the fallout extended</p> <p>5 quite a long way out to sea and they were exposed to</p> <p>6 radiation whilst at sea.</p> <p>7 The other is that it seems that the sailors came on</p> <p>8 shore at Christmas Island and swam in the sea, some</p> <p>9 bathed on the sand and whatever it was.</p> <p>10 Now, if the Tribunal were to come to the conclusion</p> <p>11 that the probability was, or at least the possibility --</p> <p>12 we must always remember what the test is we are dealing</p> <p>13 with -- that those royal naval New Zealanders were --</p> <p>14 probably were exposed to radiation, and the most likely</p> <p>15 thing is it's because they came to Christmas Island, how</p> <p>16 would that affect your overall conclusions?</p> <p>17 A. As you said before, there's a lot of question marks over</p> <p>18 that evidence and so there would be a lot of caveats</p> <p>19 that I would have to put to that because there may well</p> <p>20 be other explanations for it. I'm just trying to keep</p> <p>21 an open mind on that.</p> <p>22 Q. I understand that. I made clear, this -- as between my</p> <p>23 clients and the Secretary of State it's a highly</p> <p>24 contentious area, epidemiology.</p> <p>25 A. Yes. So allowing for huge uncertainty as to the cause</p> <p style="text-align: center;">Page 76</p>

<p>1 of the chromosome aberration, but unquestionably one of 2 the possible causes of chromosome aberration, one of 3 several, is radiation. It is used occasionally as a way 4 of assessing whether somebody has received a significant 5 radiation dose. 6 So, given all those uncertainties, I'm slightly 7 loath to go in the direction of your question because it 8 does assume a certain outcome. But, if I may, and just 9 answering your question as you've asked it, given all of 10 those caveats, were the Tribunal to conclude that the 11 likely cause of that chromosome aberration was radiation 12 then it would have to cause me to look at the dose 13 assessment, which I've done. 14 Q. Thank you very much. 15 A. I would be remiss, frankly, if I didn't. 16 Q. That's very frank and very helpful. 17 I want to go on to a different topic, which is this, 18 which is resuspension. 19 A. Right. 20 MR JUSTICE BLAKE: We are moving away from seafood and 21 seawater. That's all you wanted to deal with. 22 MR TER HAAR: I have submissions but I am not going to deal 23 any more with Mr Hallard. Unless there's any points 24 which the Tribunal would find helpful to explore at this 25 stage.</p> <p style="text-align: center;">Page 77</p>	<p>1 a question, can I simply say I would benefit from your 2 assistance, if you are able to give it, on the 3 question: what were the techniques for seafood sampling? 4 Insofar it was a Geiger counter on a captured fish once 5 a week, twice a day, it seems vary, is the Geiger 6 counter good evidence, moderate evidence, no evidence at 7 all? Or whatever the answer may be. 8 A. Right. I'll look for the reference this afternoon. 9 Unfortunately, I have made those calculations, but 10 I just cannot remember them. 11 MR JUSTICE BLAKE: Right. 12 A. But I may be able to repeat some of the calculations 13 quickly in terms of just to give an order of magnitude 14 answer to that. 15 MR JUSTICE BLAKE: It's just a topic. I don't want to take 16 you out of your course or anybody else out of their 17 course, but it's something -- 18 MR TER HAAR: My Lord -- 19 A. I will do what I can to answer that question, my Lord. 20 MR TER HAAR: My Lord, as far as I'm concerned, if, on this 21 limited issue, Mr Hallard wants to talk Mr Heppinstall 22 just to get a reference in the bundles, I'm -- you know, 23 we are not in a criminal court -- I am very happy for 24 that to be done. Mr Heppinstall knows what the rules 25 are and if that is of assistance.</p> <p style="text-align: center;">Page 79</p>
<p>1 MR JUSTICE BLAKE: Well, if you are moving on can I just ask 2 one? Seafood monitoring. 3 A. Yes, my Lord. 4 MR JUSTICE BLAKE: Am I right in thinking that it was done 5 by a Geiger counter on captured fish? 6 A. It would certainly -- that was certainly one of the 7 techniques, my Lord. 8 MR JUSTICE BLAKE: What other techniques are there? 9 A. I actually read that in something I'd seen before I came 10 into court this morning, but unfortunately the reference 11 which I would have used is currently 300 miles away. 12 MR JUSTICE BLAKE: Yes. Well, I'm not going to ask you to 13 do a memory test. But, I mean -- and it may be 14 therefore -- it may be some purpose in asking this 15 question so you can think about it, since I think we are 16 going to have the benefit of your presence tomorrow -- 17 well, no -- 18 A. But it is a standard AWRE reference, my Lord, so I may 19 be able to find it in these bundles. And if I can, it 20 is actually one of the reports by Major MacDougall. 21 MR JUSTICE BLAKE: MacDougall? 22 A. Yes, that it's the results of the Pacific sampling 23 regime. I mentioned the Pacific sampling regime 24 a few minutes ago. 25 MR JUSTICE BLAKE: Without being too precise about</p> <p style="text-align: center;">Page 78</p>	<p>1 MR JUSTICE BLAKE: So, despite the general principle of 2 non-communication pending evidence, if you needed 3 a reference and a steer, you can get that. 4 A. Thank you, my Lord. 5 MR JUSTICE BLAKE: Let's get back to your questions 6 Mr ter Haar. 7 MR TER HAAR: I was going to move on to resuspension. 8 We've already established that compared, for 9 example, to Dr Nicholson, you don't have the same 10 expertise as he does on such matters as radioactive 11 aerosols? 12 A. Yes. 13 Q. Now when it comes to resuspension this is very much part 14 of the environmental pathway expertise, isn't it? And 15 what I am going to ask you a bit about is this: as 16 I understand it, there is an understandable relationship 17 between a dry deposit of something that is radioactive 18 and the amount of radioactivity that is likely to be in 19 the air which is the resuspension figure. 20 A. Yes, that's correct. 21 Q. Also, conversely, if you are trying to measure what the 22 amount of radioactivity in the air was before it became 23 a deposit on the ground, you need to know the 24 relationship between deposition, velocity and the 25 deposit on the ground?</p> <p style="text-align: center;">Page 80</p>

1 **A. Yes.**
 2 Q. And what I am instructed is that your calculations of
 3 resuspension do not take into account, or do not show
 4 how you take into account, deposition velocity. So can
 5 you help? How did you go about taking account of
 6 deposition velocity in your approach to resuspension?
 7 **A. I've no expertise in deposition velocity. I know a very**
 8 **small amount about it, but that's beyond my expertise in**
 9 **terms of the environmental issues. The area that I have**
 10 **used and the area which I am familiar with is working in**
 11 **the other direction, which I think is what you were**
 12 **asking originally or what you mentioned originally,**
 13 **which is given a deposition of activity on the ground so**
 14 **many becquerels per square metre that you can then**
 15 **estimate the amount of activity that would become**
 16 **airborne using what's called a resuspension factor or**
 17 **a resuspension coefficient.**
 18 **Now the Carter report contains some discussion about**
 19 **that, a significant degree of discussion about that,**
 20 **based on measurements which were actually made in**
 21 **Australia prior to the report being written, and I can**
 22 **go through my reasoning, if that would be helpful, in**
 23 **terms of why I chose the resuspension factor which**
 24 **I did.**
 25 Q. Well, first of all, choosing a resuspension factor is

Page 81

1 not within your expertise at all in any event, is it?
 2 **A. No. I based my judgment on the information which was in**
 3 **the Carter report.**
 4 Q. Now, the Carter report, part of it is in the bundles we
 5 have in front of us, but not all of it, I think.
 6 **A. Ah, right.**
 7 Q. Particularly this part of it isn't, I believe.
 8 **A. Ah, right.**
 9 Q. I'll check that again. I believe that's right. I may
 10 be corrected. But just to set the background to the
 11 Carter report, the Carter report was a report produced
 12 by a committee --
 13 **A. Yes.**
 14 Q. -- headed by Mr Carter?
 15 **A. Yes.**
 16 Q. It did not include in its membership any
 17 environmentalist, did it?
 18 **A. I don't know.**
 19 Q. I think that's what I understand.
 20 **A. Right, okay.**
 21 Q. And when it reported the conclusions were so
 22 controversial that one member of the committee refused
 23 to sign up to its conclusions. Do you remember that?
 24 **A. No, I was not aware of that.**
 25 Q. Amongst other things, what has caused some eyebrows to

Page 82

1 be raised in some quarters is its conclusions in
 2 relation to causes of cancers, that though it's
 3 established that there was compared to a control group
 4 an unusual level of cancer and particularly leukaemia as
 5 a result of the -- exhibited among the veterans, the
 6 report concludes that is probably because they were
 7 probably all smokers rather than because they'd been
 8 underneath an atomic bomb. Are you aware of that?
 9 **A. No, I don't think I've seen that.**
 10 Q. It is perhaps not entirely surprising that quite a lot
 11 of questions marks have been raised as to how that can
 12 be a scientific and probable conclusion. But you are
 13 unaware of that?
 14 **A. The section of the report that I've read is on dosimetry**
 15 **and that's the bit that I've focused on.**
 16 Q. Well, first of all, do you have somewhere the
 17 calculation that you carried out in relation to
 18 resuspension? Just to help you, in your own report, the
 19 best I think I can find on this is to be found at
 20 page 81 of your report.
 21 **A. Yes, that's correct.**
 22 Q. You are not there using a deposition velocity approach,
 23 you are dealing with a resuspension factor?
 24 **A. Ah right. Well, the deposition velocity actually works**
 25 **in the other direction. If you have activity, which is**

Page 83

1 **falling to ground, so activity in the air which is**
 2 **falling to ground, you would use the deposition velocity**
 3 **to calculate what the deposit of radioactivity was on**
 4 **the ground.**
 5 **So if you have a certain level of air activity in**
 6 **units of becquerel per metre cubed, the becquerel being**
 7 **the unit of radioactivity, then you can estimate what**
 8 **the deposition on the ground would be in becquerels per**
 9 **square metre using a deposition of velocity.**
 10 **That wasn't the calculation which I was doing which**
 11 **I needed. The calculation which I needed was: given**
 12 **a certain deposition of activity on the ground in**
 13 **becquerels per square metre, how much air activity would**
 14 **you estimate is likely to arise from that? And the**
 15 **actual resuspension coefficient, the resuspension factor**
 16 **which you would use would be dependent particularly on**
 17 **the amount of -- if I call it agitation of the ground,**
 18 **for want of a better word. So that if you were dragging**
 19 **something across the ground, across a dusty ground, you**
 20 **would expect intuitively, I think, that you would see**
 21 **a very high level of dust produced, and that would**
 22 **therefore give you a very high resuspension coefficient.**
 23 **If the ground was not being disturbed or lightly**
 24 **disturbed it would be very low.**
 25 Q. So that's very helpful. So we're dealing with

Page 84

<p>1 potentially two different situations I think. The first 2 is trying to measure how much radioactivity in the air 3 before it hits the ground can be deduced from the fact 4 that there's this amount of deposit on the ground. And 5 for that purpose you do need to know about deposition 6 velocity in order to say -- and just to spell it out -- 7 assume you have a cloud coming across a piece of land, 8 it's going to be blown across full of radioactivity you 9 need to know about the velocities and movements within 10 that body of air so that you can say if there's this 11 amount of deposition on the ground, how much 12 radioactivity must there be in the air as it passed 13 over.</p> <p>14 That's the first -- if you like that's trying to go 15 backwards to judge from what's on the ground as to what 16 must have been in the body of air as it passed over?</p> <p>17 A. Right, so the activity in the air is the source, and 18 therefore you are then trying to estimate how much 19 activity would fall onto the ground.</p> <p>20 Q. I think what you are saying is that's not what you are 21 dealing with here.</p> <p>22 A. No.</p> <p>23 Q. That is what you tried to do with your Shackleton 24 exercise, I think, if I can put it that way?</p> <p>25 A. I didn't use resuspension factor but I can expand on</p> <p style="text-align: center;">Page 85</p>	<p>1 Q. You say it's the most conservative but are you aware 2 that at the previous hearing what was being talked about 3 was a resuspension factor which might be 10 to the minus 4 3 rather than 10 to the minus 4?</p> <p>5 A. I saw that but it was just almost a throwaway statement. 6 I don't think there was any elaboration or any 7 justification. I wasn't even sure whether it was -- 8 I've never seen the supporting information or supporting 9 evidence. Carter does quote two papers, both I think 10 by -- he references two papers by NRPB, I think, and 11 I did try to find both of those two papers and 12 unfortunately I couldn't. I couldn't find access to 13 them. I think they'd gone to the -- well, they'd gone 14 to the archive and when I looked through the archive 15 I just couldn't find them, so I was not able to get the 16 raw data so I've relied on the Carter information.</p> <p>17 Q. Just to deal with this quite quickly and then I suspect 18 my Lord would want to rise for lunch.</p> <p>19 Certainly you're aware that at the previous hearing 20 there were some questions raised in the 21 cross-examination of Dr Nicholson --</p> <p>22 A. Yes.</p> <p>23 Q. -- of what the proper level was. The way it was put was 24 that Mr Johnston was not challenging 10 to the minus 3 25 for this purpose and Dr Nicholson was saying that could</p> <p style="text-align: center;">Page 87</p>
<p>1 that.</p> <p>2 Q. I'll come back to the Shackleton, probably after lunch, 3 but what you are doing here is a different exercise and 4 saying -- this is why it's resuspension -- having got, 5 for whatever reason deposition on the ground, what are 6 the risks of that being kicked up in whatever way and 7 getting into the air and therefore being a pathway to 8 a serviceman who is nearby the soil being kicked up, the 9 sand being kicked up?</p> <p>10 A. Indeed.</p> <p>11 Q. Now, so far as that is concerned you have to make some 12 sort of assessment as to what -- putting it in broad 13 terms -- what amount of material is going to be kicked 14 back up in particular circumstances?</p> <p>15 A. Yes.</p> <p>16 Q. And that is the exercise that you are, as I now 17 understand, carrying out at pages 81 and 82 in 18 particular (d) at the bottom of 81 through to (h) on 82?</p> <p>19 A. Yes, that's correct.</p> <p>20 Q. Now, that is highly sensitive, isn't it, to the 21 resuspension factor which you take?</p> <p>22 A. That effectively is the method that I've used to make 23 a judgment as to what is the most conservative 24 resuspension factor. So that's my logic to choose that 25 resuspension factor.</p> <p style="text-align: center;">Page 86</p>	<p>1 well be the figure. Do you remember that?</p> <p>2 A. I think if my memory serves me correctly, Mr Johnston 3 had used the figure of 10 to the minus 5 and 4 Mr Nicholson had said that was not conservative and had 5 just made a comment that the range could vary from 10 to 6 the minus 3 to 10 to the minus 5.</p> <p>7 Q. I think that's accurate. He said that using 10 to the 8 minus 5 had the potential to underestimate the air 9 contamination.</p> <p>10 A. Yes.</p> <p>11 Q. And he said the proper range, as you rightly say, would 12 be from 10 to the minus 3.</p> <p>13 Now if it's a legitimate view that 10 to the minus 3 14 would be appropriate, viewed from an environmental 15 scientist's point of view, would you agree that one 16 should revise your (h) on page 82 to say at least 17 this: that a legitimate body of opinion could hold that 18 10 to the minus 3 would be more suitable than 10 to the 19 minus 4?</p> <p>20 A. Okay, perhaps this comes back to my innate caution that 21 I would like to see certainly some supporting evidence 22 of that, which I haven't been able to find. The Carter 23 report explained -- I think I have broken it down 24 here -- explained quite well in my view why it had 25 decided to use a resuspension factor actually of 10 to</p> <p style="text-align: center;">Page 88</p>

1 the minus 5. So Carter uses 10 to the minus 5 in his
 2 report, and the comment was made -- and that was based
 3 on empirical measurements which had been done in
 4 Australia by Turner, I think.
 5 So measurements had been done, so-called dragging
 6 experiments, where something had been dragged in a very
 7 dusty environment. And the outcome of that, again going
 8 on memory, was that a value of 10 to the minus 6 had
 9 produced significant dust and that at 10 to the minus 5
 10 the dust level would have been at a level which most
 11 people would not have tolerated. So based on that,
 12 I think he said that the most that they had seen just
 13 briefly was 10 to the minus 4, and therefore I decided
 14 to use what I believed based on that evidence was the
 15 absolute worst case.
 16 So reflecting the fact that I think even at 10 to
 17 the minus 5 the dust level would have been almost
 18 intolerable from the resuspension I decided to go for
 19 a resuspension factor which was an order of magnitude
 20 beyond that, presumably at a point where the dust would
 21 have been intolerable but nevertheless I felt that was
 22 appropriate in a worst case assessment.
 23 Q. But you are making the assumption in that that the
 24 conditions in the middle of the Australian desert are to
 25 be taken straight across as being representative of the

Page 89

1 conditions on a coral island in the South Pacific?
 2 A. I would've thought the conditions in Australia are
 3 likely to be worse than the conditions on a coral
 4 island.
 5 Q. Absolutely.
 6 A. But I mean the potential would be worse, therefore if
 7 anything that would indicate -- certainly according to
 8 my logic it would indicate that resuspension factors on
 9 a less dusty environment would actually have been lower
 10 and I think the rainfall on Christmas Island is higher
 11 too and that would also in itself cause that.
 12 MR JUSTICE BLAKE: Do you want to get one in or up stumps
 13 for lunch?
 14 MR TER HAAR: One in.
 15 MR JUSTICE BLAKE: One more.
 16 MR TER HAAR: The point I make is this. If the benchmark is
 17 whether or not the resuspension factor would produce --
 18 assumes a world which is intolerable, you have to look
 19 very carefully at what is actually being thrown up in
 20 a particular physical environment, don't you?
 21 A. Yes, in terms of the nature of the dust you mean?
 22 Q. Yes.
 23
 24 A. Yes.
 25 Q. If what you have is not a very dusty environment in the

Page 90

1 same way as the desert but something where you can throw
 2 up small particles then this resuspension factor in
 3 relation to the particles may actually be massively out?
 4 A. I don't think so because the activity is going to be
 5 mixed with dust. The activity has been deposited on the
 6 surface and therefore, the activity will be re-suspended
 7 with the dust. So if you are in an area which has got
 8 a very fine dust -- a dusty environment -- I would
 9 believe that the activity -- that more dust would be
 10 re-suspended and therefore more activity with it and
 11 therefore you're likely to have a higher resuspension
 12 factor. If you are in an area which is less dusty, then
 13 there is less potential for the activity to be
 14 re-suspended with the dust. Therefore you would be more
 15 likely to have a lower resuspension factor. That is
 16 certainly the logic that I have applied.
 17 MR JUSTICE BLAKE: We'll break now for lunch. We'll come
 18 back at five past two. The usual proceedings but if you
 19 need a reference to look something up over the luncheon
 20 adjournment you can make contact.
 21 THE WITNESS: Thank you, my Lord.
 22 MR JUSTICE BLAKE: Thank you.
 23 (1.08 pm)
 24 (The short adjournment)
 25 (2.05 pm)

Page 91

1 MR JUSTICE BLAKE: Just before we resume, over the short
 2 adjournment we were copied in to a number of e-mails,
 3 including one that Dr Busby appears to have sent to
 4 a number of people including Professor Thomas.
 5 Dr Busby, it's forensically extremely unwise to send
 6 such an e-mail even if in error. Can you ensure that
 7 you do not contact any of the witnesses on the other
 8 side by e-mail or any other means hereafter?
 9 DR BUSBY: Yes, my Lord.
 10 MR JUSTICE BLAKE: I should point out in case it's necessary
 11 that the e-mail that I've seen in fact is inaccurate
 12 since there wasn't a complaint of intimidation made to
 13 me, and the contents of the e-mail in fact does touch
 14 upon the evidence that the witness gave, whereas a more
 15 detailed reading of the previous bundle seems to be
 16 dealing with a BBC interview rather than the evidence.
 17 So this is closer to the heart of the issue.
 18 If you will ensure that there is no further
 19 communication by you taking great care with who you send
 20 e-mails to, I hope we can move on. If not, it will
 21 become a very serious matter.
 22 DR BUSBY: Thank you, my Lord.
 23 MR JUSTICE BLAKE: Thank you.
 24 Something has arrived on our desk.
 25 MR HEPPINSTALL: That's the bundle that Mr Hallard wants to

Page 92

<p>1 go to. He was looking for a reference. It's not in the 2 SBs, it's from the library. We will have that copied 3 overnight. 4 MR JUSTICE BLAKE: If it needs to migrate from the library, 5 which as far as I'm concerned is pristine and 6 unexplored, as yet, to our SBs so be it. But I mean 7 despite -- it seems likely that I shall have to one day 8 read things in the library. 9 MR HEPPINSTALL: I'm afraid so. This particular document 10 Mr Hallard told me he wants to go to, it's only in that 11 bundle for the moment. 12 MR JUSTICE BLAKE: Right. That's what that is. Well, we'll 13 have to share it for the time being. 14 A. I've done the calculation that you asked me to, my Lord. 15 MR JUSTICE BLAKE: Right. Did I ask you to do the 16 calculation? 17 MR TER HAAR: I think Mr Hallard offered to do the 18 calculation. 19 MR JUSTICE BLAKE: Right. 20 A. It's the question about I think the sensitivity of 21 measuring activity in a fish -- 22 MR JUSTICE BLAKE: Yes. 23 A. -- using a Geiger counter. 24 MR JUSTICE BLAKE: Yes. I think my question was 25 sufficiently blunt not to invite a calculation but just</p> <p style="text-align: center;">Page 93</p>	<p>1 A. Yes, my Lord, that's an ingestion dose, so that if you 2 ate the fish that's the kind of dose that you would get 3 based on the data in Carter and my supplementary report. 4 MR JUSTICE BLAKE: Thank you. 5 MR TER HAAR: Do put that bundle aside to give yourself 6 space, please. 7 I want to turn to this question of suspension in 8 air, the resuspension. You deal with that in your 9 report at pages 72 and following. But let me see if 10 I can approach it in this direction. Could you please 11 be given bundle SB13. I am going to take you there. 12 Could you go, please, to tab 46, which is 13 Dr Nicholson's report, and a section which starts at 14 page 3, which is headed "Deposition of radionuclides". 15 Then could we go, please, to page 4, the heading 16 "Wet deposition". 17 A. Right. 18 Q. Now I have a feeling that what he sets out here is 19 within his sphere of expertise, not yours, but -- 20 A. Yes. 21 Q. -- I want to go through it and see whether you see any 22 reason to doubt what he is saying here. 23 A. Right. 24 Q. So paragraph 13: 25 "Wet deposition is categorised as either in-cloud or</p> <p style="text-align: center;">Page 95</p>
<p>1 how effective that means of examination was. 2 A. Okay. Using their figures -- and I don't get quite the 3 same figures but that doesn't matter -- the lowest level 4 that they say they can detect would amount to a few 5 millisieverts in a typically-sized fish. 6 Does that help? 7 MR JUSTICE BLAKE: In this context, does a few millisieverts 8 mean under 20 millisieverts, 20 to 50, 50 to 100? 9 A. It's under 20. It depends precisely on how far -- on 10 how long after the detonation the fish has been caught. 11 But if I just assume a general period of a few tens or 12 a few -- perhaps 200 days, that kind of thing, which 13 would give a higher level, it would be less than 10 14 millisieverts. 15 MR JUSTICE BLAKE: Right. So if I understood that answer, 16 putting it all together, you calculate that if you 17 caught and examined a fish with a Geiger counter of the 18 sort used at the time we're interested in on 19 Christmas Island -- 20 A. Yes. 21 MR JUSTICE BLAKE: -- between 10 to 200 days after 22 detonation, putting a Geiger counter on a fish would be 23 able to give you an estimate of radioactive dosage 24 within up to -- in a few millisieverts, that is to say 25 under 20 millisieverts?</p> <p style="text-align: center;">Page 94</p>	<p>1 below cloud scavenging, according to where the 2 contaminant becomes incorporated into the...(Reading to 3 the words)... snow is formed, not the cloud of 4 contamination. Note also that in-cloud is usually 5 called 'rainout' and that below cloud is usually called 6 'washout', although the terms are not used consistently. 7 To avoid confusion herein the expressions 'in-cloud' and 8 'below cloud' scavenging will be used." 9 I don't imagine there's anything you disagree with 10 in that paragraph. 11 A. No. 12 Q. 14: 13 "Below cloud scavenging involves the interception of 14 material by falling rain or snow. The efficiency of the 15 process is...(Reading to the words)... position at 16 least sufficient for particles in the size range in 0.1 17 to 1.0 ..." 18 Micrometres is that? 19 A. Yes, micrometres. 20 Q. "... because they tend to follow the stream lines around 21 the drops, large particles being impacted due to 22 ...(Reading to the words)... affected by gravity." 23 Again, outside your territory, I imagine? 24 A. Yes. 25 Q. 15:</p> <p style="text-align: center;">Page 96</p>

<p>1 "In-cloud scavenging involves various processes 2 including those leading to nucleation, the formation of 3 droplets or snowflakes, and the incorporation of 4 ...(Reading to the words)... later process complicated 5 and can involve charge effects, among other things." 6 Again, no reason to doubt that? 7 A. No. 8 Q. 16: 9 "It is impossible to confirm from the available 10 measurements alone that rain did form in a mushroom 11 cloud from Grapple Y. It is certainly possible for 12 a number of reasons. Firstly there was a high 13 concentration of cloud droplets in a rapidly cooling and 14 highly turbulent environment and it seems reasonable 15 that there may have also been a significant charge 16 associated with the cloud facilitating this process. 17 Any such precipitation formed would almost certainly 18 have included high levels of scavenged radioactive 19 materials from both droplets, nucleation processes and 20 direct incorporation into in-cloud elements. It may 21 also become further contaminated during the descent." 22 Again, happy with that? 23 A. I mean, certainly in terms of the first bit about the 24 formation of rain I simply can't comment. 25 The comment about including high levels of scavenged</p> <p style="text-align: center;">Page 97</p>	<p>1 height. I'd need to use a table in Mr Stretch's report 2 to tell you what 700 millibars corresponds to in terms 3 of height. 4 Q. It look as though it's something around 10,000 feet. It 5 gives the figure in brackets. 6 A. I beg your pardon. Right. 7 Q. "... seven hours before the blast. This is not 8 conclusive proof that ...(Reading to the words)... it is 9 evidence for it being possible." 10 Again I think you would accept that that's outside 11 your expertise what's in that paragraph? 12 A. Yes. 13 Q. "In terms of raindrops on the mushroom cloud reaching 14 ground level without evaporating, this is likely to 15 depend on how quickly they freeze. Rain originating 16 from such an event is unusual. It would be falling from 17 a relatively warm environment to a much colder one, as 18 low as around minus 70 degrees Centigrade and as such 19 would soon freeze. It difficult to find a ...(Reading 20 to the words)... Droplets will fall faster at higher 21 altitudes because the air is less dense. However, the 22 aerodynamic shape of the droplets can be affected on 23 freezing, slowing down the speed of descent. 24 "Consequently it seems reasonable to assume 25 ...(Reading to the words)... transit time from the base</p> <p style="text-align: center;">Page 99</p>
<p>1 radioactive material, it's difficult for me to comment. 2 I think it goes beyond my expertise. 3 Q. 17: 4 "Extensive efforts were made ...(Reading to the 5 words)... to model rain caused by nuclear detonation 6 termed 'self-induced rainout'. I am not aware of any 7 experimental measurements made on this subject. Part of 8 the problem on the experimental front is that many US 9 ...(Reading to the words)... data from the Hiroshima and 10 Nagasaki blasts to validate a theoretical model that 11 rain was found to fall shortly after both these 12 detonations. He concluded that self-induced rainout is 13 possible. This effect is further modelled by 14 ...(Reading to the words)... yields up to 100 15 kilotonnes. They added that self-induced rainout will 16 not be significant for low relative humidities but could 17 be very important for high relative humidities of up to 18 80 per cent and could be moderately important for 19 relative humidities down to about 50 per cent up 20 ...(Reading to the words)... suggest relative humidities 21 of 80 per cent up to 700 mb ..." 22 What is mb? 23 A. It's millibars. It's pressure. They have a strange way 24 of describing height so when you talk about 700 25 millibars they're actually referring to a certain</p> <p style="text-align: center;">Page 98</p>	<p>1 of the developed mushroom would be of the order of 2 20/25 minutes. This would appear to be consistent with 3 witness reports of when rain was observed on the Island 4 and is in agreement with the estimate made in the expert 5 report of Richard Stretch." 6 Again, nothing to disagree with there? 7 A. No. I have read this quite carefully and indeed the 8 report by Mr Stretch. Mr Stretch, if my memory serves 9 me correctly, also considered the possibility of rain 10 from lower cloud, I think cumulonimbus. 11 Q. That is dealt with in the next paragraph actually. Your 12 recollection is absolutely correct. So Dr Nicholson 13 comments on that here. 14 A. Right. 15 Q. "It has been noted in the expert report of Richard 16 stretch that precipitation from lower level cumulus 17 clouds could have been initiated by gravity ... This is 18 theoretically possible. However, it is difficult to 19 comment given the information available. The Grapple Y 20 footage suggest that low level ...(Reading to the 21 words)... In any event, if the rain had been caused by 22 low level cloud I would expect it to be more widely 23 reported even considering the patchy nature of rainfall. 24 "In summary, it is theoretically possible that 25 rainfall could have originated from lower level clouds</p> <p style="text-align: center;">Page 100</p>

<p>1 although I do not believe it can be stated that such 2 clouds were the probable cause of rain." 3 Just looking at that conclusion in the last 4 sentence, that's well outside your area of speciality? 5 A. Absolutely. 6 Q. When we get to the end of the report at page 8, 7 Dr Nicholson has a summary at the bottom of the page, 8 and my impression is that you find nothing to disagree 9 with in anything that's in his summary but let's be 10 clear that I'm right about that. 11 The first proposition: there is a reference to 12 an atmospheric pressure that would suggest a lower 13 detonation height than the one reported. 14 Outside your territory, I think? 15 A. Yes. 16 Q. Some dry deposition on Christmas Island is possible, 17 although it's likely to have been sporadic. 18 I think you'd agree with that? 19 A. Yes, again it's outside my expertise. 20 Q. Wet deposition, i.e. in rain, from the mushroom cloud is 21 possible. 22 Yes? 23 A. Outside my expertise but I wouldn't argue. 24 Q. At the top of the next page: 25 "The environmental sampling programme was inadequate</p> <p style="text-align: center;">Page 101</p>	<p>1 calculations have been optimistic by considering average 2 exposures. In addition, the contamination assumed when 3 levels were below detection limits, there needs to be 4 taken into consideration the sampling and measurement 5 areas and an appropriate figure should be adopted on 6 this basis." 7 I don't think you entirely agree with that. But do 8 you at least agree that that is a legitimate view which 9 can be taken? 10 A. Yes, I think he's talking about different dose 11 estimates. I think he might be referring to some of the 12 dose estimates that were made by Mr Johnston. 13 The level of activity that I've assumed would be 14 readily detectable by probes. The probes would be what 15 are called "off-scale". The level that would be 16 measured on a probe in contact with the amount of 17 contamination which I've assumed on the ground would be 18 above the maximum that the probe was capable of 19 measuring so the needle if you like on the probe would 20 be hard over to the extreme end of its measurement 21 scale. 22 So the level of contamination which I've assumed is 23 much higher than the level of contamination that was 24 assumed in some of the earlier dose estimates. 25 Q. Well, the trouble is that of course if it's off the</p> <p style="text-align: center;">Page 103</p>
<p>1 in terms of giving an accurate picture of deposition and 2 potential dose to those on Christmas Island during the 3 Grapple Y test. 4 "The exercise was undertaken during a time when 5 concerns over environmental radioactivity and exposure 6 pathways was still new and modern safety standards would 7 dictate the need for a much more extensive measurement 8 network and detailed reporting." 9 We've been over part of that before and I think you 10 agree with that paragraph? 11 A. Broadly, with the qualification that my judgment is that 12 the probe sampling does give us the indications of the 13 extent of the probe sampling, nevertheless the deduction 14 is based on evidence that the probe sampling actually 15 gives us some reasonable information with regards to 16 ground deposition. In terms of sticky sampling, air 17 sampling, yes, we've been over that and really it's not 18 satisfactory. 19 Q. We've been over probe sampling as well? 20 A. Yes. 21 Q. Doubts as to where it was done, taking on board your 22 evidence as to Port London? 23 A. Yes. 24 Q. Next bullet point: 25 "There is evidence that some of the dose</p> <p style="text-align: center;">Page 102</p>	<p>1 scale it could be even a great deal higher than you've 2 taken as an assumption? 3 A. What I'm saying is that I've assumed a value -- and 4 I can explain why later when we go through that. I've 5 assumed a certain value based on the procedures which 6 were in place on the Island at the time. And what I'm 7 saying is that had those levels existed as widespread 8 levels across the Island it would have been very 9 obvious. The probes would have been -- the probes and 10 the radiation meters would have been readily able to 11 detect it, and indeed a contamination probe placed on 12 the ground would have been off-scale. That's the point 13 I'm making. 14 Q. The problem that we have -- and this is what we've been 15 over -- first of all, one has to be sure that the level 16 you have taken is in fact a maximum? 17 A. Yes, we can discuss that. 18 Q. But secondly, you're then relying upon principally the 19 evidence of surveys which, for reasons we've been into, 20 is inadequately set out as a systematic set of surveys 21 and is inadequately recorded? 22 A. And we've been over that, without wishing to repeat it 23 -- 24 Q. I agree. 25 A. -- that there is evidence of surveys being done but the</p> <p style="text-align: center;">Page 104</p>

<p>1 records I agree are poor. It really comes down to the 2 witness evidence and the statement in the residual 3 measurements report.</p> <p>4 Q. And ultimately -- and your report is very fair about 5 this -- you just have to build in a lot of assumptions, 6 don't you?</p> <p>7 A. Yes, and I hope I've justified the assumptions and 8 explained where they've come from. I've tried to be as 9 transparent as possible, perhaps excessively so, but 10 I have had to make quite a few assumptions, yes.</p> <p>11 Q. One thing you don't do, which is sometimes done in this 12 sort of exercise, is to build in a calculation of 13 uncertainty levels.</p> <p>14 A. Right. I did that in the replies to Dr Busby and Group 15 Captain Ades. I agree, it was an omission in the first 16 report and the second -- and the replies to the 17 questions that they raised goes into the issue of 18 uncertainties in some detail. I haven't been able to 19 quote uncertainties for everything. I've quoted 20 uncertainties, my estimated uncertainties for my 21 calculations.</p> <p>22 Q. Again, the trouble is -- I am not criticising you -- you 23 end up estimating the uncertainties of uncertainties, 24 don't you?</p> <p>25 A. Yes, you can, yes.</p> <p style="text-align: center;">Page 105</p>	<p>1 number of calculations I've realised that I haven't 2 actually gone quite to the extreme and on those 3 occasions I've actually redone and republished the 4 calculations based on what I then believe are the upper 5 limit of those uncertainties.</p> <p>6 Q. I am going to come back to a particular example of where 7 you built in a lot of assumptions and I understand why 8 --</p> <p>9 A. Yes.</p> <p>10 Q. -- and test that little. Can I go back to page 9 of 11 this. The last bullet point again I suggest is a fair 12 comment or at least a comment which an experienced man 13 can make:</p> <p>14 "A high measurement of deposited radioactive 15 material at one site needs to be explained. It is 16 insufficient to interpret it simply in terms of dose. 17 Its very existence suggests a pathway for the 18 contamination of Christmas Island and, given the 19 extremely limited dataset, areas of even higher 20 deposition are likely to have occurred."</p> <p>21 I don't think you would agree with that in terms but 22 would you at least agree with me that that is 23 a viewpoint which somebody experienced in the field 24 could hold?</p> <p>25 A. I would actually agree with the paragraph.</p> <p style="text-align: center;">Page 107</p>
<p>1 Q. When we really step back and look at it, what we have 2 here is a series of tests which have not been carried 3 out by the British Government before in usual 4 circumstances?</p> <p>5 A. Yes.</p> <p>6 Q. Where they were done, as we discussed earlier, set up at 7 relatively short notice, without the sort of scientific 8 controls we would now expect?</p> <p>9 A. Yes, certainly that we would now expect, yes.</p> <p>10 Q. And we know that the records kept were, even by the 11 standards of the time, inadequate or at least in terms 12 of preserving the records?</p> <p>13 A. And in terms of trying to look back now to see, to get 14 detail of what sampled, it's very hard to do that. We 15 can only get an indication. There are no records.</p> <p>16 Q. At every point in the whole of your report -- this is 17 not a criticism -- you have to make assumptions and 18 build in this assumption upon which you then take 19 yourself forward to the next assumption and to the next 20 assumption?</p> <p>21 A. That's correct. What I've tried to do in the report is 22 to use what I believe are worst case assumptions. So 23 you mentioned a minute ago about the uncertainties. 24 What I've sought to do in the report is work at the 25 upper end of those uncertainties, and indeed on a small</p> <p style="text-align: center;">Page 106</p>	<p>1 Q. You would.</p> <p>2 All right, I want to then go to -- we are getting 3 close to the end, but a couple of -- first of all on the 4 question of suspension, air suspension. What I want to 5 do is if you remember before lunch we were talking about 6 the difference between working out what might be 7 re-suspended and what might be in the air before 8 deposition.</p> <p>9 A. Yes.</p> <p>10 Q. What I would suggest is that you can calculate air 11 concentration by looking at the deposition and doing 12 a calculation in relation to it. First of all, as 13 a concept you understand that?</p> <p>14 A. Yes.</p> <p>15 Q. The calculation you carry out is to take a deposition 16 velocity --</p> <p>17 A. Yes.</p> <p>18 Q. -- and an exposure time.</p> <p>19 A. Yes. You are going outside of my expertise, I'm afraid. 20 Going in that direction, I've seen the formulae and I've 21 got a broad understanding -- I've got a broad knowledge 22 of the range of deposition velocities but in terms of 23 how it's used I'm afraid that's outside my expertise.</p> <p>24 Q. Let's see if you can go with me this far and if you 25 can't you can't.</p> <p style="text-align: center;">Page 108</p>

<p>1 I am suggesting that the standard deposition 2 velocity you'd use in this circumstance is 0.001 metres 3 per second. 4 A. I think I've seen that figure. 5 Q. And if you took an exposure time of 100 seconds that 6 would be reasonable as a way of testing what the air 7 concentration might be? 8 A. You mean just taking an arbitrary figure of 100 seconds? 9 Q. Yes. Assume you're exposed for 100 seconds. 10 A. Okay. 11 Q. What you then would do on that basis is to take your 12 figure of 16 mbq per square metres. That's the actual 13 deposition you calculated? 14 A. It is, yes. 16 megabecquerels per square metre. 15 Q. And then you work backwards with the formula I've just 16 been -- and you get to 160 megabecquerels, if I've got 17 it right, per cubic metre. That would be the volume in 18 the air? 19 A. Right. I'm afraid that is outside my expertise. 20 I couldn't comment on that. 21 Q. Let's look at what you did do about suspension in the 22 air because I suspect you were actually, for the reason 23 I just commented, outside your territory -- 24 A. Perhaps I could just make a comment on that. What I've 25 assumed in the report is that reading Dr Nicholson's</p> <p style="text-align: center;">Page 109</p>	<p>1 expertise and anyway because I felt that there was so 2 much uncertainty about whether any rainfall had been 3 contaminated that I would never be able to answer that 4 question with any certainty whatsoever. I felt that 5 there was more reliability in the monitoring on the 6 ground and that is what I've taken as the starting 7 point. 8 Q. I understand and you have made that very clear. The 9 difficulty for this Tribunal is that what this Tribunal 10 is looking at are possibilities -- 11 A. Yes, I understand that. 12 Q. -- rather than probabilities or the balance of 13 probabilities. The reason I took you to that part of 14 Dr Nicholson's report at some length is that he 15 certainly regarded it as being, in his own language 16 if you like, a serious possibility that there was 17 radioactive rain falling on the Island very soon after 18 the explosion. 19 And this I think is within your expertise, that 20 radioactive material suspended in rain may not yet be 21 wet deposition but is actually a very effective way of 22 taking in material that is suspended in the air? 23 A. Can I just test I understand what you mean by that 24 question? Do you mean that if it was raining and if 25 that rain was contaminated that that's a very effective</p> <p style="text-align: center;">Page 111</p>
<p>1 expert report, his transcript, and Mr Stretch's report, 2 the likelihood of dry deposition appeared to be quite 3 low. My interpretation of what they were saying was 4 that wet deposition, if any deposition had occurred, was 5 much more likely. 6 And also we clearly have reports, well documented in 7 Mr Stretch's report, of heavy rain at Port London, Main 8 Camp and other areas. What I have done is to -- and the 9 reports of rain, if I read them correctly, and some of 10 them were a little bit ambiguous, but I believe the 11 reports of the rain were between 30 minutes and an hour. 12 So what I'd assumed is that the rainfall had carried on 13 for an hour, at an unspecified activity, had deposited 14 activity on the ground at the levels that 15 I calculated -- and again I can explain why I've chosen 16 that figure if need be -- and that those levels were 17 then deposited on the ground and that activity in the 18 form of fission products, plus plutonium, plus uranium 19 but the fission products in particular would have then 20 decayed at the standard rate if I can use that term, 21 which is a very rapid decay rate. But I've then made my 22 calculations based on that and integrated some of those 23 estimates in order to get the total activity over 24 a period of time. 25 So I've not sought -- because it's outside my</p> <p style="text-align: center;">Page 110</p>	<p>1 way of inhaling the activity in that rain? 2 Q. Yes. 3 A. I'm not sure I would agree with that, simply on the 4 basis -- and there is some intuitive judgment here -- 5 that if you are standing or walking in rainfall you 6 don't tend to inhale the raindrops. It tends to be 7 because the particle size is too big, apart from 8 anything else, that we don't walk across the street and 9 inhale raindrops. The things that we would inhale would 10 tend to be much smaller particle size, much more akin to 11 a dusty environment where the activity has already been 12 deposited on the ground and then re-suspended in the way 13 that I've indicated in the report, particularly the 14 smaller particles of the order of 1 micrometre or 15 smaller. 16 Q. I think the reason why what I suggest to you is right is 17 that what you are talking about to an extent is how 18 rapidly things fall out of the air? 19 A. Yes. 20 Q. So obviously as I walked through that shower as I came 21 here this morning -- 22 A. Yes. 23 Q. -- I didn't find myself breathing in huge amounts of 24 water. 25 A. No.</p> <p style="text-align: center;">Page 112</p>

<p>1 Q. Although it felt as though I might at any moment, but 2 what I am doing is breathing in the air that is around 3 me which is of course air coming out of a rain-laden 4 atmosphere.</p> <p>5 A. Yes.</p> <p>6 Q. What is suggested is that if that is the atmosphere that 7 is much more -- when you breathe in you are much more 8 likely to take in the radioactive materials than if 9 there is dry deposition on a sunny day.</p> <p>10 A. I think that's more in Dr Nicholson's area of expertise 11 than mine.</p> <p>12 Just to make a comment. Water is a very good 13 suppressant for dust. Indeed, I've noticed a comment 14 about HMS Diana, I think, in one of the reports, where 15 the ship which had been involved in testing at 16 Australia, the instruction was given to damp down the 17 deck because the deck had found to be contaminated and 18 then there was some debate as to how effective that was. 19 If you put water on to a contaminated surface it's 20 a very good way of damping down dust. I mean we might 21 do that in our homes.</p> <p>22 Therefore, I'm a little surprised -- surprised from 23 an intuitive point of view. I think I would just ask 24 a question and I don't think I have the expertise to be 25 able to answer that adequately. I think I would just</p> <p style="text-align: center;">Page 113</p>	<p>1 aircraft was already contaminated before take-off.</p> <p>2 At 5 you make the assumption, which I think you say 3 is a conservative assumption, the increase in dose rate 4 was due to flying through fallout.</p> <p>5 Then at 7 you make the same assumption about gamma 6 radiation due to fallout cloud over the sea.</p> <p>7 Then you assume at 1 on page 73 that the anvil is 8 a more likely source, and you say a speculative and 9 working assumption only.</p> <p>10 And at 2 you talk about what is plausible. You then 11 carry on to follow through the consequences of those 12 assumptions.</p> <p>13 Can we just look at -- well, first of all we don't 14 know exactly what the relationship was between this 15 aircraft and the centre of the radioactive cloud through 16 which it was to travel?</p> <p>17 A. We have some information on that. I think -- ah, there 18 is a copy of the survey in fact done at the time, 19 presumably by the air crew, on page 75. And a lot of 20 the information that I've used and copied here came from 21 the Grapple Y residual radiation measurements report 22 which also contains quite a lot of information on this 23 particular event. But I felt it was important because 24 apart from anything else it demonstrated real fallout so 25 we have real evidence of fallout -- quite some way out</p> <p style="text-align: center;">Page 115</p>
<p>1 ask the question: why would we assume that raindrops 2 falling, particularly within 2 metres of the earth, 3 would be likely to release the dust which it contains 4 rather than deposit it on the ground? But I don't have 5 the expertise to be able to go beyond asking that simple 6 question.</p> <p>7 Q. Then we'll note the question. I want to come back -- 8 I think it's almost the last topic I want to ask you 9 about. Could you go to page 72 of your report, please.</p> <p>10 A. Okay.</p> <p>11 Q. This is where you deal with the Shackleton evidence.</p> <p>12 A. Ah yes.</p> <p>13 Q. You also deal with it at some length in the answers to 14 Professor Busby's questions.</p> <p>15 A. Yes.</p> <p>16 Q. But I suggest in this part of your report you have to 17 make a particularly large number of assumptions along 18 the way and if we just look at it, if you start at 19 72(ii).</p> <p>20 A. Yes.</p> <p>21 Q. You make assumptions as to fallout over the whole 22 Island. I understand that.</p> <p>23 A. Right.</p> <p>24 Q. You then set out some facts about the Shackleton. 25 Then at 4, you make assumptions about whether the</p> <p style="text-align: center;">Page 114</p>	<p>1 to sea, but nevertheless there was evidence of fallout 2 in rain and therefore it I think self-evidently is 3 a significant event.</p> <p>4 Q. I don't disagree about it being significant, but we 5 don't know exactly how far the measurements that are 6 taken are from the centre of this cloud of radioactivity 7 at the time when the measurements are taken, do we?</p> <p>8 A. Yes, it is difficult to see it on here but from my 9 recollection the radiation levels which were measured by 10 the aircraft -- and I can describe those in more 11 detail -- showed a rise towards the far western side of 12 the central part of that survey, but that the rise in 13 radiation levels slowed down at the far western end. 14 I have to admit that this is based partially on memory.</p> <p>15 MR JUSTICE BLAKE: You're referring to the plan at 75 of 16 your report?</p> <p>17 A. I'm referring to that plan, my Lord. (Indicated).</p> <p>18 MR JUSTICE BLAKE: Well, did you look at something a bit 19 more blown-up than what we have?</p> <p>20 A. I had an electronic version of this, my Lord, and I was 21 able to expand it on a computer screen.</p> <p>22 MR JUSTICE BLAKE: Jolly good.</p> <p>23 A. Which doesn't help you very much. I have to be honest.</p> <p>24 MR JUSTICE BLAKE: No, no, it's trying to follow what you 25 say about it without necessarily being able to follow it</p> <p style="text-align: center;">Page 116</p>

1 on the plan.
 2 **A. Yes.**
 3 MR JUSTICE BLAKE: Putting it landscape we can see that
 4 there is some very faint writing apart from the header
 5 at the top. Then we have the grid with the plan of the
 6 Island. Then we have the various red lines. Then
 7 a number of what? Are they numbers?
 8 **A. Yes, they are numbers, my Lord. Each of those has two**
 9 **numbers. One is a radiation measurement and the other**
 10 **is a time. And so what you can do is -- I'm sorry,**
 11 **I think perhaps I should have blown this up. I don't**
 12 **think -- I should have made sure --**
 13 MR JUSTICE BLAKE: You can describe to me what you can
 14 remember that you saw, and using this as
 15 an aide-memoire. But any attempt, certainly by myself,
 16 to plunge in to follow you with the detail would be
 17 a futile exercise.
 18 **A. Yes, I can understand that, my Lord.**
 19 **What was happening -- I think it's worthwhile just**
 20 **describing the event first of all.**
 21 MR JUSTICE BLAKE: Yes.
 22 **A. The Shackleton took off from Christmas Island with the**
 23 **intention of flying out in the direction that they**
 24 **believed that any fallout cloud would have gone, with**
 25 **the intention of flying through the cloud. Subsequently**

Page 117

1 **I think they didn't do that afterwards because of the**
 2 **experience here but the intention was to fly through the**
 3 **fallout cloud. When they started making measurements**
 4 **they discovered that the first measurement was already**
 5 **showing quite a high level of gamma radiation. That**
 6 **level remained constant for a period of several minutes,**
 7 **I think, perhaps even several tens of minutes.**
 8 **Several minutes, certainly, without rising.**
 9 **Then as they flew further towards the west they**
 10 **found that the levels of radiation started to rise**
 11 **slowly at first, but then more rapidly as they got**
 12 **towards the western end of the route that they were**
 13 **planning to fly.**
 14 **Then if my memory serves me correctly, the rate of**
 15 **rise at the extreme western end slowed. But as they**
 16 **turned round and came back, so at the moment they were**
 17 **flying from -- they were flying towards the west.**
 18 MR JUSTICE BLAKE: And just orientate us on the plan. This
 19 is the southern hemisphere.
 20 **A. So they started here, they were flying in this direction**
 21 **and they were following this path (Indicated).**
 22 MR JUSTICE BLAKE: Right.
 23 **A. Before taking a diagonal route up here and flying back**
 24 **to the Island.**
 25 MR JUSTICE BLAKE: Yes.

Page 118

1 **A. So at the extreme western end of the first transit**
 2 **I believe that the rate of rise slowed. As they turned**
 3 **round and started to fly east again, the rate of rise**
 4 **increased and then slowed again at the extreme eastern**
 5 **end. So there was some indication from that -- and**
 6 **I think this is the way that they interpreted it at the**
 7 **time, because I have used quite a number of their**
 8 **conclusions and their assumptions -- the way that they**
 9 **interpreted that was that the aircraft was already**
 10 **contaminated before it took off from Christmas Island.**
 11 **The aircraft had been involved in some maritime**
 12 **protection work earlier in the day and their**
 13 **assumption -- their primary assumption -- there was**
 14 **perhaps another conclusion, but the one that they**
 15 **thought was more likely was that the aircraft had become**
 16 **contaminated during that earlier flight in the day so**
 17 **was already contaminated when it took off.**
 18 **So the first measurements that they made roughly in**
 19 **line with the edge of Christmas Island, those first**
 20 **measurements --**
 21 MR JUSTICE BLAKE: The eastern --
 22 **A. Eastern end.**
 23 MR JUSTICE BLAKE: -- end of the measurements.
 24 **A. Yes.**
 25 **Those first measurements, which I think say 660**

Page 119

1 **microR, those measurements at the extreme eastern end**
 2 **reflected the level of contamination which was already**
 3 **on the plane.**
 4 MR JUSTICE BLAKE: Yes.
 5 **A. As the plane flew towards the west it then encountered**
 6 **the main fallout cloud, and as it got deeper into the**
 7 **fallout cloud the rate of rise of the gamma that they**
 8 **were observing increased.**
 9 **So the gamma radiation in the time intervals, at**
 10 **each time interval, the interval, the rise, in each of**
 11 **those increased, indicating that they were flying into**
 12 **an area of a higher concentration of activity.**
 13 **At the far end of that -- I hope my memory is**
 14 **correct -- at the far end of that the fact that the rate**
 15 **of increase slowed suggested that they'd flown through**
 16 **the highest area and were then experiencing a slightly**
 17 **lower area of contamination.**
 18 **But then as they turned round and came back, again**
 19 **the rate of rising increased. That's when I think they**
 20 **saw the peak. So the incremental rise between -- they**
 21 **saw the peak incremental rise between two of the survey**
 22 **points. Then levels -- then the incremental rise**
 23 **steadied off again.**
 24 **So their conclusion was that the plane was already**
 25 **contaminated, it had flown through a fallout cloud, and**

Page 120

1 **part of the evidence in support of that was that when**
 2 **the plane then arrived back on Christmas Island they**
 3 **surveyed it and discovered that the skin of the aircraft**
 4 **was quite badly contaminated.**
 5 MR JUSTICE BLAKE: Yes.
 6 **A. They took smears of the surface of the aircraft, that is**
 7 **a piece of absorbent paper that they rub over it, and**
 8 **those levels were showing high levels.**
 9 MR JUSTICE BLAKE: Thank you for unpacking the statistics to
 10 me. Insofar as the questions you were answering from
 11 Mr ter Haar are concerned, do I understand that
 12 explanation, linked with what you say in your report,
 13 suggests that that is some evidence for the proposition
 14 that the more intense radiation was between the eastern
 15 and the western points?
 16 **A. Yes. Again relying on memory the highest point of**
 17 **radiation would have been just inside the extreme --**
 18 MR JUSTICE BLAKE: Just angle that so Mr ter Haar can see
 19 it.
 20 **A. I beg your pardon. (Indicated). That the highest**
 21 **levels would have been around about here. What I will**
 22 **do --**
 23 MR JUSTICE BLAKE: Somewhere on the western edge?
 24 **A. Yes. What I will do, and I'm sorry I haven't come armed**
 25 **to answer that question in detail, but I think I can**

Page 121

1 **expand this on my own laptop computer with the hope of**
 2 **being able to confirm what I've said. If I'm in error**
 3 **could I let you know in the morning?**
 4 MR TER HAAR: Certainly as far as I'm concerned.
 5 But one of the problems we have with this is in
 6 order to interpret this material you do need to make
 7 a number of meteorological assumptions, don't you?
 8 Shall I explain why?
 9 **A. Please, yes.**
 10 Q. Well, first of all this is a plane flying in an area
 11 a little remote from the Island?
 12 **A. Yes.**
 13 Q. Some seven hours after the explosion?
 14 **A. Yes.**
 15 Q. During the course of which the radioactivity is likely
 16 to have dispersed, at least to some extent?
 17 **A. Yes, and I'll perhaps come back to that comment in**
 18 **a minute with regards to the comment you highlighted**
 19 **about the anvil as opposed to the stem.**
 20 Q. I am going to come to the anvil/stem debate. It's
 21 a separate point.
 22 But simply the fact that a cloud of material is
 23 blown for some seven hours through the air, gradually
 24 dispersing, makes it very difficult to calculate back to
 25 how intense the radioactivity was in that cloud seven

Page 122

1 hours earlier?
 2 **A. Okay. Two points on the assumptions, just to clarify**
 3 **the assumptions that I've made.**
 4 **The radiation levels that actually appear on the**
 5 **survey have been corrected back for decay. So the**
 6 **levels on the survey actually represent H plus 1 hour,**
 7 **i.e. that is 1 hour after the time of detonation. It's**
 8 **a slight -- it's an unusual nomenclature. H plus 1H is**
 9 **one hour after detonation.**
 10 MR JUSTICE BLAKE: Right.
 11 **A. D plus 1D is one day after detonation, D plus 5D is 5**
 12 **days, Y plus 1Y is one year after. I was confused with**
 13 **it at the start as well.**
 14 MR JUSTICE BLAKE: I think I'll pick that up on the
 15 transcript.
 16 **A. Right.**
 17 MR JUSTICE BLAKE: But what I think what you are telling us
 18 is that the figures which you've been able to read --
 19 **A. Yes.**
 20 MR JUSTICE BLAKE: -- which you've described being at that
 21 plan at page 75, when they were logged in they were
 22 already back-calculating to one hour after the explosion
 23 --
 24 **A. Yes.**
 25 MR JUSTICE BLAKE: -- using radioactive half life --

Page 123

1 **A. Yes.**
 2 MR JUSTICE BLAKE: -- techniques. So this wasn't what they
 3 were actually picking up on their machinery, equipment
 4 at the time, that was the base figure subject to
 5 a recalculation backwards. Is that it?
 6 **A. That's exactly right, my Lord. It's actually quite**
 7 **confusing when you first see the diagram because you**
 8 **have to understand that that's what they've done. So**
 9 **the levels they were measuring were actually lower than**
 10 **this.**
 11 MR TER HAAR: But --
 12 **A. Then in terms of the size of the cloud that I've**
 13 **assumed, what I've assumed is that since the point of**
 14 **detonation was at the south west corner -- well, at the**
 15 **bottom of the Island, whether you call that south west**
 16 **or south-east I don't know, but at the corner of the**
 17 **Island some 40 kilometres from the inhabited areas of**
 18 **Main Camp and Port London particularly, assuming that**
 19 **and assuming the time to what I believe is the centre of**
 20 **the cloud would indicate that the cloud was travelling**
 21 **at a certain speed. I think 20 kilometres an hour or**
 22 **something like that.**
 23 **So what I then assumed was on the basis that the**
 24 **cloud would have had to have been over the inhabited**
 25 **areas for about an hour, whatever cloud it was, in**

Page 124

<p>1 order -- if contaminated rain had fallen from that 2 cloud, that the cloud must have been -- that the 3 activity from whatever source it was, whether the anvil 4 or whatever, would have had to have been of the order of 5 50 kilometres, perhaps a little more, 60 kilometres, in 6 diameter, as a simple assumption that Main Camp is about 7 40 kilometres from surface zero, the cloud would have 8 had to overlap Main Camp by some margin in order that it 9 would take an hour for the cloud to be clear of the 10 inhabited areas, if that makes sense. And that that 11 would therefore represent the maximum -- sorry, the 12 minimum size of cloud and therefore the maximum 13 concentration.</p> <p>14 It seemed unreasonable to assume -- the stem could 15 not have been that big. The only thing that could have 16 been that big would have been the anvil of the cloud and 17 that's why I've made that assumption in my report, that 18 in order for it to have overlapped the inhabited areas 19 that the radius could only have been from the anvil of 20 the cloud.</p> <p>21 I think, looking at Mr Stretch's report, although 22 the wind directions were varying a lot, again if my 23 recollection is correct, the bottom part of the anvil 24 would have experienced wind which would have taken it 25 out towards the west -- the bottom part of the anvil and</p> <p style="text-align: center;">Page 125</p>	<p>1 The bit about the wind in the end which I agree is 2 outside of my expertise I'm just quoting what I read or 3 interpreting what I've read in Mr Stretch's report but 4 it's simply a mathematical construct that says that the 5 cloud -- that for rainfall from the cloud to have fallen 6 on the inhabited areas it would need to have been this 7 size, and therefore if we then translate that to the 8 information on the survey I would draw this conclusion.</p> <p>9 That's simply a way of saying what might the 10 activity have been in the cloud because I think the 11 residual radiation measurements report estimated the 12 activity in the cloud.</p> <p>13 I actually doubled that activity because I thought 14 that the maximum incremental rise that they were 15 quoting, I felt actually that the survey data was 16 showing the maximum incremental rise was about twice 17 that rate. So I doubled the activity that they had 18 estimated, and then in this report I used that activity. 19 Later, in I think my answers to Dr Busby and Group 20 Captain Ades, I've qualified that slightly but perhaps 21 it's not worth going into that.</p> <p>22 Q. I am going to suggest to you there are a number of 23 problems with your analysis at this point. Let's take 24 them one by one.</p> <p>25 A. Okay.</p> <p style="text-align: center;">Page 127</p>
<p>1 the top part of the stem would have experienced wind 2 which would have taken it out to the west of the Island.</p> <p>3 I think perhaps at the very top part of the anvil 4 there was a lot of wind shear going on and the very top 5 part of the anvil would have perhaps gone in a different 6 direction but again outside of my area of expertise. 7 I'm simply quoting from memory now.</p> <p>8 Q. Mr Hallard, with the greatest of respect, the whole of 9 this theory is way outside your expertise -- let me 10 finish, please -- and it's somewhat unfortunate it's 11 raised at this point. Because this theory was not, as 12 I understand it, one which was explored before the 13 previous First Tier Tribunal when there was evidence 14 from meteorologists.</p> <p>15 So what you've done is taken this piece of evidence 16 and apply what are essentially meteorological judgments 17 in order to draw conclusions from it.</p> <p>18 A. I've tried to take -- I've been very aware of my lack of 19 meteorological expertise and if I have stepped outside 20 of my expertise then I must apologise.</p> <p>21 What I've tried to do is to make mathematical 22 assumptions that simply say if the cloud -- or if 23 rainfall had fallen on the inhabited parts of the Island 24 then the cloud would have had to have been this size. 25 So I've not tried to make a meteorological assessment.</p> <p style="text-align: center;">Page 126</p>	<p>1 Q. First of all, you assumed that the radioactivity 2 encountered by the people in the aircraft came from the 3 anvil, not the stem, and I am going to suggest to you 4 that the probability, or at least the possibility is 5 that it came from the stem, not the anvil. The reason 6 for that is that the anvil rises and gets very close to 7 the tropics(?).</p> <p>8 A. Yes.</p> <p>9 Q. I.e., the top of the world?</p> <p>10 A. Yes.</p> <p>11 Q. And, therefore, any radioactivity which is encountered 12 by the Shackleton at a much lower level is more likely 13 to come from the stem than from the anvil of the 14 explosion. Would you agree at least that's a strong 15 possibility?</p> <p>16 A. It's certainly a possibility but the stem at the time of 17 the detonation would not have extended to the inhabited 18 parts of the Island. The stem would have been much 19 narrower than that.</p> <p>20 Q. Let's move on.</p> <p>21 A. Okay.</p> <p>22 Q. The second point is that if it came from the stem then 23 there would have been diffusion both vertically and 24 horizontally of the radioactive material. Do you agree 25 with that?</p> <p style="text-align: center;">Page 128</p>

<p>1 A. Presumably there would have been some, yes.</p> <p>2 Q. Therefore, in terms of what you are measuring when you</p> <p>3 find yourself in an aircraft seven hours later, you are</p> <p>4 not necessarily measuring the concentration of</p> <p>5 radioactivity that there was in and coming from the stem</p> <p>6 even at H plus 1?</p> <p>7 A. Okay.</p> <p>8 Q. Would you agree that's at least a possible --</p> <p>9 A. It is, but if I can just take that comment and translate</p> <p>10 it back. I can understand what you are postulating,</p> <p>11 I think, if I can just test it. What you are saying is</p> <p>12 that the diameter that I've estimated here actually</p> <p>13 represents a hugely expanded stem rather than a slightly</p> <p>14 extended anvil. Is that what --</p> <p>15 Q. I am not using such expressions as "hugely extended". I</p> <p>16 am at the moment just pointing out that it's more likely</p> <p>17 that radioactivity which is found in the air seven hours</p> <p>18 later by the Shackleton, at the height that Shackletons</p> <p>19 fly -- which is not as high as a Canberra?</p> <p>20 A. Oh no.</p> <p>21 Q. We are talking about piston engine planes, not jet</p> <p>22 planes.</p> <p>23 A. And I think it was flying quite low at this time as</p> <p>24 well. I have a feeling it was a few hundred feet.</p> <p>25 Q. It is at least as likely if not more likely to have come</p> <p style="text-align: center;">Page 129</p>	<p>1 is false, or may be false.</p> <p>2 A. If this came from the stem, then that would certainly be</p> <p>3 true. But if this when the detonation occurred was from</p> <p>4 the much narrower stem then clearly the concentration</p> <p>5 would have been higher but that would have been quite</p> <p>6 local to the bottom part of the Island.</p> <p>7 Q. I would suggest -- I am sorry, you haven't finished.</p> <p>8 A. Okay.</p> <p>9 The other point is that if you look at the rate of</p> <p>10 rise at the extreme outer part of the cloud it's</p> <p>11 actually quite a lot smaller than in the middle. And</p> <p>12 therefore again if you assume that that is over the</p> <p>13 inhabited part of the Island, actually the</p> <p>14 concentrations would have been lower.</p> <p>15 So the reason that I've assumed -- it is a worst</p> <p>16 case assumption and from that point of view I think</p> <p>17 perhaps, if anything, is likely to exaggerate rather</p> <p>18 than to underestimate but by assuming it's the anvil,</p> <p>19 recognising the fact that Mr Stretch thought that it was</p> <p>20 I think "not impossible that rainfall from the anvil</p> <p>21 could fall on the Island" -- I think Dr Nicholson was</p> <p>22 a little more positive about it than that but neither</p> <p>23 concluded that there was a high probability. I think</p> <p>24 that's a fair comment.</p> <p>25 Certainly Mr Stretch didn't. Dr Nicholson I think</p> <p style="text-align: center;">Page 131</p>
<p>1 from the stem rather than the anvil?</p> <p>2 A. Okay, and if it had come from the stem then activity</p> <p>3 would only have extended to the bottom part of the</p> <p>4 Island. It would not have extended to the inhabited</p> <p>5 part of the Island. So the assumption that I've made --</p> <p>6 as I say, if it is a meteorological assumption then I've</p> <p>7 gone beyond my expertise, then I apologise for that,</p> <p>8 that was not my intention -- the assumption that I've</p> <p>9 made was that it actually did extend to the inhabited</p> <p>10 part of the Island and therefore would have been</p> <p>11 a source of inhalation. It was intended to be a worst</p> <p>12 case assumption. Because if it was the stem it would</p> <p>13 not have extended -- by my understanding it would not</p> <p>14 have extended to the inhabited part of the Island and</p> <p>15 therefore would not have been a source of exposure. So</p> <p>16 I had deliberately taken what I believed was the worst</p> <p>17 case.</p> <p>18 Q. The next part, I suggest, which is questionable in your</p> <p>19 assumption is that you've assumed that the peak measured</p> <p>20 by the Shackleton was the same as the peak concentration</p> <p>21 on the Island itself?</p> <p>22 A. Yes.</p> <p>23 Q. I suggest that that's not necessarily the case because</p> <p>24 the concentration could well in the seven-hour period</p> <p>25 have diminished or reduced and therefore your assumption</p> <p style="text-align: center;">Page 130</p>	<p>1 perhaps indicated that there was certainly a reasonable</p> <p>2 possibility that rain could have come from the anvil but</p> <p>3 it was certainly not definite.</p> <p>4 So by assuming that the rain had come from the anvil</p> <p>5 and that the anvil had overlapped the inhabited areas,</p> <p>6 it was a mathematical construct in order to create that</p> <p>7 worst case assumption. It was not intended to take</p> <p>8 account of meteorological conditions or anything else.</p> <p>9 It was to say it was a series of -- if I can call them</p> <p>10 logical steps and nothing more than that.</p> <p>11 Q. What I am suggesting is you haven't taken a worst case</p> <p>12 assumption because you haven't taken account of the fact</p> <p>13 that the peak concentration might have been markedly</p> <p>14 different and that's where it's important to have</p> <p>15 meteorological input if one is to carry out this</p> <p>16 exercise?</p> <p>17 A. Okay, that comes back to what I am saying, that if it</p> <p>18 was the stem and therefore that the concentration</p> <p>19 reflected a relatively small stem which had expanded</p> <p>20 to -- I can't remember exactly what it was -- say</p> <p>21 a diameter of 120 kilometres or whatever it was, then</p> <p>22 clearly the concentration in a cloud that had expanded</p> <p>23 to that size from the small stem, that the</p> <p>24 concentrations would have therefore been much lower</p> <p>25 within the large cloud than they would on the stem.</p> <p style="text-align: center;">Page 132</p>

1 What I am saying is that if it was the stem it is
 2 unlikely, very unlikely as I read it from the various
 3 reports, very unlikely that that would have been
 4 a source of exposure because the people would have been
 5 some considerable distance outside of the perimeter of
 6 the stem. And that is why I've assumed this much larger
 7 diameter, and I've said: if we take this cloud of
 8 activity, in order for it to extend over the inhabited
 9 parts of the Island, it can only have shrunk from
 10 I think a radius of 60 to 70 kilometres from memory that
 11 is indicated by this survey, it could only have shrunk
 12 down to about 50 kilometres, and that if it had shrunk
 13 to any less than that it would not have been a source of
 14 exposure because it would then have been too far from
 15 the inhabited areas for that to have been a source of
 16 contaminated rainfall.

17 That was my thought process. So it's purely
 18 a mathematical thought process rather than an attempt at
 19 meteorology.

20 Q. The point I have just made as to peak concentration
 21 applies whether or not we are considering this to be
 22 rainfall from the anvil or from the stem.

23 A. Peak concentration. Okay, so as a strict -- yes, if you
 24 are saying, well, it could have been the stem, and
 25 therefore if I --

Page 133

1 Q. I am now taking your hypothesis and saying: let's
 2 assume --

3 MR JUSTICE BLAKE: You are switching back to the anvil one.

4 MR TER HAAR: Yes, assuming it was anvil you are still not
 5 taking account of the fact that what is being measured
 6 is not necessarily the same peak concentration because
 7 seven hours have gone by in the meantime.

8 A. Okay. I think from memory I calculated that the likely
 9 radius of the cloud at sea was something like 60 to
 10 70 kilometres, the radius. In order for the inhabited
 11 parts of the Island to have been overlapped such that it
 12 would have taken about an hour for the cloud which was
 13 moving in this direction to clear those inhabited areas,
 14 the diameter of the cloud would have to be of the order
 15 of 50 to 60 kilometres. Therefore, in order for the
 16 cloud which was later, which I later estimated at about
 17 60 to 70 kilometres, if that had indeed overlapped the
 18 Island the minimum radius that it could have been would
 19 have been about 50 kilometres, i.e. of that same order.

20 Therefore the concentration, the spread, could not
 21 have been that great, which is why I'd assumed that the
 22 peak level, which of course was only measured at
 23 a relatively narrow area in the centre of the cloud, but
 24 I'd assumed that that level would be the same level that
 25 overlapped the inhabited areas even though the

Page 134

1 concentration indicated by this survey would have shown
 2 significantly lower levels of concentration at that
 3 distance from the cloud.

4 So again it's purely a mathematical construct that
 5 the diameters would have to be -- in order for those
 6 inhabited areas to have been exposed the cloud would
 7 have had to have been a similar size, slightly smaller
 8 but not hugely smaller.

9 Now, had it been the stem -- and I agree with you,
 10 at some level is it more likely to be the stem, is it
 11 more likely to be the anvil? Perhaps it is more likely
 12 to be the stem, but as I think I indicated to you
 13 before, had it been the stem certainly my judgment was,
 14 based purely on reading of other people's reports not on
 15 any expertise on my part, had it been the stem it would
 16 not have been -- it would have given -- it could have
 17 given rise to significant local contamination, although
 18 I don't believe there's great evidence of that.

19 But the concentration of the stem, had it shrunk
 20 from the 60 to 70-kilometre radius observed by the
 21 Shackleton to the radius of the stem, then the
 22 concentration would have been significantly higher, but
 23 it would have been local to that bottom part of the
 24 Island and therefore I couldn't see how that could have
 25 been a likely source of exposure.

Page 135

1 Q. I think we may be at cross-purposes.

2 A. Okay.

3 Q. The explosion takes place.

4 A. Yes.

5 Q. Up in the air goes an enormous amount of material.

6 A. Yes.

7 Q. Some of it goes up in the stem, some of it is in the
 8 anvil.

9 A. Yes.

10 Q. The wind is blowing it in a direction.

11 A. Yes.

12 Q. First of all, that direction may not be absolutely
 13 constant over seven hours?

14 A. No, I agree.

15 Q. In the course of that seven hours, what has been blown
 16 may not stick together. Friendly atom A may decide to
 17 go off in a different direction from another friend B?

18 A. Yes, diffusion.

19 Q. So in order to assess what the level of concentration is
 20 you have to be making some assumption that the
 21 concentration after seven hours is the same as at the
 22 outset, which can't be a realistic assumption unless you
 23 have meteorological evidence to establish that that is
 24 correct.

25 A. Okay. What I would say in reply to that is that if you

Page 136

<p>1 made that assumption, that this cloud must have been 2 originally significantly smaller than that because of 3 the way that it would spread out over seven hours -- and 4 I agree that's a reasonable assertion -- but that if we 5 made the assumption that it was much smaller, it would 6 have then been localised to the bottom part of the 7 Island. It would not have overlapped the two main 8 inhabited parts of the Island, Port London and Main 9 Camp, and therefore it would not have been a source of 10 activity over the whole Island. It might have been 11 a source of localised activity at the bottom part of the 12 Island, close to surface zero, but would not have been 13 a source of widespread activity in the inhabited areas. 14 That was my thought process, anyway.</p> <p>15 Q. I do suggest this is one area where you really have 16 moved outside your field of expertise, and the contrast 17 here is whereas the rest of the theories we've looked at 18 have been the subject of examination by those who have 19 greater and more specialised expertise than you, here 20 you've moved outside areas which are within your 21 expertise without the assistance of such people as 22 meteorologists and those experienced in experimental 23 pathways in order to assist you.</p> <p>24 A. Perhaps. As I say, what I've tried to do is simply to 25 make a logical deduction based on dimensions, based on</p> <p style="text-align: center;">Page 137</p>	<p>1 said to start -- I think it was slightly ambiguous. 2 I couldn't quite tell if it was saying the rain started 3 half an hour after detonation or it started an hour 4 after detonation and carried on for half an hour. But 5 I think I assumed in the report it would start at about 6 half an hour afterwards and continue for about an hour.</p> <p>7 Q. That's right. What we are concerned about is not 8 a reverse calculation to H plus 1, but a reverse 9 calculation to H plus 0.5.</p> <p>10 A. That would be the case at the start of the rainfall but 11 at the end of the rainfall the calculation would be to H 12 plus 1.5 if you like. And broadly, okay, it's a rough 13 approximation, but if you average that then you would 14 get approximately the activity at about H plus 0. So it 15 would be a little higher at H plus a half, a little 16 lower at H plus 1.5, and therefore H plus 1, I've just 17 taken that, within the errors inherent with 18 a calculation of this sort, as being adequate.</p> <p>19 Q. At this point you are not taking the most conservative 20 or very conservative; you are really starting to build 21 in assumptions which are less favourable than other 22 assumptions might be. Do you agree?</p> <p>23 A. Well, if the rain takes an hour, which is what I've read 24 into it, there will be about an hour's decay.</p> <p>25 Q. What about taking the other reading, which is certainly</p> <p style="text-align: center;">Page 139</p>
<p>1 the size of the cloud is so many kilometres. In order 2 for it to be a source of activity to the inhabited 3 areas, the size of the cloud would need to be not 4 a dissimilar size, and therefore the concentration is 5 likely to be similar. I've assumed that the depth of 6 the cloud, I should say, is similar, that there's not 7 been very much in the way of vertical spreading.</p> <p>8 Q. I suggest there's another problem which is inherent in 9 this, which is that the exercise which you carried out 10 is to record the reverse calculation to work out what 11 the radioactivity was at H plus 1.</p> <p>12 A. Yes.</p> <p>13 Q. But as we know, over 55 per cent of the effective 14 radioactive activity takes place in the first hour, 15 doesn't it, because of the half lives of many of the 16 chemicals involved?</p> <p>17 A. You mean between if you like H plus 0 and H plus 1?</p> <p>18 Q. Yes.</p> <p>19 A. Yes, certainly, and it's a very rapid rate of decay at 20 that point. It will be slight lower by the time you get 21 to H plus 1 but it's still decaying extremely rapidly. 22 But you've also got to fold into that the 23 assumption, or the indication both from what 24 Dr Nicholson says and from the information on the 25 rainfall given in Mr Stretch's report that the rain was</p> <p style="text-align: center;">Page 138</p>	<p>1 the reading we were impressed with, that the rain starts 2 within half an hour of this explosion?</p> <p>3 A. I think that's what I assumed, that it started within 4 half an hour but it then continued for an hour, so 5 therefore at the start the rainfall would have been at 6 a certain activity but by the end of the rainfall it 7 would have decayed and therefore as a simple assumption 8 I've just taken the activity at H plus 1, which is the 9 starting point of most people's assessment. Most people 10 start at H plus 1 Carter and others start at H plus 1, 11 and I've simply taken that as being a reasonable 12 mid-point. As you point out, there are huge 13 uncertainties in this calculation.</p> <p>14 Q. Can we fold back into this some of the evidence you gave 15 earlier about the probes?</p> <p>16 A. Yes.</p> <p>17 Q. When were the probes at Port London, for example, when 18 was that survey carried out? How many days after the 19 explosions?</p> <p>20 A. I certainly interpreted it as saying that that was only 21 an hour or two after the detonation because it was -- it 22 was either Mr Baker or Mr Armer -- and I can't remember 23 which -- commented that when they got back to Port 24 London they were met by people with Geiger counters, as 25 he called them, who monitored -- who asked them first</p> <p style="text-align: center;">Page 140</p>

<p>1 had they been in the rain, and when they confirmed that</p> <p>2 they had, they then monitored them.</p> <p>3 So my understanding, certainly my reading of that</p> <p>4 witness statement, was that it was on return from the</p> <p>5 ship which -- yes, certainly my reading of it, I'll read</p> <p>6 it again -- certainly my reading of it was that that</p> <p>7 would have been within a short period of the detonation,</p> <p>8 perhaps two hours, I don't know.</p> <p>9 Q. Well, the trouble is you --</p> <p>10 A. But it wasn't said specifically.</p> <p>11 Q. What you are dealing with there, what you described as</p> <p>12 an important area of evidence, is trying to put a fix on</p> <p>13 this -- let's call it a survey -- when you are dealing</p> <p>14 with a recollection of human beings 50 years after the</p> <p>15 event as to when something actually happened.</p> <p>16 A. Yes.</p> <p>17 Q. It is not a very satisfactory basis for saying there was</p> <p>18 little radioactivity over Port London, is it?</p> <p>19 A. Of course all the witness statements are based on that.</p> <p>20 But certainly my recollection of the witness statement</p> <p>21 and my interpretation of the witness statement was that</p> <p>22 as they arrived back in Port London from the ship with</p> <p>23 the people, with the Island inhabitants that they were</p> <p>24 transporting back to the Island, that they were met by</p> <p>25 monitors who asked them if they'd been in the rain and</p> <p style="text-align: center;">Page 141</p>	<p>1 you haven't given evidence in your report about. I was</p> <p>2 just wondering if you can assist.</p> <p>3 You were involved in the closing years of your</p> <p>4 career with Sellafield amongst other nuclear plants?</p> <p>5 A. Yes.</p> <p>6 Q. And I'm told that in 2015 there was a paper published as</p> <p>7 to the effect of certain problems which occurred at</p> <p>8 Sellafield on the health of employees with reversed</p> <p>9 dosimetry being carried out. Were you aware of that</p> <p>10 survey?</p> <p>11 A. I'd already left Sellafield by then.</p> <p>12 Q. I understand it, because I think you'd left three or</p> <p>13 four years.</p> <p>14 A. I'd left Sellafield in 2010 and then I'd started working</p> <p>15 in developing a foundation degree in radiation</p> <p>16 protection.</p> <p>17 Are you talking about the INWORKS study?</p> <p>18 Q. No. This is a study using what we've heard called in</p> <p>19 this Tribunal mFISH cell survey.</p> <p>20 A. Ah. I'm not aware of that in that case.</p> <p>21 Q. Just in case it jogs any memory, I'm told it's in order</p> <p>22 to try to work out whether there had been exposure of</p> <p>23 certain workers to radiation. Cell samples were taken</p> <p>24 and then were examined using the mFISH technique to work</p> <p>25 back and see whether they had radiation exposure. But</p> <p style="text-align: center;">Page 143</p>
<p>1 then monitored them and told them that they would be</p> <p>2 fine, I think was the expression that they used.</p> <p>3 Q. The final point on the question of the Shackleton is</p> <p>4 that we cannot square your calculation of a peak</p> <p>5 activity of 20,000 becquerels per cubic metre with your</p> <p>6 calculation of the deposition on the ground. Would you</p> <p>7 agree that it's difficult to reconcile the two?</p> <p>8 A. I think that would depend on what deposition velocity is</p> <p>9 assumed but I've not tried to do that calculation.</p> <p>10 Q. Again, those who understand these things tell me that</p> <p>11 you can't square the two but you can't -- it's outside</p> <p>12 your expertise?</p> <p>13 A. Yes. I could find the equation quite quickly and</p> <p>14 I could seek to do that but I wouldn't feel very</p> <p>15 confident about the result.</p> <p>16 Q. I want to go very finally, subject to just checking with</p> <p>17 those beside me and in front of me, to a completely</p> <p>18 different area altogether.</p> <p>19 A. Okay.</p> <p>20 MR JUSTICE BLAKE: Is this the time for a short break?</p> <p>21 MR TER HAAR: I think this could be very quick and then if</p> <p>22 we take a break I'll check if that's the very last</p> <p>23 point. Would that be convenient?</p> <p>24 MR JUSTICE BLAKE: Let's see how we go.</p> <p>25 MR TER HAAR: This is on a completely different issue which</p> <p style="text-align: center;">Page 142</p>	<p>1 you aren't aware of that?</p> <p>2 A. No, I'm not. I'd like to read it but I'm not aware.</p> <p>3 MR TER HAAR: I am sure that would be possible. Well,</p> <p>4 my Lord, I think that's the end of my questions. I may</p> <p>5 be told there's something.</p> <p>6 MR JUSTICE BLAKE: We'll take a break and you can confirm or</p> <p>7 deny.</p> <p>8 We'll take a break until 25 to 4.</p> <p>9 A. Thank you, my Lord.</p> <p>10 (3.25 pm)</p> <p>11 (A short break)</p> <p>12 (3.35 pm)</p> <p>13 MR TER HAAR: No more questions, my Lord.</p> <p>14 MR JUSTICE BLAKE: Thank you very much.</p> <p>15 Cross-examination by DR BUSBY</p> <p>16 DR BUSBY: Mr Hallard, good afternoon. I want to start just</p> <p>17 to explore something about your function in the</p> <p>18 arguments that are going on in this Tribunal.</p> <p>19 I want to start by asking you about your work</p> <p>20 history with the nuclear industry. It's true that from</p> <p>21 the time you left university until quite recently you</p> <p>22 worked for the nuclear industry and for a long time at</p> <p>23 British Nuclear Fuels, Sellafield.</p> <p>24 A. I did.</p> <p>25 Q. Now, what I want to ask you is a question about the</p> <p style="text-align: center;">Page 144</p>

<p>1 scientific culture, ways of seeing the picture, if you 2 like. I mean, for example, you must have been at 3 Sellafield for much of the time that this discussion was 4 going on about the childhood leukaemia cluster at 5 Seascale? 6 A. Yes. 7 Q. And it's correct, is it not, that for a long time -- 8 perhaps even as far as I know up until the present 9 day -- the argument has been that the statistically 10 significant excess of childhood leukaemia at Seascale 11 could not have been caused by the radiation because the 12 doses were too low, is that fair? 13 A. I think that's a fair summary. As I understand it, 14 I think from the most recent COMARE report that I've 15 read I think the size of the cluster is actually 16 starting to shrink now, if that's the correct term, that 17 the excess is getting smaller if my memory serves me 18 correctly. But you're quite right, there has been -- 19 Q. But there is still an excess -- 20 A. There is still an excess risk there. 21 Q. -- risk of childhood leukaemia. Of course childhood 22 leukaemia is a well known consequence of exposure to 23 ionising radiation, is it not? 24 A. Ionising radiation, yes, is a possible cause. I don't 25 think it's the only one.</p> <p style="text-align: center;">Page 145</p>	<p>1 MR JUSTICE BLAKE: That maybe the hypothesis of childhood 2 leukaemia in Sellafield should make us question the 3 dose. 4 A. I understand, my Lord. 5 MR JUSTICE BLAKE: I tried to summarise but I think that's 6 the question. 7 A. Yes. 8 MR JUSTICE BLAKE: Yes. 9 A. Childhood leukaemia in Seascale has been a cause of 10 concern for many years, not least among the Sellafield 11 workforce, because of course some of the children were 12 children of the Sellafield workforce and in fact I knew 13 one of them. So it has been a cause of significant 14 worrying concern, as indeed have some of the other 15 episodes. When Dr Gardner came on to the site to 16 explain his hypothesis that caused a great deal of 17 concern. I heard him give his presentation. That was 18 another theory about the possible cause of the leukaemia 19 excess in Sellafield. That caused a great deal of 20 worry. It changed quite a lot of practices on the site 21 as well. 22 But I think the most important -- and can I just 23 stress first of all that I'm not an epidemiologist. 24 I hope that's understood. 25 DR BUSBY: Of course. I just wondered -- I just wanted to</p> <p style="text-align: center;">Page 147</p>
<p>1 Q. No, of course not. 2 But I think basically what I'm asking you is 3 this: that does it not seem curious to you that here you 4 have evidence of an effect, which is an effect that can 5 be caused by radiation, it's a well known consequence of 6 exposure to radiation, and causation has been denied 7 because you start with the dose rather than looking at 8 the effect and working backwards to the dose. 9 Is that a fair -- 10 A. Okay, there's quite a lot I could say about that. 11 Q. Well, of course, please do. 12 A. I think -- sorry, I'm just getting my thoughts together 13 when I said that. 14 Q. It's just that I think that this is an important area 15 because what's happening here also in this Tribunal is 16 very largely the same thing. On the one hand people are 17 saying the doses are too low to cause the effect. On 18 the other hand a lot of people are saying "Hey, look 19 here's a lot of effects and surely we should be working 20 from the effects back to the doses," or at least there 21 are some people who are saying that. It's a reasonable 22 logical inference, if you like. 23 A. Okay. 24 MR JUSTICE BLAKE: You got the gist of that question? 25 A. I have.</p> <p style="text-align: center;">Page 146</p>	<p>1 explore this idea -- 2 MR JUSTICE BLAKE: I think he has a further answer to give. 3 A. Yes, please, yes. 4 I think the most important thing in terms of trying 5 to establish what's going on is to look at the effect 6 and to look at all the possible explanations that you 7 can come up with in order to try and explain it. 8 And that's a personal opinion but perhaps reflecting 9 the scientific method, if I can put it like that, 10 I think it's important not to assume any cause, but to 11 approach the observation with an open mind. 12 That's very important. Because I've seen two 13 possible explanations. I'm obviously aware of the 14 explanation which you've put forward and others, which 15 is to say, if I may try and paraphrase and you'll tell 16 me if I've understood this correctly: here is 17 an observation, the only logical explanation for that, 18 because it occurs round -- it's been observed to occur 19 around a number of nuclear sites, the only logical 20 explanation for that is that radiation must be the cause 21 and therefore given that, that the risks of radiation 22 must be several hundred times greater than assumed by 23 ICRP. 24 But there's another way of looking at it. Are there 25 other possible explanations? There is at least one</p> <p style="text-align: center;">Page 148</p>

<p>1 other that I'm aware of. It's outside my area of 2 expertise and I would make no comment on it, but I know 3 that COMARE have looked at it, COMARE being the 4 committee on the medical aspects of radiation in the 5 environment. You may be familiar with it. Sorry, we 6 use acronyms sometimes.</p> <p>7 MR JUSTICE BLAKE: We've come across that one.</p> <p>8 A. But --</p> <p>9 MR JUSTICE BLAKE: He is just going to finish his answer.</p> <p>10 A. But there is at least one other explanation and COMARE 11 have said that they believe that it's at least partially 12 responsible, and that's an hypothesis based on 13 population mixing which I think you're probably also 14 familiar with. This was first put forward by 15 Professor Kinlen from Oxford University, because he has 16 looked at the issue of clusters more broadly. He hasn't 17 limited his looking for clusters purely to nuclear 18 sites. He has looked at other kinds of sites which are 19 not nuclear. I think some people have also looked at 20 sites which were originally going to be nuclear power 21 stations but for whatever reason have not.</p> <p>22 Leukaemia excesses have been found in some of those 23 sites as well. So villages close to some non-nuclear 24 sites, villages close to facilities that were going to 25 be reactors but a reactor has not been built have also</p> <p style="text-align: center;">Page 149</p>	<p>1 MR JUSTICE BLAKE: But does the fact of the observations and 2 the present state of knowledge cause you to doubt the 3 dosimetry levels that you're applying?</p> <p>4 A. Ah, right. Perhaps I did misunderstand the question.</p> <p>5 MR JUSTICE BLAKE: At the back of the mind is the idea that 6 maybe the present estimates of what is a dose which is 7 not likely to cause a cluster maybe themselves need to 8 be re-examined. I think that's --</p> <p>9 DR BUSBY: Yes, my Lord, that is very helpful, very precise. 10 Yes.</p> <p>11 A. Thank you, my Lord. I'm not sure I have the expertise 12 to be able to comment on that properly.</p> <p>13 If you simply ask the question, I think it's 14 a legitimate question to be asked --</p> <p>15 MR JUSTICE BLAKE: You are applying dosimetry levels; you 16 are being brought into this case to help us with this 17 rather difficult task of retrospective dosimetric 18 analysis. When you have a figure or a range of figures 19 others are then saying that's not going to raise any 20 issues about causation, or people say well, it might do 21 in certain hypotheses, which we then have to go off and 22 explore. But if the whole dosimetry might itself be the 23 thing that's called into question by these clusters or 24 other hypothesis, then is this a line of legitimate --</p> <p>25 A. Okay. I think the only way I can answer that -- I don't</p> <p style="text-align: center;">Page 151</p>
<p>1 shown those clusters, as I understand it. Therefore --</p> <p>2 MR JUSTICE BLAKE: Right. You wouldn't go back to a nuclear 3 power station as being the preferable course (?). 4 I appreciate that you've given an answer with the caveat 5 that epidemiology is not your expertise.</p> <p>6 A. No, so I'm simply commenting.</p> <p>7 MR JUSTICE BLAKE: You can ask a question now.</p> <p>8 DR BUSBY: Yes. Well, I did ask the question, my Lord, but 9 that wasn't really the point.</p> <p>10 MR JUSTICE BLAKE: If you want to expand that, please go 11 ahead.</p> <p>12 DR BUSBY: Yes. Well, really it was the more general point 13 about whether you went from the dose to the effect or 14 from the effect to the dose that I was talking about.</p> <p>15 MR JUSTICE BLAKE: Let me try and put that question again, 16 which is to understand the area you are knocking around 17 on, perhaps just to sort of see that. Let me have a go 18 and see whether this reflects where you want to go.</p> <p>19 DR BUSBY: Yes.</p> <p>20 MR JUSTICE BLAKE: I am getting a sense of the line of 21 inquiry here. We all know that there are many 22 hypotheses and the epidemiology which might exclude some 23 or make others more probable is not your line of 24 business.</p> <p>25 A. No, it isn't, my Lord.</p> <p style="text-align: center;">Page 150</p>	<p>1 think I have the necessary dosimetry expertise to be 2 able to make a technical answer to that.</p> <p>3 MR JUSTICE BLAKE: Mm-hm.</p> <p>4 A. So I think the answer I would make is based on reports 5 that I've read, written by people who do have that 6 appropriate level of expertise, and of those the report 7 I think that I would go back to was the COMARE response 8 to the CERRIE committee. The CERRIE was the committee 9 that Dr Busby obviously was involved in.</p> <p>10 MR JUSTICE BLAKE: We've come across that one as well.</p> <p>11 A. Right. So COMARE commented that they accepted that 12 there could be uncertainties up to a factor of 10 with 13 internal dosimetry. Although they also comment 14 elsewhere in that report that they would say that the 15 true value is likely to be close to the central 16 estimate, and I can expand on that term if need be. 17 They are talking particularly about the internal dose 18 risks there, the so-called internal dose co-efficients.</p> <p>19 But COMARE's conclusion was that they did not 20 believe there was evidence to support the belief of some 21 that the dangers from radiation were between 100 and 500 22 times greater than the ICRP risk estimates.</p> <p>23 I don't believe that I can really say any more than 24 that, my Lord. I don't believe that I have the 25 necessary expertise to be able to add more than that.</p> <p style="text-align: center;">Page 152</p>

<p>1 MR JUSTICE BLAKE: Okay.</p> <p>2 A. Does that help to answer your question?</p> <p>3 MR JUSTICE BLAKE: I think that's an answer to the question.</p> <p>4 DR BUSBY: Well, actually it wasn't really quite entirely</p> <p>5 what I was -- although very helpful.</p> <p>6 A. Right.</p> <p>7 Q. But I suppose if I can put it a different way. Do you</p> <p>8 agree that it is possible that there are ways of</p> <p>9 understanding a problem or a question which might become</p> <p>10 quite innocently coloured by the culture of the</p> <p>11 environment or group or surroundings in which the person</p> <p>12 is embedded? For example, you have worked for the</p> <p>13 nuclear industry all your life. They have a particular</p> <p>14 view, a way of seeing things. They employ the ICRP</p> <p>15 model, all of this stuff. So is it possible that you</p> <p>16 have a specific, particular way of seeing things which</p> <p>17 may be wrong?</p> <p>18 A. You mean am I biased, effectively?</p> <p>19 Q. I guess I do. Yes. I'm certainly not suggesting that</p> <p>20 you are biased. I'm talking about a kind of cultural</p> <p>21 bias, a prism through which you see the world, one that</p> <p>22 is perfectly valid but I am saying that is one way of</p> <p>23 interpreting a set of data and there may be other ones</p> <p>24 that are equally valid and possibly more correct.</p> <p>25 A. I accept that culture is enormously important. In terms</p> <p style="text-align: center;">Page 153</p>	<p>1 Q. But this is an epidemiological paper, and it makes</p> <p>2 a point on the first page, I think, or is it maybe the</p> <p>3 second page? This paper is an epidemiological paper</p> <p>4 which tries to look at the increases in -- I don't seem</p> <p>5 to have all the pages. It's on the back, sorry.</p> <p>6 I always print on one side so it always confuses me when</p> <p>7 people put it on two sides.</p> <p>8 If we could go to page 2 of 13, that's on the</p> <p>9 reverse side of the first page. If you go down the</p> <p>10 first column on the left-hand side you'll see that we</p> <p>11 have four error types, type 1, type 2, type 3 and type</p> <p>12 4. And I would just like to take you to type 3, which</p> <p>13 is written here. This is a peer review paper, and I was</p> <p>14 involved in writing it, but the point is that the</p> <p>15 referees, who were quite strict, they wanted to know how</p> <p>16 it was possible that the ICRP risk model could be wrong</p> <p>17 assuming it was, of course, and there's a lot of</p> <p>18 evidence here that there is --</p> <p>19 MR JUSTICE BLAKE: It is type 3 you want to put to this</p> <p>20 witness, is it?</p> <p>21 DR BUSBY: Type 3 here. It says "The philosophical method</p> <p>22 problem" so it says:</p> <p>23 "If data is interpreted through a particular</p> <p>24 scientific model, evidence which cannot fit the model</p> <p>25 will be ignored, dismissed or invisible."</p> <p style="text-align: center;">Page 155</p>
<p>1 of the use of ICRP, I've used ICRP because it is taken</p> <p>2 as the international benchmark, it's taken as the</p> <p>3 international standard.</p> <p>4 We've talked briefly about the International Atomic</p> <p>5 Energy Agency basic safety standards yesterday. The</p> <p>6 ICRP internal dose co-efficients which I've used, for</p> <p>7 example, are quoted in the current -- in the new IAEA</p> <p>8 basic safety standards. The ICRP references which give</p> <p>9 the dose co-efficients are quoted in the European Union</p> <p>10 Directive basic safety standards.</p> <p>11 So I've used the ICRP data because it is the</p> <p>12 internationally accepted standard. If that reflects</p> <p>13 a culture then perhaps -- I'm not aware of any sense of</p> <p>14 bias, if I can put it like that, but perhaps I wouldn't</p> <p>15 be. Perhaps I would be the last person to be aware of</p> <p>16 that. If there was a cultural issue of bias, perhaps</p> <p>17 others would be in a better position to establish that</p> <p>18 than I am. But I'm not aware of any bias. It's been</p> <p>19 taken on what I believe to be a logical basis.</p> <p>20 Q. I think that's a very good, honest reply.</p> <p>21 Could I take you to SB6/89 just briefly.</p> <p>22 A. 89?</p> <p>23 Q. Yes. I'm not going to ask you about anything</p> <p>24 epidemiological.</p> <p>25 A. Good.</p> <p style="text-align: center;">Page 154</p>	<p>1 Is that a fair summary of what it is we've just been</p> <p>2 discussing, do you think?</p> <p>3 A. You mean is that a possibility?</p> <p>4 Q. Yes, yes, just the possibilities. Just that.</p> <p>5 A. It's possible. I've not seen any evidence to support it</p> <p>6 in this case.</p> <p>7 Q. Do you mean in the test vets case?</p> <p>8 A. This particular case. No, sorry, in the case we were</p> <p>9 discussing about the use of ICRP and the ICRP risk</p> <p>10 factors.</p> <p>11 Q. Right.</p> <p>12 A. The ICRP documents that I've looked at -- and I've</p> <p>13 looked at some, there are many that I haven't looked at,</p> <p>14 I've looked at some -- seem to me to be quite thorough</p> <p>15 in comparing different papers. So they seem to be quite</p> <p>16 thorough in comparing evidence which would lead to</p> <p>17 different conclusions. So on the one hand it could be</p> <p>18 this, on the other hand it could be this, and then they</p> <p>19 come to a conclusion which is explained briefly I think</p> <p>20 in the main but it's explained.</p> <p>21 So I haven't observed anything that indicates</p> <p>22 a selection process going on. I think the type 3 that</p> <p>23 you are referring to here does imply some kind of</p> <p>24 selection process -- the model would be ignored,</p> <p>25 dismissed or invisible. So I think all I can say with</p> <p style="text-align: center;">Page 156</p>

<p>1 that is I haven't been aware of any selection bias, if 2 you like, going on in the conclusions that they draw, if 3 that answers your question. 4 Q. Is it not true to say that the Sellafield leukaemia 5 cluster is exactly such an example and all these 6 leukaemia clusters on nuclear sites have been dismissed 7 because the dose was too low? Doesn't that come under 8 the "dismissed", would be ignored, dismissed -- 9 MR JUSTICE BLAKE: I think the witness has said he has 10 pointed to COMARE's evaluation. He's not making that 11 evaluation. So there might be a limit to how much we're 12 going to get on this exchange. 13 DR BUSBY: Yes, my Lord. I'll leave that at that point. 14 I think that we've learned all that is necessary on that 15 issue. 16 So I would now like to move to something which -- 17 I recognise this wasn't your area of expertise but 18 I just wanted to ask you about which way you could go, 19 whether you could go both ways, dose to effect and 20 effect to dose, and you've been very helpful on that. 21 Now, you have explained to Mr ter Haar what health 22 physics is so we don't have to talk about that. But 23 I raised the issue of a broad dose with 24 Professor Thomas -- I'm not sure if you were here at the 25 time -- and she said that absorbed dose was the amount</p> <p style="text-align: center;">Page 157</p>	<p>1 A. I will certainly seek to -- 2 Q. First of all, you say it's generally averaged over 3 a fairly substantial amount of tissue -- kilogram, 4 joules per kilogram, the size of the organ. Very often 5 these organs are -- for example, the lymphatic system, 6 what would be the size of that in terms of kilograms? 7 A. Oh, I would guess -- I don't really know, to be 8 honest -- I would guess hundreds of grams, perhaps up to 9 a kilogram, but I don't really know. 10 Q. Would you be able to say it's untrue if I said it was 11 about 2 or 3 kilograms represented quite a lot of 12 tissue, the lymphatic system -- 13 A. I will take your word. 14 Q. Anyway, we'll say quite a lot of kilograms. 15 Of course, as I said to Professor Thomas and now I'm 16 asking you, what happens when you consider doses to very 17 small amounts of tissue from particles? 18 A. Okay. Again, I've said before, I think, that I'm not 19 an expert on internal dosimetry but I have read quite 20 a bit about this. If you have a very small particle -- 21 sorry, was that what you said? 22 Q. Yes, say a particle small enough to get inside a cell, 23 the sort of particle that Professor Sawada was talking 24 about, and Professor Howard also, sub-micron particles, 25 100 nanometres, that sort of thing?</p> <p style="text-align: center;">Page 159</p>
<p>1 of radioactivity that you got. In a sense that's 2 correct, of course, and she compared it with the amount 3 of paracetamol, for example, or any other drug that you 4 get. But it has a slightly more technical -- 5 A. It does. 6 Q. -- aspect which I would like to go through with you, if 7 I may. 8 A. Certainly. 9 Q. Because you are an expert in this. In fact, you are the 10 expert in this area. 11 A. I wouldn't go to that final point. 12 Q. Certainly for this Tribunal you are the expert in this 13 area. Could you just tell us what absorbed dose is and 14 how it is calculated? 15 A. The absorbed dose is the energy deposited in the tissue, 16 and it's measured in a unit of energy called a joule, 17 and the unit of the absorbed dose is joules per kilogram 18 of tissue. And specifically it's averaged over the 19 tissue or over the organ which is I suspect the point 20 you are coming to. 21 Q. I think we want to go through this in rather the same 22 way as I went through it with Professor Thomas but with 23 an expert so we can be sure we're talking about the same 24 thing and the Tribunal understands where we're going 25 with this.</p> <p style="text-align: center;">Page 158</p>	<p>1 A. You would get a high localised exposure. If the 2 particle was big enough, and I think by implication the 3 particles you're talking about probably are if they were 4 active enough, the likelihood is, I think the most 5 likely outcome is that that cell would die, it would 6 receive so much radiation that it would actually die. 7 If the particle was less active then potentially you 8 could get radiation damage or some kind of mutation to 9 that particle. 10 The view of ICRP and another paper particularly 11 which I've read and the CERRIE report as well, if my 12 memory serves me correctly -- 13 Q. We'll go to that. 14 A. Okay, but the view of those papers, ICRP and a paper by 15 Charles and Harrison by implication was that the 16 assumption that the absorbed dose can be averaged over 17 the tissue is likely to be a conservative assumption, 18 but it's likely to be that the actual damage, if you 19 like, to the organ is actually likely to be less 20 averaged over the organ from a hot particle, single 21 active particle, and if that activity was uniformly 22 deposited through the tissue. Again stressing the fact 23 that I'm not an expert on internal dosimetry, my 24 interpretation of that is that some cells getting the 25 highest doses would be killed and therefore the risk of</p> <p style="text-align: center;">Page 160</p>

<p>1 mutation from those cells clearly is zero, and that that 2 is the reason that it's a conservative assessment. But 3 that latter statement is my interpretation of papers 4 that I've read.</p> <p>5 Q. That's not really my question. My question was what was 6 the dose to local tissue from a particle, not what was 7 the effect. You are telling us that maybe the tissue is 8 killed or the cells are killed if it's very high, or if 9 it's very low it might be mutated. But that was not 10 really the question. The question is: what is a dose in 11 if you like sieverts or millisieverts or whatever?</p> <p>12 A. The dose could be very high. I've seen the calculation 13 in the CERRIE minority report which I suspect is what 14 you are referring to. There's a calculation on a table 15 there, I think, of the doses to cells, I think based on 16 a range for alpha particles of about 30 micron from 17 plutonium and uranium and the calculation there was 18 sieverts of dose from a particle I think it was 1 micron 19 -- sorry, my memory is playing tricks with me there.</p> <p>20 Certainly I could reproduce the maths. I could do 21 the calculation which gave me the same numbers that were 22 there for plutonium. The uranium I tried to do it and 23 it seemed to me that a factor of 1,000 had been 24 introduced into that calculation and if you effectively 25 multiply the effect by 1,000 then you would get the</p> <p style="text-align: center;">Page 161</p>	<p>1 is absorbed dose. That can then be converted into 2 a type of dose called equivalent dose.</p> <p>3 MR JUSTICE BLAKE: Yes?</p> <p>4 A. And the conversion from absorbed dose to equivalent dose 5 you get by multiplying the absorbed dose by what is 6 called a radiation weighting factor. The radiation 7 weighting factor for gamma and beta radiation is 1, and 8 the radiation weighting factor for alpha is 20. That 9 reflects the much higher local ionising that you get 10 from alpha radiation. It's more damaging.</p> <p>11 MR JUSTICE BLAKE: Right. So that's how you move from 12 absorbed dose to equivalent dose?</p> <p>13 A. That's correct. The unit for equivalent dose is 14 a sievert.</p> <p>15 MR JUSTICE BLAKE: Yes.</p> <p>16 A. Which is also joules per kilogram, because there's no 17 dimensions in the radiation weighting factor.</p> <p>18 Then the final type of dose, which is one that's 19 usually used for risk estimates, is to go from 20 equivalent dose to effective dose. The effective dose 21 can be calculated by multiplying the equivalent dose by 22 another weighting factor called the tissue weighting 23 factor, which reflects the sensitivity of different 24 organs and tissues within the body.</p> <p>25 So the lung will have 1 tissue weight in factor, the</p> <p style="text-align: center;">Page 163</p>
<p>1 doses that were on that part of the table.</p> <p>2 Q. Well, we're not going to the table. I'm just basically 3 asking you to tell us what the doses would be, you know, 4 a small particle like that and you agree that they are 5 very large?</p> <p>6 A. I'm agreeing that I can understand the maths. In terms 7 of being able to understand whether that or how that 8 would translate into a dosimetric effect, I don't think 9 I have that expertise.</p> <p>10 MR JUSTICE BLAKE: The last time I got an answer I recorded 11 it was about the meaning of absorbed dose which is 12 joules per kilogram.</p> <p>13 A. That's correct, my Lord.</p> <p>14 MR JUSTICE BLAKE: The conversation has now moved on to can 15 you give estimates in sieverts, I think, of small 16 uranium particles; but I just don't know whether you are 17 able to do that or whether you are exploring other 18 people's calculations or quite what your answer is.</p> <p>19 A. Right, okay, so perhaps taking a step back, my Lord. 20 First of all, maybe to explain where you get from 21 absorbed dose into some of the other doses, if that 22 would help.</p> <p>23 MR JUSTICE BLAKE: Yes. Well, tell us how --</p> <p>24 A. The unit of absorbed dose is a unit called a gray, which 25 is 1 joule per kilogram, and that can be measured. That</p> <p style="text-align: center;">Page 162</p>	<p>1 kidney will have another one, the liver will have 2 another one.</p> <p>3 So you're now using two weighting factors, the 4 radiation weighting factor and the tissue weighting 5 factor. Those two together give you a quantity called 6 effective dose, which is the dose that I've calculated 7 in most situations in most of my report. Units for 8 effective dose are also sievert. Slightly confusingly. 9 So the unit for equivalent dose and effective dose is 10 the same. That is also measured in joules per kilogram, 11 because again the tissue weighting factor has no 12 dimensions.</p> <p>13 So when we talk about calculating the absorbed dose, 14 in fact thinking -- sorry, yes -- the absorbed dose that 15 we're talking about is actually an equivalent dose. The 16 dose measured in the cell would be an equivalent dose in 17 those circumstances because it multiplied the absorbed 18 dose by the radiation weighting factor for alpha of 20.</p> <p>19 So if you know the activity of a particle in tissue, 20 then mathematically if you know -- if we take an alpha 21 emitting nuclide, plutonium, typically, and you know how 22 far the alpha radiation will travel in tissue -- which 23 Dr Busby's calculation assumed 30-micron, I might have 24 gone for a slightly larger figure but I'm not going to 25 argue about that, it's only a small factor between</p> <p style="text-align: center;">Page 164</p>

<p>1 them -- if you assume that all of the radiation from the 2 alpha particle -- from the plutonium, I beg your 3 pardon -- is absorbed -- from the alphas emitted from 4 the plutonium is absorbed in a sphere in tissue of 5 radius 30 micron, so you calculate the energy deposited, 6 you divide it by the mass of the tissue, which clearly 7 is very small, you then get the absorbed dose. And if 8 you multiply that by a factor of 20 you would then get 9 the equivalent dose to that volume of tissue. 10 That is the calculation I think that you're 11 referring to, Dr Busby. 12 DR BUSBY: That would be an extremely high dose? 13 A. It would be an extremely high dose. As I say, bearing 14 in mind what I've said about dosimetry, many of the 15 cells exposed within that -- or there would be a number 16 of cells exposed by that -- a number of those would die 17 because of the size of the radiation. So the ones 18 closest to that particle plutonium would die because of 19 the dose; the ones a little further away, some of those 20 might survive, and potentially be a source of mutation. 21 But my understanding of the ICRP conclusion, or the 22 ICRP statement, that they believe that the consequence 23 of a hot particle, of the radiation, the localised 24 radiation from a hot particle, actually being less than 25 the consequence of all of that activity being deposited</p> <p style="text-align: center;">Page 165</p>	<p>1 low to cause pancreatic cancer. 2 But, on the other hand, if we were to look at the 3 doze to the tissue surrounding the uranium particle, it 4 would be of the order of a sievert, or possibly greater, 5 depending on how long the particle stayed there. 6 So would that be a fair outline of a possible -- you 7 know, the difference between the ICRP way of doing this 8 and a more realistic approach, perhaps? 9 A. Okay. Again you are probing to the limits of my 10 expertise by probing -- by asking specific questions -- 11 Q. Well, we can place the particle anywhere, it doesn't 12 matter. 13 A. Right. I think I would make a comment, first of all, on 14 your statement about the dose being vanishingly small 15 and therefore the risk of cancer being low. Of course, 16 on a linear, no threshold model, that is a graph, 17 a straight line, a straight line of risk against dose 18 which would go through what's called the origin, the 00 19 point on the graph, it would start there and just go up 20 in a straight line. But, based on that model, no dose 21 of radiation would give -- the only dose that would give 22 zero risk is zero dose. Any dose from radiation gives 23 a finite dose, and clearly the higher the dose the 24 higher the risk to that cancer. 25 So the ICRP approach, effectively, is to say assume</p> <p style="text-align: center;">Page 167</p>
<p>1 throughout the tissue. My interpretation of that is 2 that it's because some of the cells would die just 3 because the radiation so is high. Whereas if it was 4 uniformly deposited you would actually get fewer cells 5 dying and therefore potentially more mutation. 6 MR JUSTICE BLAKE: More cells available for genetic 7 mutation. 8 A. Indeed. 9 MR JUSTICE BLAKE: That was quite a lengthy answer, but 10 I think I have the logic of it. Pause there. 11 DR BUSBY: Just to be absolutely certain about this, because 12 I mean that was a very full answer which went into all 13 the different types of dose there are, but really my 14 question was aimed at making certain that we agreed that 15 if, for example, there was a small particle of uranium 16 that had been inhaled and went through the lung -- 17 because it was less than the size that goes through the 18 lung, which is about 1 micron, so let's say half 19 a micron of plutonium was inhaled by somebody -- it went 20 through the lung and then ended up in the bloodstream 21 and then it was taken into the liver and ended up in the 22 pancreatic joint bile duct and stuck there. The ICRP 23 would divide the energy from that into the whole of the 24 pancreas and the dose would be vanishingly small, it 25 would be considered, on the ICRP model, to be far too</p> <p style="text-align: center;">Page 166</p>	<p>1 that all of the activity is deposited throughout the 2 organ, that will give a certain dose and therefore you 3 can estimate the risk from that. 4 You are looking at the very local dose and saying, 5 well -- I think if the inference of your question is -- 6 well, the risk must be higher, because you've got such 7 a high dose in so few cells. As I said before, a number 8 of those cells, particularly from alpha, will be killed 9 by the radiation. The number of cells remaining which 10 will be exposed -- and this is my extrapolation based on 11 a logical deduction, if you like, but not expertise -- 12 but my deduction from that is saying that the number of 13 cells which are exposed and which survive, and therefore 14 potentially could give rise to a mutation, would 15 actually be less from that hot particle than if it was 16 evenly distributed. 17 It is it's also worth pointing out, I think, that 18 you talked about particle sizes of the order of 0.5 to 1 19 micron, but the principal particle sizes which ICRP 20 quote for the dose co-efficients are 1 micron, that's 21 1 micrometre -- I'm sorry, so a micron and a micrometre 22 are the same thing -- that the principal particle sizes 23 which ICRP quote their internal dose -- their inhalation 24 dose coefficient for is 1-micron and 5-micron. So their 25 models are specifically intended to look at particles of</p> <p style="text-align: center;">Page 168</p>

<p>1 the order of size of 1-micron.</p> <p>2 DR BUSBY: So, in response to that, given that most of the</p> <p>3 particles produced in a nuclear explosion are less than</p> <p>4 .1 of a micron, you could argue that the ICRP risk model</p> <p>5 really was not applicable anyway on that level. Is that</p> <p>6 right?</p> <p>7 A. I wouldn't interpret it that way, but again you're going</p> <p>8 beyond my specific expertise. But, if my recollection</p> <p>9 is right, the inhalation dose co-efficients in general</p> <p>10 for 1 micron are actually lower than they are for 5</p> <p>11 micron. The exception, of course, is plutonium.</p> <p>12 I think that might also be true of uranium, if I can</p> <p>13 stretch my memory, but certainly for plutonium the risk</p> <p>14 co-efficients are actually the inhalation dose</p> <p>15 coefficient for 1 micron is higher than for 5 micron,</p> <p>16 but not by a huge margin.</p> <p>17 Q. If we go back to the particle, the hypothetical</p> <p>18 particle, you pointed out that there is a view that, if</p> <p>19 the particle is a hot particle, that the energy that's</p> <p>20 sent out into the local tissue would be sufficient to</p> <p>21 kill a lot of cells and therefore it would be less</p> <p>22 efficient. But of course that must depend upon the</p> <p>23 hotness of the particle, if I can develop such an idea.</p> <p>24 I mean, for example, a uranium particle would not be</p> <p>25 a hot particle because of its very low activity. Would</p> <p style="text-align: center;">Page 169</p>	<p>1 committee -- that even they were not sure about the</p> <p>2 consequence of what they referred as to a warm particle.</p> <p>3 Q. It's a bit of an unknown area altogether, isn't it?</p> <p>4 A. Slightly, yes.</p> <p>5 Q. So that is to say there's a lot of uncertainty around</p> <p>6 it.</p> <p>7 Perhaps we could just have a look at the CERRIE</p> <p>8 report briefly on this subject. So that's SB6/60.</p> <p>9 A. 60, did you say?</p> <p>10 Q. SB6/60. If we could first of all turn to page 10. Do</p> <p>11 we all have that?</p> <p>12 A. I have 10. This is "uncertainties in internal radiation</p> <p>13 risks".</p> <p>14 Q. Yes. Page 2. That's right, yes, the box. It says</p> <p>15 there, "It was noted" -- I think you've already said</p> <p>16 this, but effectively, just to make sure that we agree</p> <p>17 that they have said that it could be a factor of 10 for</p> <p>18 internal -- well over a factor of 10 for other</p> <p>19 radionuclides. This is uncertainties that the CERRIE</p> <p>20 Committee agreed, and this is the main committee, not</p> <p>21 just the dissenters. So in this box, just the second</p> <p>22 line from the bottom -- well, this is paragraph 19 -- if</p> <p>23 we go to the bottom of paragraph 19:</p> <p>24 "Well over a factor of 10 for other radionuclides."</p> <p>25 MR JUSTICE BLAKE: Do you see the sentence? Have you read</p> <p style="text-align: center;">Page 171</p>
<p>1 that be true?</p> <p>2 A. It depends on the activity, of course. The specific</p> <p>3 activity of uranium is much lower than plutonium.</p> <p>4 Q. Very much slower, yes.</p> <p>5 A. Very much lower by several -- many orders of magnitude.</p> <p>6 Q. So if you had a very small uranium particle -- let's now</p> <p>7 say 100 nanometres or 50 nanometres, the sort of thing</p> <p>8 that you get in these nuclear explosions, which</p> <p>9 effectively work as a gas -- the killing, the power of</p> <p>10 that, if you like, the sort of hotness of it in the</p> <p>11 tissue would be much much less than plutonium. In fact,</p> <p>12 you could argue that therefore it could be more</p> <p>13 dangerous as it was mutating the tissue rather than</p> <p>14 killing it.</p> <p>15 Is that a reasonable deduction from what you said?</p> <p>16 A. Possibly. I mean I remember that debate in the CERRIE</p> <p>17 report, because I think the CERRIE report did actually</p> <p>18 discuss that. It was what they referred to as a "warm</p> <p>19 particle".</p> <p>20 Q. Yes.</p> <p>21 A. If my recollection serves me.</p> <p>22 Q. Okay. Well --</p> <p>23 A. I think, actually, that CERRIE really indicated that --</p> <p>24 and this is going beyond my expertise -- that CERRIE</p> <p>25 indicated that even they -- given the expertise on that</p> <p style="text-align: center;">Page 170</p>	<p>1 this?</p> <p>2 A. I have.</p> <p>3 MR JUSTICE BLAKE: Right.</p> <p>4 A. I have seen this.</p> <p>5 MR JUSTICE BLAKE: Can you comment upon this?</p> <p>6 A. Well, again, the detail of it is beyond my expertise.</p> <p>7 In fact, the CERRIE Committee was a source of useful</p> <p>8 information for me. I thought it was a well-written</p> <p>9 report.</p> <p>10 What it actually says is that the uncertainties vary</p> <p>11 from factors of 2 to 3 above and below the central</p> <p>12 estimates for radionuclides where good data is</p> <p>13 available. From another report that I've seen written</p> <p>14 by Harrison, John Harrison, amongst others, he included</p> <p>15 a table which included a number of nuclides where he had</p> <p>16 estimated the uncertainties as being about between 2 and</p> <p>17 3. He'd included a number of common nuclides in that,</p> <p>18 if I can use that term, which included plutonium,</p> <p>19 uranium and a number of other quite common nuclides.</p> <p>20 So that where good data was available the</p> <p>21 uncertainty was a factor of 2 to 3; where good data was</p> <p>22 not available then it was a factor of 10 or more.</p> <p>23 I can't comment on that, to be honest, but I'm just</p> <p>24 amplifying --</p> <p>25 DR BUSBY: I just wanted to register that there was this</p> <p style="text-align: center;">Page 172</p>

<p>1 uncertainty. John Harrison is of course the Director of 2 the National Radiological Protection Board? 3 A. I think he's retired now. 4 Q. He was at the time that he wrote what you were talking 5 about. 6 A. Yes, he was. 7 Q. So perhaps he might be put in the same box as you in 8 terms of where you are all coming from with regard to 9 culture. 10 A. Right. 11 Q. He was also on the ICRP, I think, so he's not likely to 12 dis it? 13 A. He is still on one of the ICRP committees because he is 14 actually involved in calculating the replacement dose 15 co-efficients for the new modelling. 16 Q. Well, I'm not trying to say that anybody is, you know -- 17 I am not trying to attack anybody here, I am just trying 18 to investigate this area of scientific culture and 19 interpretation, that's all. 20 A. I haven't said I am biased. 21 Q. No. Nor have I, nor have I said that you are biased. 22 A. I am just saying that I am perhaps not the best person 23 to make that judgment. 24 Q. Well, can we just, while we're here, have a look at 25 paragraph 11, which is on page 13. At the bottom --</p> <p style="text-align: center;">Page 173</p>	<p>1 Q. Right. 2 A. And what I believe that ICRP have said in ICRP/103 3 particularly in terms of hot particles. But you are 4 asking for my comments on it, and beyond what I've 5 already said, which is really commenting on what true 6 experts have already said rather than myself, who is 7 definitely not an expert, I really don't think it would 8 be safe for me to go. 9 Q. So the CERRIE Committee -- well, you say John Harrison 10 said a factor of 2 or 3 -- have you incorporated 11 a factor of 2 or 3 into your dose co-efficients that you 12 employed in calculating your doses? 13 A. No. 14 Q. No. 15 A. Perhaps I could expand on that. 16 Q. Of course. 17 A. I had some considerable difficulty in this area because 18 one of the questions that you asked in February was to 19 quote the -- was to give the uncertainties associated 20 with the parameters that I'd used. I sought to quantify 21 as many of those uncertainties as I felt able to do, 22 which was principally the uncertainties associated with 23 my assumptions. 24 When it came to the internal dosimetry and 25 estimating the uncertainties in the ICRP risk factors,</p> <p style="text-align: center;">Page 175</p>
<p>1 A. Paragraph 11. 2 Q. Yes. At the bottom of that it says: 3 "There are important concerns with respect to the 4 heterogeneity of dose delivery within tissues and cells 5 from short range charge particle emission [I think we 6 could say alpha particles would be included within that] 7 the extent to which current models adequately represent 8 such interactions with biological targets [that would be 9 DNA] and the specification of target cells at risk. 10 Indeed, the actual concepts of absorbed dose become 11 questionable and sometimes meaningless when considering 12 interactions at the cellular and molecular level." 13 Would you agree with that? 14 A. That is outside my expertise, and indeed was one of the 15 reasons why I said that I can duplicate your 16 mathematical -- or the mathematical calculations that 17 you were referring to before. But in terms of giving 18 an expert opinion on that, I don't think I'm qualified 19 to answer that question. 20 Q. But isn't this sort of rather a kind of long-winded way 21 of saying what it is we were just discussing about the 22 doses close to particles? That would be one example of 23 this? 24 A. Yes, I mean I've given you my interpretation of what 25 I believe this report says later.</p> <p style="text-align: center;">Page 174</p>	<p>1 I think I said in my replies that I didn't have the 2 appropriate expertise to do that, and really the best 3 I could do was to copy and include a table from the 4 report by John Harrison. There was another report, 5 I think, by a Mr Puncher, I think, or something like 6 that. 7 Q. I think somewhere in your report -- and we'll go there 8 -- 9 MR JUSTICE BLAKE: Did you finish your answer? 10 A. I think so, my Lord, that I don't really think that -- 11 in terms of -- so why didn't I include it? 12 DR BUSBY: No, I just ask if you did include it, that's all. 13 A. I didn't include it. Part of the reason that I didn't 14 include it was (1) for the reasons, as I say, in terms 15 of expertise, what is a reasonable number to choose. 16 I would simply have had to take a number from the 17 John Harrison paper or from CERRIE and apply it without 18 fully understanding it, which I didn't feel comfortable 19 doing. 20 But also the CERRIE report -- and I think, if I'm 21 not mistaken, the COMARE response -- also comment that 22 the central value was likely to be close to the real 23 value. So that's a second point. 24 The third point is that where you have a random mix 25 of radioisotopes -- which certainly you do in the mix of</p> <p style="text-align: center;">Page 176</p>

<p>1 nuclides which we're talking about here -- COMARE also</p> <p>2 comment that uncertainties, of course, can be higher or</p> <p>3 lower than the real value, there's a distribution which,</p> <p>4 without getting into the detail, it looks a bit like</p> <p>5 a bell. There's a distribution. So the uncertainties</p> <p>6 can be either higher or lower, and particularly if the</p> <p>7 most likely is the middle, that, for a large range of --</p> <p>8 random range of nuclides -- that the average value is</p> <p>9 likely to be in the middle.</p> <p>10 But it was principally based on the fact that</p> <p>11 I really didn't feel -- and I think I said this in my</p> <p>12 reply to your questions -- I really didn't feel that</p> <p>13 I had the appropriate expertise to be able to do that.</p> <p>14 Now, maybe I'm wrong in doing that.</p> <p>15 MR JUSTICE BLAKE: That's your answer.</p> <p>16 Right, pause there. I'm looking at the time.</p> <p>17 Unless you have a follow-up to that specific answer, it</p> <p>18 might be the time to adjourn until tomorrow?</p> <p>19 DR BUSBY: That's fine, my Lord. I can pick it up --</p> <p>20 without having to go to that answer, I can pick it up.</p> <p>21 MR JUSTICE BLAKE: Quite. Given that the questions have</p> <p>22 prompted quite lengthy answers, it may be that that's</p> <p>23 a moment --</p> <p>24 DR BUSBY: Well, I will be pursuing this particular line for</p> <p>25 a short while, but it's probably best we don't do that</p> <p style="text-align: center;">Page 177</p>	<p>1 cross-examination?</p> <p>2 DR BUSBY: Well, I had thought I would finish in the</p> <p>3 morning, my Lord, but Mr Hallard does tend to go on</p> <p>4 a bit. Which I don't mind, it's fine.</p> <p>5 MR JUSTICE BLAKE: Well, I think we'll have to -- maybe some</p> <p>6 of the questions have been rather big issue questions</p> <p>7 and we may need to narrow it down a bit. Because we</p> <p>8 made a degree of process but we need to get back on the</p> <p>9 road again. So is one o'clock a realistic contender?</p> <p>10 DR BUSBY: I will endeavour to get it sorted by one o'clock,</p> <p>11 if you will permit me to just stop him if you think</p> <p>12 that's okay. Or you might want to do that, my Lord.</p> <p>13 MR JUSTICE BLAKE: I'll see what the question is.</p> <p>14 DR BUSBY: Okay.</p> <p>15 MR JUSTICE BLAKE: If it's explaining the meaning of life he</p> <p>16 may need a few more minutes than something a bit more --</p> <p>17 DR BUSBY: I do tend to have a big issue approach to this,</p> <p>18 my Lord, that's the problem.</p> <p>19 MR JUSTICE BLAKE: Yes. I can see that. Maybe you've</p> <p>20 kicked off some of the big issues, and maybe we now need</p> <p>21 to focus on the issues which might had to the learning</p> <p>22 that we already have.</p> <p>23 DR BUSBY: Very good, my Lord.</p> <p>24 MR JUSTICE BLAKE: But there we are.</p> <p>25 If we can achieve that, you are going to be the rest</p> <p style="text-align: center;">Page 179</p>
<p>1 any more now.</p> <p>2 MR JUSTICE BLAKE: I think we'll stop this evening. We will</p> <p>3 continue tomorrow.</p> <p>4 Can we start at ten o'clock tomorrow?</p> <p>5 DR BUSBY: Fine by me.</p> <p>6 MR JUSTICE BLAKE: Is that all right with when? Thank you.</p> <p>7 Can we see you back at ten o'clock tomorrow.</p> <p>8 THE WITNESS: Certainly my Lord.</p> <p>9 MR JUSTICE BLAKE: Thank you very much.</p> <p>10 THE WITNESS: If my answers have been too lengthy</p> <p>11 I apologise for that.</p> <p>12 MR JUSTICE BLAKE: Well, no, you need to be as lengthy as</p> <p>13 you are to answer the question properly. But I am just</p> <p>14 trying to find a point to bring proceedings to a close</p> <p>15 this evening.</p> <p>16 THE WITNESS: Thank you, my Lord.</p> <p>17 MR JUSTICE BLAKE: If you go now, I am just going to have</p> <p>18 a quick discussion about general timing and I don't</p> <p>19 think that would involve you.</p> <p>20 THE WITNESS: Thank you.</p> <p>21 (The witness withdrew)</p> <p>22 Housekeeping</p> <p>23 MR JUSTICE BLAKE: The witness has now departed.</p> <p>24 Can we just see what tomorrow might look like then?</p> <p>25 How long do you think you are likely to be with your</p> <p style="text-align: center;">Page 178</p>	<p>1 of the afternoon in re-examination?</p> <p>2 MR HEPPINSTALL: I wouldn't have thought so, no. It's quite</p> <p>3 hard to tell at this moment in time. I wouldn't have</p> <p>4 thought so. So we were proposing to warn Dr Haylock for</p> <p>5 tomorrow afternoon.</p> <p>6 MR JUSTICE BLAKE: Yes. All right. If he doesn't mind</p> <p>7 hanging around or waiting to get on. Once we get on to</p> <p>8 Dr Haylock, whether it's at 3.00 or 3.30, current</p> <p>9 estimate, roughly?</p> <p>10 MR TER HAAR: Half a day, perhaps.</p> <p>11 MR JUSTICE BLAKE: Half a day. All right. I thought it</p> <p>12 might have been a bit longer. Your reserve list from</p> <p>13 Dr Thomas.</p> <p>14 MR TER HAAR: There is that. The approach I intend to</p> <p>15 adoption, I am hoping for half a day, sometimes we get</p> <p>16 it wrong.</p> <p>17 MR JUSTICE BLAKE: Dr Busby?</p> <p>18 DR BUSBY: I think we need to have a fair bit of time for</p> <p>19 Dr Haylock, my Lord.</p> <p>20 MR JUSTICE BLAKE: What might "a fair bit of time" mean?</p> <p>21 DR BUSBY: A day.</p> <p>22 MR JUSTICE BLAKE: But that's for everybody or just for you?</p> <p>23 DR BUSBY: No, that's just for me.</p> <p>24 MR JUSTICE BLAKE: That's not quite the estimate that you</p> <p>25 put in the timetable.</p> <p style="text-align: center;">Page 180</p>

<p>1 DR BUSBY: Oh, is it not? You just tell me how much I have 2 and I'll cut my cloth according to my pocket. 3 MR JUSTICE BLAKE: If you look at the time -- I thought that 4 the timetable said something different. But I cannot 5 find it at the moment. 6 MR HEPPINSTALL: Professor Haylock was down -- well, half 7 a day. 8 MR JUSTICE BLAKE: I think it was half a day all over. 9 DR BUSBY: Was it? 10 If I could have half a day then, my Lord. 11 MR JUSTICE BLAKE: Yes. I think if you can aim to 12 cross-examine for no more than half a day, and 13 particularly if Mr ter Haar has already done half a day. 14 DR BUSBY: Right. 15 MR JUSTICE BLAKE: So that might be the whole of Wednesday. 16 We have Thursday as a run-on, if necessary, yes? 17 MR HEPPINSTALL: Yes, my Lord. 18 MR JUSTICE BLAKE: But Dr Haylock is the last witness? 19 MR HEPPINSTALL: Indeed, my Lord. 20 MR JUSTICE BLAKE: You are not going to call anybody else? 21 MR HEPPINSTALL: No, my Lord. 22 MR JUSTICE BLAKE: So that does look, even on the more 23 pessimistic scenario, that we might complete the 24 evidence by, say, between some time between ten o'clock 25 and one o'clock on Thursday?</p> <p style="text-align: center;">Page 181</p>	<p>1 MR HEPPINSTALL: Yes. 2 MR JUSTICE BLAKE: If that looks like the wheels are coming 3 off that particular bus, and I don't notice it, someone 4 tell me. 5 MR HEPPINSTALL: We'll let you know, my Lord. 6 Two additional items, or at least one additional 7 item, which has hopefully arrived on your desk, that is 8 Violet that was requested on Friday. We can put that in 9 SB22/10. 10 MR JUSTICE BLAKE: Is that -- 11 MR HEPPINSTALL: The French Polynesian iodine thyroid -- 12 MR JUSTICE BLAKE: Yes. I thought that is maybe what 13 I requested, but there we are. 14 MR HEPPINSTALL: Hopefully it's arrived. Then I think 15 Dr Busby wanted to make sure a document was in the 16 bundle. It is a well-known document to these 17 proceedings. In fact, I note it has High Court and 18 Court of Appeal references on it. But it hasn't made 19 its way into this bundle, but I'm quite happy for it to 20 go in. So that would be SB22/11. That looks like it to 21 me, yes. (Handed) 22 MR JUSTICE BLAKE: What is it? 23 MR HEPPINSTALL: It's the minutes of a meeting at Harwell in 24 1951. 25 MR JUSTICE BLAKE: Right. So this didn't get into your</p> <p style="text-align: center;">Page 183</p>
<p>1 MR HEPPINSTALL: Perhaps, my Lord, with a fair wind. 2 MR JUSTICE BLAKE: You are being very cautious. All right. 3 Are we going to need Friday? 4 MR HEPPINSTALL: It doesn't look like it at the moment, 5 my Lord. 6 MR JUSTICE BLAKE: You'll let me know if it starts to look 7 different. 8 MR HEPPINSTALL: Indeed. 9 MR JUSTICE BLAKE: I don't quite know what the measuring 10 device is you are going to use for that rather gloomy 11 prognostication, whether it's grays, millisieverts, or 12 something else, but, whatever it is, alert me. 13 MR HEPPINSTALL: I will, my Lord. 14 MR JUSTICE BLAKE: It seems to me at the moment we should 15 aspire -- assuming we get him on either late tomorrow or 16 first thing on Wednesday -- we can aspire for the 17 cross-examination to be completed by the end of that 18 day, probably 4.30, and I can sit at ten o'clock, if 19 that helps. 20 MR HEPPINSTALL: Yes. 21 MR JUSTICE BLAKE: But there will be some run over, I think. 22 MR HEPPINSTALL: Perhaps. 23 MR JUSTICE BLAKE: If the run over terminates by one 24 o'clock, as the worst case scenario, I think that will 25 be helpful for our particular planning.</p> <p style="text-align: center;">Page 182</p>	<p>1 tab 17. 2 MR HEPPINSTALL: Curiously, notwithstanding that this 3 document is something that Dr Busby has referred to 4 several times, it's never gone into this FTT bundle or 5 the one below. But it's certainly well-known to the 6 Secretary of State and we are happy for it to go in. 7 MR JUSTICE BLAKE: So it goes in 22/11. 8 MR HEPPINSTALL: 22/11. 9 MR JUSTICE BLAKE: All right. We are not sure that 10 Polynesia has quite arrived at the shores of -- 11 MR HEPPINSTALL: Your clerk is ahead of you. 12 MR JUSTICE BLAKE: We got there without realising. Thank 13 you. (Pause) And B5 we can put back? 14 MR HEPPINSTALL: Yes. 15 MR JUSTICE BLAKE: Right. Ten o'clock tomorrow then. Thank 16 you. 17 (4.35 pm) 18 (The court adjourned until 19 Tuesday, 21 June 2016 at 10.00 am) 20 21 22 23 24 25</p> <p style="text-align: center;">Page 184</p>

1	I N D E X	
2		
3	MR RICHARD HALLARD (continued)1	
3	Cross-examination by MR TER HAAR1	
	(continued)	
4	Cross-examination by DR BUSBY144	
5	Housekeeping178	
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
	Page 185	

A				
aberration 77:1,2 77:11	accurate 2:2 25:10 31:10 52:3 70:4 88:7 102:1	addressed 41:17	101:18 102:10	akin 112:10
ability 37:6	accurately 5:9	adequate 74:4 139:18	103:7,8 104:24	al 50:21
able 6:4,9 19:21 38:10,25 52:8 69:20 78:19 79:2 79:12 87:15 88:22 94:23 104:10 105:18 111:3 113:25 114:5 116:21,25 122:2 123:18 151:12 152:2,25 159:10 162:7,17 175:21 177:13	achieve 179:25	adequately 113:25 174:7	105:1,15 107:21 107:22,25 112:3 127:1 128:14,24 129:8 135:9 136:14 137:4 139:22 142:7 153:8 162:4 171:16 174:13	Albury 69:17
abnormalities 75:23	acronyms 149:6	Ades 105:15 127:20	129:8 135:9 136:14 137:4 139:22 142:7 153:8 162:4 171:16 174:13	Aldermaston 13:4 19:25 21:8,16 41:20 42:1
absence 12:23 13:10 18:21 52:2	action 5:7 21:18	adhesive 47:18	153:8 162:4 171:16 174:13	alert 182:12
absolute 89:15	activation 9:8,25	adjourn 177:18	171:16 174:13	allow 48:4
absolutely 22:20 55:8 90:5 100:12 101:5 136:12 166:11	active 24:23 37:20 38:2 69:20 73:16 160:4,7,21	adjourned 184:18	agreed 30:19 58:10 166:14 171:20	allowing 76:25
absorbed 157:25 158:13,15,17 160:16 162:11,21 162:24 163:1,4,5 163:12 164:13,14 164:17 165:3,4,7 174:10	activity 8:15 18:3 20:14 37:17,18,21 37:24 38:12,13 39:1,25 46:19 48:5 58:21,23,24 59:4,6,7,8,16,18 66:15 69:2 70:17 81:13,15 83:25 84:1,5,12,13 85:17,19 91:4,5,6 91:9,10,13 93:21 103:13 110:13,14 110:17,23 112:1 112:11 120:12 125:3 127:10,12 127:13,17,18 130:2 133:8 137:10,11,13 138:2,14 139:14 140:6,8 142:5 160:21 164:19 165:25 168:1 169:25 170:2,3	adjournment 91:20 91:24 92:2	agreeing 13:13 162:6	allows 68:17
absorbent 121:7	actual 47:21 68:6,6 68:18 84:15 109:12 160:18 174:10	admit 116:14	agreement 30:18 100:4	alpha 8:7 11:18,23 14:2 15:15,19 18:25 20:11 24:11 24:14,19 25:6,19 73:12,15,16 161:16 163:8,10 164:18,20,22 165:2 168:8 174:6
accept 4:6 35:22 62:7,11 72:19 99:10 153:25	acutely 16:2	adopted 16:3,3 35:15 103:5	ah 1:17 17:2 82:6,8 83:24 114:12 115:17 143:20 151:4	alphas 165:3
accepted 39:9 152:11 154:12	ad 72:15,15	adoption 180:15	ahead 41:4 150:11 184:11	alternative 48:10
accepting 33:19	add 152:25	advance 20:22	aide-memoire 117:15	alternatives 43:24
access 11:16 68:17 70:8 87:12	added 98:15	advise 72:23	aim 181:11	altitudes 99:21
account 6:23 7:8 33:19,25 34:2,6 34:10 39:18 53:1 75:14 81:3,4,5 132:8,12 134:5	addition 27:23 103:2	AERE 24:15	aimed 166:14	altogether 142:18 171:3
	additional 53:1,2 183:6,6	aerial 56:15	air 6:17 27:9 29:20 31:4 46:10 54:6 73:19,21,24 80:19 80:22 84:1,5,13 85:2,10,12,16,17 86:7 88:8 95:8 99:21 102:16 108:4,7,10 109:6 109:18,22 111:22 112:18 113:2,3 115:19 122:23 129:17 136:5	ambiguous 110:10 139:1
		aerodynamic 56:5 57:19,25 60:11 61:17 99:22	airborne 28:5 47:9 81:16	amending 34:23
		aerodynamics 55:22 56:14	aircraft 52:7 115:1 115:15 116:10 119:9,11,15 121:3 121:6 128:2 129:3	amount 7:2 61:25 80:18,22 81:8,15 84:17 85:4,11 86:13 94:4 103:16 136:5 157:25 158:2 159:3
		aerosols 28:5 29:21 80:11	airmen 31:4	amounts 112:23 159:17
		affect 37:5 76:16	airport 72:1	amplifying 172:24
		afraid 21:19 34:1 93:9 108:19,23 109:19		analysing 32:20
		afternoon 79:8 144:16 180:1,5		analysis 4:6 21:9 32:15 33:14 42:12 44:3,5 127:23 151:18
		Agency 154:5		and/or 50:23
		agitation 84:17		angle 121:18
		ago 16:4 46:1 78:24 106:23		Anglia 27:21
		agree 8:12,13,25 9:10,12 10:1,11 11:21 12:14,14 14:5 15:7 18:18 18:24 24:25 28:24 35:14 38:17 48:10 49:13 50:4 51:2 53:4,17 60:20 61:7 63:10 66:16 69:4 73:23 88:15		answer 13:12 55:15 57:16 71:5 79:7

79:14,19 94:15 111:3 113:25 121:25 148:2 149:9 150:4 151:25 152:2,4 153:2,3 162:10,18 166:9,12 174:19 176:9 177:15,17 177:20 178:13 answering 77:9 121:10 answers 34:25 114:13 127:19 157:3 177:22 178:10 anticipated 13:9 anvil 57:9 115:7 122:19 125:3,16 125:19,23,25 126:3,5 128:3,5,6 128:13 129:14 130:1 131:18,20 132:2,4,5 133:22 134:3,4 135:11 136:8 anvil/stem 122:20 anybody 1:8 16:4 17:11 49:14 79:16 173:16,17 181:20 anyway 2:3 23:18 41:16 54:10 111:1 137:14 159:14 169:5 apart 42:14 46:25 64:14 69:22 70:5 112:7 115:24 117:4 aperture 47:25 apologise 34:19 126:20 130:7 178:11 apparatus 49:11 apparent 30:15 Appeal 183:18 appear 14:3 62:15 71:7,12 100:2	123:4 appeared 65:8,23 110:2 appears 3:6 21:12 41:12 92:3 appellants 30:23,24 31:23 32:20 applicable 169:5 applied 91:16 applies 133:21 apply 17:5 126:16 176:17 applying 17:10 151:3,15 appreciate 150:4 approach 3:11 4:5 4:10,12 5:25 29:12 81:6 83:22 95:10 148:11 167:8,25 179:17 180:14 appropriate 88:14 89:22 103:5 152:6 176:2 177:13 approximate 10:4 10:6 approximately 11:1 28:12 54:12 139:14 approximation 139:13 arbitrary 62:3 109:8 archive 87:14,14 area 6:18 24:18 27:16 29:18,24 30:18 34:3,3 35:14 48:9,23 61:14,18 63:18 64:5,6 66:14 67:3 67:4,7,14 69:8,8 70:15,17,25 71:8 76:24 81:9,10 91:7,12 101:4 113:10 120:12,16 120:17 122:10	126:6 134:23 137:15 141:12 142:18 146:14 149:1 150:16 157:17 158:10,13 171:3 173:18 175:17 areas 17:7 24:20 27:14 28:15,23 30:17 34:5 53:11 53:11 54:1,2,6,13 54:17 61:21 65:25 67:19,20 68:3 70:21,25 71:10,10 71:13,17 72:7 73:6,10 75:9 103:5 107:19 110:8 124:17,25 125:10,18 127:6 132:5 133:15 134:13,25 135:6 137:13,20 138:3 argon 25:4 argue 60:17 101:23 164:25 169:4 170:12 argument 75:25 145:9 arguments 144:18 arises 8:15 armed 121:24 Armer 64:20 140:22 arose 13:22 arrived 65:6,16 92:24 121:2 141:22 183:7,14 184:10 aside 6:5 95:5 asked 17:19 33:24 75:10 77:9 93:14 140:25 141:25 151:14 175:18 asking 16:13 32:4 78:14 81:12 114:5 144:19 146:2	159:16 162:3 167:10 175:4 aspect 158:6 aspects 29:15 149:4 aspire 182:15,16 assay 52:3 assertion 137:4 assess 15:5 136:19 assessing 16:5 39:19 63:8 77:4 assessment 16:8 63:21 77:13 86:12 89:22 126:25 140:9 161:2 assist 137:23 143:2 assistance 79:2,25 137:21 associated 62:1 97:16 175:19,22 association 24:22 assume 6:16 18:6 25:14,17 77:8 85:7 94:11 99:24 109:9 114:1 115:7 125:14 131:12 134:2 148:10 165:1 167:25 assumed 40:2,4 58:23,24 59:4,6 59:16,22,25 103:2 103:13,17,22,24 104:3,5 109:25 110:12 124:13,13 124:23 128:1 130:19 131:15 133:6 134:21,24 138:5 139:5 140:3 142:9 148:22 164:23 assumes 90:18 assuming 13:21 124:18,19 131:18 132:4 134:4 155:17 182:15 assumption 21:1 65:22,22 67:17	89:23 104:2 106:18,19,20 115:2,3,5,9 119:13,13 125:6 125:17 130:5,6,8 130:12,19,25 131:16 132:7,12 136:20,22 137:1,5 138:23 140:7 160:16,17 assumptions 4:9 68:1,2 105:5,7,10 106:17,22 107:7 114:17,21,25 115:12 119:8 122:7 123:2,3 126:22 139:21,22 175:23 ate 95:2 atmosphere 113:4 113:6 atmospheric 18:9 26:23 27:22 28:4 28:8,14 101:12 atoll 39:6 atom 136:16 atomic 29:7 52:20 54:8 83:8 154:4 attached 47:19 attack 173:17 attempt 117:15 133:18 attention 14:21 34:8,11 53:24 Australia 29:7 81:21 89:4 90:2 113:16 Australian 29:5 89:24 author 28:19 automatically 49:7 49:9,10 available 2:2 18:23 20:16 35:9 46:6 97:9 100:19 166:6 172:13,20,22
--	---	--	--	--

average 61:21 103:1 139:13 177:8	background 13:21 38:14 71:22,24 72:4 82:10	142:5	bias 153:21 154:14 154:16,18 157:1	149:7,9 150:2,7 150:10,15,20 151:1,5,15 152:3 152:10 153:1,3 155:19 157:9 162:10,14,23 163:3,11,15 166:6 166:9 171:25 172:3,5 176:9 177:15,21 178:2,6 178:9,12,17,23 179:5,13,15,19,24 180:6,11,17,20,22 180:24 181:3,8,11 181:15,18,20,22 182:2,6,9,14,21 182:23 183:2,10 183:12,22,25 184:7,9,12,15
averaged 158:18 159:2 160:16,20	backwards 38:11 38:25 85:15 109:15 124:5 146:8	beg 4:18 38:4 64:10 99:6 121:20 165:2	biased 153:18,20 173:20,21	blast 99:7
avoid 96:7	bad 32:5	beginning 75:10	big 73:7 112:7 125:15,16 160:2 179:6,17,20	blasts 98:10
awarded 27:20	badges 8:9 10:3,4 12:23,24 13:10 16:16,21,25	behalf 23:19	bile 166:22	bloodstream 166:20
aware 1:6 4:14 5:10 14:4 18:12 20:18,19 21:18 26:13,18 46:6,11 46:11 70:11 82:24 83:8 87:1,19 98:6 126:18 143:9,20 144:1,2 148:13 149:1 154:13,15 154:18 157:1	balance 45:22 111:12	behaviour 28:3	bioaerosols 29:15 29:17	blow 58:8
AWE 5:5 50:21	balloon 70:15	beings 27:6,6 141:14	biological 174:8	blowing 136:10
AWRE 24:15 78:18	ban 18:10	believe 5:4 7:9 11:24 13:3 23:21 25:13,16 68:4 82:7,9 91:9 101:1 106:22 107:4 110:10 119:2 124:19 135:18 149:11 152:20,23 152:24 154:19 165:22 174:25 175:2	bit 2:17 8:13 25:22 25:24 27:12 33:14 35:4 55:23 68:15 80:15 83:15 97:23 110:10 116:18 127:1 159:20 171:3 177:4 179:4 179:7,16 180:12 180:18,20	blown 85:8 117:11 122:23 136:15
B	bar 34:3	believed 21:16 89:14 117:24 130:16	BLAKE 1:5,9,17 1:20,23 2:3 10:12 10:18 11:11 19:18 20:1,10,16 23:3,7 23:13 26:1,4,6 33:2,4,6,8,11 37:3 37:25 38:3,5,7 43:17,20 44:3,8 44:12 48:19 49:4 49:7 74:22 77:20 78:1,4,8,12,21,25 79:11,15 80:1,5 90:12,15 91:17,22 92:1,10,23 93:4 93:12,15,19,22,24 94:7,15,21 95:4 116:15,18,22,24 117:3,13,21 118:18,22,25 119:21,23 120:4 121:5,9,18,23 123:10,14,17,20 123:25 124:2 134:3 142:20,24 144:6,14 146:24 147:1,5,8 148:2	blown-up 116:19
b 63:4 136:17	base 99:25 124:4	bell 177:5	BLAKE 1:5,9,17 1:20,23 2:3 10:12 10:18 11:11 19:18 20:1,10,16 23:3,7 23:13 26:1,4,6 33:2,4,6,8,11 37:3 37:25 38:3,5,7 43:17,20 44:3,8 44:12 48:19 49:4 49:7 74:22 77:20 78:1,4,8,12,21,25 79:11,15 80:1,5 90:12,15 91:17,22 92:1,10,23 93:4 93:12,15,19,22,24 94:7,15,21 95:4 116:15,18,22,24 117:3,13,21 118:18,22,25 119:21,23 120:4 121:5,9,18,23 123:10,14,17,20 123:25 124:2 134:3 142:20,24 144:6,14 146:24 147:1,5,8 148:2	blunt 93:25
B5 184:13	based 10:25 12:20 14:13 59:23,25 81:20 82:2 89:2 89:11,14 95:3 102:14 104:5 107:4 110:22 116:14 135:14 137:25,25 141:19 149:12 152:4 161:15 167:20 168:10 177:10	benchmark 90:16 154:2	BLAKE 1:5,9,17 1:20,23 2:3 10:12 10:18 11:11 19:18 20:1,10,16 23:3,7 23:13 26:1,4,6 33:2,4,6,8,11 37:3 37:25 38:3,5,7 43:17,20 44:3,8 44:12 48:19 49:4 49:7 74:22 77:20 78:1,4,8,12,21,25 79:11,15 80:1,5 90:12,15 91:17,22 92:1,10,23 93:4 93:12,15,19,22,24 94:7,15,21 95:4 116:15,18,22,24 117:3,13,21 118:18,22,25 119:21,23 120:4 121:5,9,18,23 123:10,14,17,20 123:25 124:2 134:3 142:20,24 144:6,14 146:24 147:1,5,8 148:2	board 75:19 102:21 173:2
back 4:4 5:24 19:22 19:24 20:17 29:11 29:23 30:2 36:6 42:11 44:21 45:2 45:6 50:18 53:21 57:17 59:10,12 60:2,3 63:4 65:6 65:16 80:5 86:2 86:14 88:20 91:18 106:1,13 107:6,10 114:7 118:16,23 120:18 121:2 122:17,24 123:5 129:10 132:17 134:3 140:14,23 141:22,24 143:25 146:20 150:2 151:5 152:7 155:5 162:19 169:17 178:7 179:8 184:13	basic 154:5,8,10	benefit 35:16 74:15 78:16 79:1	body 30:23 72:25 85:10,16 88:17 163:24	boat 65:3
back-calculating 123:22	basically 146:2 162:2	Bernard 64:20,20	board 75:19 102:21 173:2	blow 58:8
	basis 13:9 103:6 109:11 112:4 124:23 141:17 154:19	best 7:15 19:13 35:13 38:21 53:3 67:23 83:19 173:22 176:2 177:25	boat 65:3	blowing 136:10
	bathed 76:9	beta 10:7,9 25:6 68:17 73:14 163:7	body 30:23 72:25 85:10,16 88:17 163:24	blown 85:8 117:11 122:23 136:15
	Bay 64:5,15 65:19 67:3 69:8	beta/gamma 24:23	bottom 11:13 36:16 41:18 47:6 54:10 86:18 101:7 124:15 125:23,25 130:3 131:6 135:23 137:6,11 171:22,23 173:25 174:2	blown-up 116:19
	bearing 165:13	betas 8:22	boundaries 2:13	blunt 93:25
	becquerel 84:6,6	better 48:12,18 49:12 60:24 84:18 154:17		board 75:19 102:21 173:2
	becquerels 62:3 81:14 84:8,13	beyond 26:18 29:25 72:9 81:8 89:20 98:2 114:5 130:7 169:8 170:24 172:6 175:4		boat 65:3

72:6 boundary 72:10 bow 6:21 26:8 27:16 box 55:5 171:14,21 173:7 brackets 99:5 break 44:13,14,17 91:17 142:20,22 144:6,8,11 breakdown 48:5 52:3 breathe 113:7 breathed 6:18 breathing 112:23 113:2 bridge 39:15,16 briefly 89:13 154:4 154:21 156:19 171:8 bring 178:14 British 106:3 144:23 broad 3:13 10:6,11 86:12 108:21,21 157:23 broadly 4:5 102:11 139:12 149:16 broken 88:23 brought 151:16 build 105:5,12 106:18 139:20 buildings 70:22 built 107:7 149:25 bullet 57:13 102:24 107:11 bundle 2:16,21 21:22 23:9 25:23 26:1 31:1,17 34:16,18,19 40:18 40:20,24 46:24,25 54:20,21 92:15,25 93:11 95:5,11 183:16,19 184:4 bundles 23:2 78:19 79:22 82:4	bundling 22:22 23:16 bus 183:3 Busby 92:3,5,9,22 105:14 127:19 144:15,16 147:25 150:8,12,19 151:9 152:9 153:4 155:21 157:13 165:11,12 166:11 169:2 172:25 176:12 177:19,24 178:5 179:2,10,14 179:17,23 180:17 180:18,21,23 181:1,9,14 183:15 184:3 185:4 Busby's 114:14 164:23 business 150:24 Butler 63:22 <hr/> C <hr/> calculate 84:3 94:16 108:10 122:24 165:5 calculated 109:13 110:15 134:8 158:14 163:21 164:6 calculating 164:13 173:14 175:12 calculation 6:24 83:17 84:10,11 93:14,16,18,25 105:12 108:12,15 138:10 139:8,9,11 139:18 140:13 142:4,6,9 161:12 161:14,17,21,24 164:23 165:10 calculations 6:16 57:15 79:9,12 81:2 103:1 105:21 107:1,4 110:22 162:18 174:16	call 3:13 24:4 41:1 52:13 58:2 84:17 124:15 132:9 141:13 181:20 called 10:25 17:25 20:12 25:3 29:16 29:21 32:17 41:23 64:5 81:16 96:5,5 103:15 140:25 143:18 151:23 158:16 162:24 163:2,6,22 164:5 167:18 camp 43:5 54:13 65:11,25 67:18 110:8 124:18 125:6,8 137:9 campaign 41:24 42:9,18,20,25 campaigns 18:1,14 19:17 Canberra 129:19 Canberras 21:6 52:7 cancer 83:4 167:1 167:15,24 cancers 83:2 capable 103:18 Captain 105:15 127:20 captured 78:5 79:4 care 92:19 career 143:4 careful 24:16 32:15 33:14 34:12 carefully 90:19 100:7 carried 14:3,24 19:21 45:2 63:12 70:3 73:21 75:11 83:17 106:2 110:12 138:9 139:4 140:18 143:9 carry 2:9 6:15,23 15:3 17:5 18:11	20:23 29:1 69:5 108:15 115:11 132:15 carrying 18:14 20:21 69:9 86:17 Carter 29:4 52:16 52:20,25 53:3 81:18 82:3,4,11 82:11,14 87:9,16 88:22 89:1 95:3 140:10 case 11:17,22 18:19 27:2 28:23 32:19 45:20 58:22 63:8 89:15,22 92:10 106:22 130:12,17 130:23 131:16 132:7,11 139:10 143:20,21 151:16 156:6,7,8,8 182:24 cases 14:3 30:25 categorised 95:25 caught 65:13 94:10 94:17 causation 146:6 151:20 cause 76:25 77:11 77:12 90:11 101:2 145:24 146:17 147:9,13,18 148:10,20 151:2,7 167:1 caused 61:17 82:25 98:5 100:21 145:11 146:5 147:16,19 causes 77:2 83:2 caution 88:20 cautious 182:2 caveat 150:4 caveats 76:18 77:10 cell 143:19,23 159:22 160:5 164:16 cells 160:24 161:1,8	161:15 165:15,16 166:2,4,6 168:7,8 168:9,13 169:21 174:4,9 cellular 174:12 cent 15:10,16 67:13 67:16 98:18,19,21 138:13 Centigrade 99:18 central 116:12 152:15 172:11 176:22 centre 42:6 43:3,13 44:10 45:6 54:14 70:22 71:24 115:15 116:6 124:19 134:23 CERRIE 152:8,8 160:11 161:13 170:16,17,23,24 171:7,19 172:7 175:9 176:17,20 certain 8:11,16 10:25 17:24,24 22:20 25:14,17 26:15 61:2,18 77:8 84:5,12 98:25 104:5 124:21 140:6 143:7,23 151:21 166:11,14 168:2 certainly 3:1 7:13 8:9,10 14:7 16:7 18:22,24 19:3 24:24 29:23 32:24 35:18 38:25 39:17 48:13 49:9,12 50:7 52:16 59:20 66:19,24 71:14 72:21 73:2,4,5 78:6,6 87:19 88:21 90:7 91:16 97:11,17,23 106:9 111:15 117:15 118:8 122:4 128:16 131:2,25
---	---	--	---	--

132:1,3 135:13 138:19 139:25 140:20 141:3,5,6 141:20 153:19 158:8,12 159:1 161:20 169:13 176:25 178:8 184:5 certainty 111:4 cetera 46:9 71:13 challenge 6:14 challenged 72:21 72:22 challenging 87:24 chance 54:3 69:7 change 56:16 changed 147:20 changes 48:5 charge 97:5,15 174:5 Charles 160:15 check 46:17 82:9 142:22 check/monitor 13:25 checking 21:14 45:1 142:16 chemicals 138:16 childhood 145:4,10 145:21,21 147:1,9 children 147:11,12 choose 17:16 44:14 86:24 176:15 choosing 81:25 chose 81:23 chosen 110:15 Christmas 11:19 16:4 32:12 42:6 43:3 44:10 46:10 50:21 53:9 54:11 63:18 69:13 76:8 76:15 90:10 94:19 101:16 102:2 107:18 117:22 119:10,19 121:2 chromosomal	75:22 chromosome 77:1 77:2,11 circumstance 109:2 circumstances 27:7 86:14 106:4 164:17 claims 14:19 Clare 42:1 44:6 45:10 46:7 50:21 51:3,21 52:9,10 52:16 clarify 2:10 19:18 123:2 clarifying 34:23 clear 3:4 6:13 7:13 30:21 32:21 67:21 76:22 101:10 111:8 125:9 134:13 clearly 12:6,16 56:25 64:16 110:6 131:4 132:22 161:1 165:6 167:23 clerk 184:11 clients 28:10 70:7 76:23 climate 47:17 close 68:19 108:3 128:6 137:12 149:23,24 152:15 174:22 176:22 178:14 closer 92:17 closest 165:18 closing 31:15,20,22 32:22,22,23 143:3 cloth 181:2 cloud 4:23,24 5:24 21:5 31:6 48:8 52:7,8 57:9 85:7 96:1,3,5,13 97:11 97:13,16 99:13 100:10,22 101:20 115:6,15 116:6	117:24,25 118:3 120:6,7,25 122:22 122:25 124:12,20 124:20,24,25 125:2,2,7,9,12,16 125:20 126:22,24 127:5,5,10,12 131:10 132:22,25 133:7 134:9,12,14 134:16,23 135:3,6 137:1 138:1,3,6 cloud' 96:8 clouds 100:17,25 101:2 cluster 145:4,15 151:7 157:5 clusters 149:16,17 150:1 151:23 157:6 co-efficients 152:18 154:6,9 168:20 169:9,14 173:15 175:11 coast 64:5 coefficient 81:17 84:15,22 168:24 169:15 colder 99:17 collected 47:24 collection 47:9 53:16 collectors 47:15 coloured 153:10 column 155:10 COMARE 145:14 149:3,3,10 152:7 152:11 176:21 177:1 COMARE's 152:19 157:10 come 4:4,24 5:19 7:5 11:20 27:5,6 27:12 29:11,23 30:2 36:6 55:23 55:25 57:24 59:10 59:12 60:2,3,22	63:4 73:1 75:1 76:10 86:2 91:17 105:8 107:6 114:7 121:24 122:17,20 128:13 129:25 130:2 132:2,4 148:7 149:7 152:10 156:19 157:7 comes 45:10 57:17 80:13 88:20 105:1 132:17 comfortable 74:6 74:10 176:18 coming 85:7 113:3 129:5 158:20 173:8 183:2 comment 10:13 14:6,25 15:2,20 15:22 24:10 25:1 42:10 51:20,22 64:14,15 65:7 88:5 89:2 97:24 97:25 98:1 100:19 107:12,12 109:20 109:24 113:12,13 122:17,18 129:9 131:24 149:2 151:12 152:13 167:13 172:5,23 176:21 177:2 commented 33:23 57:7 64:9 109:23 140:23 152:11 commenting 150:6 175:5 comments 11:20 36:4 53:22 64:2,3 100:13 175:4 committee 82:12,22 149:4 152:8,8 171:1,20,20 172:7 175:9 committees 62:2 173:13 common 8:5 17:4	49:14 172:17,19 communication 92:19 compare 11:7 58:2 compared 59:23 80:8 83:3 158:2 comparing 156:15 156:16 competence 6:4,8 complaint 92:12 complete 15:8 43:8 46:11 65:7 72:14 181:23 completed 182:17 completely 73:25 142:17,25 completeness 21:25 complicated 97:4 component 15:24 composition 25:14 25:17 computer 116:21 122:1 concentrated 71:7 71:13 concentrating 22:7 concentration 97:13 108:11 109:7 120:12 125:13 129:4 130:20,24 131:4 132:13,18,22 133:20,23 134:6 134:20 135:1,2,19 135:22 136:19,21 138:4 concentrations 131:14 132:24 concept 61:11 108:13 concepts 174:10 concern 29:18 41:12,13 74:9 147:10,14,17 concerned 14:21 31:8 51:9 60:10
--	--	--	---	--

65:24 79:20 86:11 93:5 121:11 122:4 139:7 concerns 40:14 70:7 102:5 174:3 conclude 44:19 77:10 concluded 4:20 10:24 30:19 98:12 131:23 concludes 51:5 83:6 conclusion 73:1 76:10 83:12 101:3 119:14 120:24 127:8 152:19 156:19 165:21 conclusions 76:16 82:21,23 83:1 119:8 126:17 156:17 157:2 conclusive 99:8 conditions 24:16 89:24 90:1,2,3 132:8 conducted 18:23 conducting 18:19 confident 142:15 confirm 18:4 97:9 122:2 144:6 confirmed 141:1 confused 123:12 confuses 155:6 confusing 124:7 confusingly 164:8 confusion 96:7 consequence 145:22 146:5 165:22,25 171:2 consequences 115:11 Consequently 99:24 conservative 40:4 86:23 87:1 88:4 115:3 139:19,20	160:17 161:2 consider 33:25 55:11 159:16 considerable 4:21 37:16 54:17 72:20 73:20 74:2,14 133:5 175:17 considerably 56:18 consideration 5:20 5:21 29:20 103:4 considerations 3:17 considered 1:14 5:6 16:17 39:7 100:9 166:25 considering 100:23 103:1 133:21 174:11 considers 47:23 consistent 100:2 consistently 96:6 constant 118:6 136:13 constituents 73:13 construct 127:4 132:6 135:4 consultancy 28:2,7 consultant 26:22 28:6 consulted 1:18 consumption 18:25 contact 27:5,6 91:20 92:7 103:16 container 49:5 contains 51:21 81:18 114:3 115:22 contaminant 96:2 contaminated 48:8 97:21 111:3,25 113:17,19 115:1 119:10,16,17 120:25 121:4 125:1 133:16 contamination 5:3 6:11 14:2 24:19	25:6 40:6,7,10,11 62:22 64:10,12 66:6,6 67:21 68:20 72:3,8,9,9 72:16 73:4,6,8,11 88:9 96:4 103:2 103:17,22,23 104:11 107:18 120:2,17 135:17 contemporaneous 40:13 46:3 contemporary 45:11 46:23 contender 179:9 contenders 62:16 contentious 76:24 contents 92:13 context 14:11 18:8 18:15 27:2 32:19 94:7 continue 41:7 139:6 178:3 continued 1:3,4 28:7 140:4 185:2 185:3 continuously 45:17 contour 56:20 contrast 137:16 contrasts 47:13 control 19:9,14 21:14 83:3 controlled 70:25,25 71:13,17 72:7 controls 62:16 71:2 71:7 106:8 controversial 82:22 convenient 44:12 142:23 conversation 162:14 conversely 80:21 conversion 163:4 converted 163:1 convinced 47:7 cooling 97:13 copied 92:2 93:2	115:20 copies 1:20,20 copy 23:5 115:18 176:3 coral 90:1,3 corner 54:10 61:14 124:14,16 correct 3:15,23,24 7:4 15:7 16:12 17:1 18:5,7 27:11 31:1 43:19 64:1 71:14 80:20 83:21 86:19 100:12 106:21 120:14 125:23 136:24 145:7,16 153:24 158:2 162:13 163:13 corrected 82:10 123:5 correctly 21:6 70:12 88:2 100:9 110:9 118:14 145:18 148:16 160:12 correlate 16:22 corresponds 9:16 99:2 count 71:22 counted 42:13,15 45:9 counter 8:18,18 66:5 78:5 79:4,6 93:23 94:17,22 counters 25:5,8 62:23 140:24 counters' 24:14 counting 24:14 53:14,16 counts 8:21 couple 13:13,14 16:10 34:23 74:20 108:3 course 1:25 15:22 16:17 18:8 19:8 30:11,12 34:15	52:7 72:22 79:16 79:17 103:25 113:3 122:15 134:22 136:15 141:19 145:21 146:1,11 147:11 147:25 150:3 155:17 158:2 159:15 167:15 169:11,22 170:2 173:1 175:16 177:2 court 78:10 79:23 183:17,18 184:18 cover 36:20 43:8 44:1 crawls 75:6 create 132:6 crew 115:19 criminal 79:23 criticise 14:13 criticising 105:22 criticism 7:15 106:17 criticisms 57:14 cross-examination 1:4 30:4 87:21 144:15 179:1 182:17 185:3,4 cross-examine 181:12 cross-purposes 136:1 crucial 67:17 crude 10:8 47:12 50:5 cubed 84:6 cubic 109:17 142:5 cultural 153:20 154:16 culture 14:12 145:1 153:10,25 154:13 173:9,18 Cumbria 2:1 cumulonimbus 100:10
--	--	--	--	--

cumulus 100:16	29:18 44:22 45:25	demonstrate 18:4	39:25 41:25	develop 36:4
curious 146:3	72:10 76:12 83:23	demonstrated	123:20 141:11	169:23
Curiously 184:2	84:25 85:21 92:16	115:24	describes 26:20	developed 100:1
current 154:7	141:11,13	denied 146:6	48:20	developing 143:15
174:7 180:8	deals 26:8 50:17	dense 99:21	describing 49:3	device 8:19 182:10
currently 26:22	61:11	deny 144:7	98:24 117:20	devices 9:18 48:3
78:11	dealt 100:11	departed 178:23	description 50:4	diagonal 118:23
cut 181:2	debatable 56:19	depend 99:15 142:8	desert 89:24 91:1	diagram 124:7
	debate 5:10,16 6:1	169:22	desk 92:24 183:7	diameter 125:6
	36:24,24 113:18	depended 5:12	Desmond 33:5	129:12 132:21
D	122:20 170:16	dependent 84:16	despair 23:4,6	133:7 134:14
d 32:9 33:5 86:18	debris 24:23	depending 167:5	despite 50:1 80:1	diameters 135:5
123:11,11 185:1	decay 9:8 110:21	depends 94:9 170:2	93:7	Diana 113:14
damage 160:8,18	123:5 138:19	deposed 27:8	detail 4:12 10:2	dictate 102:7
damaging 163:10	139:24	deposit 80:17,23,25	32:17 52:18	die 160:5,6 165:16
damp 113:16	decayed 70:18	84:3 85:4 114:4	105:18 106:14	165:18 166:2
damping 113:20	110:20 140:7	deposited 9:25	116:11 117:16	difference 55:21
danger 71:5	decaying 11:5	37:21 48:5,7 59:6	121:25 172:6	56:13 108:6 167:7
dangerous 73:12	138:21	70:17 91:5 107:14	177:4	differences 52:22
170:13	decays 8:20	110:13,17 112:12	detailed 21:8 92:15	different 7:3 24:6
dangers 152:21	decide 136:16	158:15 160:22	102:8	42:2 49:4 68:14
Darroudi 22:15	decided 88:25	165:5,25 166:4	details 22:4 50:22	73:1 77:17 85:1
data 35:11 46:21	89:13,18	168:1	detect 24:20 39:24	86:3 103:10 126:5
46:22 52:25 87:16	decision 14:13	deposition 26:17	94:4 104:11	132:14 136:17
95:3 98:9 127:15	deck 113:17,17	27:22 28:20 29:16	detectable 103:14	142:18,25 153:7
153:23 154:11	deduced 85:3	38:20 39:20 54:15	detected 64:7 66:7	156:15,17 163:23
155:23 172:12,20	deduction 102:13	55:20 56:5,12,15	71:22 72:17 73:3	166:13 181:4
172:21	137:25 168:11,12	57:8 58:2,3 61:13	detecting 25:19	182:7
database 11:7	170:15	61:15,22 62:9	detection 103:3	differing 60:14
dataset 107:19	deeper 120:6	80:24 81:4,6,7,13	detector 68:6,6,7	difficult 10:2,21
date 7:22 23:22	defend 60:23 72:11	83:22,24 84:2,8,9	68:10,13	16:6,7 41:12
dated 7:21	72:23	84:12 85:5,11	detectors 9:3	64:17 98:1 99:19
day 41:10 79:5 93:7	deficiencies 60:25	86:5 95:14,16,25	determine 9:4	100:18 116:8
113:9 119:12,16	defined 9:17	101:16,20 102:1	determined 8:17	122:24 142:7
123:11 145:9	definite 132:3	102:16 107:20	48:2	151:17
180:10,11,15,21	definitely 43:14	108:8,11,15,22	determining 39:20	difficulties 35:16
181:7,8,10,12,13	175:7	109:1,13 110:2,4	detonated 5:17	45:20 73:20 74:2
182:18	definition 62:1,3	110:4 111:21	detonation 3:5 4:9	difficulty 15:4
days 10:22 94:12	definitive 45:16	113:9 142:6,8	12:22 51:6 54:16	39:10 64:13 111:9
94:21 123:12	degree 4:19 27:19	depositions 61:19	94:10,22 98:5	175:17
140:18	81:19 143:15	depth 138:5	101:13 123:7,9,11	diffusion 128:23
deal 29:7 36:1,9	179:8	descent 97:21	124:14 128:17	136:18
63:2,3 77:21,22	degrees 99:18	99:23	131:3 139:3,4	dimensions 137:25
87:17 95:8 104:1	delay 50:17	describe 26:12	140:21 141:7	163:17 164:12
114:11,13 147:16	deliberately 130:16	116:10 117:13	detonations 54:5	diminished 130:25
147:19	delivery 174:4	described 37:8	54:12 70:16 98:12	direct 8:10 63:11

66:19 97:20 direction 16:22 77:7 81:11 83:25 95:10 108:20 117:23 118:20 126:6 134:13 136:10,12,17 directions 125:22 Directive 154:10 Director 173:1 dis 173:12 disagree 57:2 96:9 100:6 101:8 116:4 discomfort 74:11 discovered 118:4 121:3 discrete 48:2 discrimination 10:7 discuss 4:11 5:2 74:13 104:17 170:18 discussed 3:6,12,16 4:15 26:7 44:1 50:18 53:16 69:22 70:5 74:5 106:6 discusses 51:16 discussing 1:14 2:19 156:2,9 174:21 discussion 3:5 4:1 33:17 34:4 81:18 81:19 145:3 178:18 dismissed 155:25 156:25 157:6,8,8 dispatched 21:8 dispersed 122:16 dispersing 122:24 disproportionate 61:25 dissenters 171:21 dissimilar 138:4 distance 7:17 54:17 133:5 135:3 distributed 37:15	42:4 168:16 distribution 39:24 50:24 53:8,12,18 53:23 177:3,5 distributions 48:2 disturbed 84:23,24 divide 165:6 166:23 divider 32:9 33:5 34:20 35:1 54:22 DNA 174:9 document 31:12 32:15 93:9 183:15 183:16 184:3 documentary 63:13 documentation 11:16 34:11 67:2 documented 110:6 documents 1:17 11:22 156:12 doing 2:8 7:15,18 10:16 26:20 27:4 38:21 65:8 84:10 86:3 108:11 113:2 167:7 176:19 177:14 dosage 94:23 dose 9:16,16 14:23 15:5,13 16:5,21 16:24 29:4 47:21 48:1 53:8,12 57:15 62:5 63:21 77:5,12 95:1,2 102:2,25 103:10 103:12,24 107:16 115:3 146:7,8 147:3 150:13,14 151:6 152:17,18 154:6,9 157:7,19 157:20,23,25 158:13,15,17 160:16 161:6,10 161:12,18 162:11 162:21,24 163:1,2 163:2,4,4,5,12,12 163:13,18,20,20 163:20,21 164:6,6	164:8,9,9,13,14 164:15,16,16,18 165:7,9,12,13,19 166:13,24 167:14 167:17,20,21,22 167:22,23,23 168:2,4,7,20,23 168:24 169:9,14 173:14 174:4,10 175:11 doses 12:11 13:21 14:1 15:18 17:2 51:15 145:12 146:17,20 159:16 160:25 161:15 162:1,3,21 174:22 175:12 dosimeters 8:2,5 9:15 12:10 13:20 15:12,17 74:5,13 74:14 dosimetric 151:17 162:8 dosimetry 6:16 13:1 83:14 143:9 151:3,15,22 152:1 152:13 159:19 160:23 165:14 175:24 doubled 127:13,17 doubt 41:16 43:16 45:19,22 59:19,20 72:20,21,24 73:2 95:22 97:6 151:2 Doubts 102:21 doze 167:3 Dr 4:18 22:10,11 22:15,24 26:5,11 29:14,24 30:11,16 39:9 53:21 54:19 55:17 56:2 57:2 60:13 61:10 62:11 80:9 87:21,25 92:3,5,9,22 95:13 100:12 101:7 105:14 109:25	111:14 113:10 127:19 131:21,25 138:24 144:15,16 147:15,25 150:8 150:12,19 151:9 152:9 153:4 155:21 157:13 164:23 165:11,12 166:11 169:2 172:25 176:12 177:19,24 178:5 179:2,10,14,17,23 180:4,8,13,17,18 180:19,21,23 181:1,9,14,18 183:15 184:3 185:4 dragged 89:6 dragging 84:18 89:5 draw 14:21 34:8,11 126:17 127:8 157:2 drawing 53:24 droplets 97:3,13,19 99:20,22 drops 54:6 96:21 drug 158:3 dry 28:20 39:16 40:15 41:8,15 56:5 57:4,6,8 80:17 101:16 110:2 113:9 duct 166:22 due 34:15 96:21 115:4,6 duplicate 174:15 dust 84:21 89:9,10 89:17,20 90:21 91:5,7,8,9,14 113:13,20 114:3 dusty 84:19 89:7 90:9,25 91:8,12 112:11 dying 166:5	E E 185:1 e-mail 92:6,8,11,13 e-mails 92:2,20 earlier 26:8 35:4 47:14,23 52:17 56:4 60:7 103:24 106:6 119:12,16 123:1 140:15 earth 5:24 114:2 easier 16:9 easiest 35:23 east 119:3 eastern 119:4,21,22 120:1 121:14 edge 119:19 121:23 effect 56:5 98:13 143:7 146:4,4,8 146:17 148:5 150:13,14 157:19 157:20 161:7,25 162:8 effective 24:21 38:19 94:1 111:21 111:25 113:18 138:13 163:20,20 164:6,8,9 effectively 38:14 40:6 43:24 48:21 68:13 86:22 153:18 161:24 167:25 170:9 171:16 effects 48:6 57:20 57:25 60:11 61:17 97:5 146:19,20 efficacy 47:8 efficiency 58:3 96:14 efficient 57:21 58:1 169:22 effort 41:8 efforts 98:4 eight 10:22 either 11:19 12:19 21:19 43:25 46:3
--	--	---	--	--

63:19 70:6 95:25 140:22 177:6 182:15 elaboration 87:6 electronic 116:20 element 59:19,20 elements 49:5 97:20 embedded 153:12 emission 8:16 174:5 emitted 165:3 emitters 11:18,23 19:1 25:18,19 68:24,25 69:1 73:12,14,15,16 emitting 8:7 15:15 164:21 emphasise 18:19 empirical 12:11 89:3 employ 153:14 employed 175:12 employees 143:8 enabling 48:1 encountered 120:5 128:2,11 endeavour 179:10 ended 166:20,21 energies 10:7 energy 10:9,9 154:5 158:15,16 165:5 166:23 169:19 engine 129:21 England 41:20,21 42:12,17 45:7 50:18 55:6 enormous 136:5 enormously 153:25 ensure 92:6,18 entirely 25:10 83:10 103:7 153:4 environment 47:12 49:17 89:7 90:9 90:20,25 91:8	97:14 99:17 112:11 149:5 153:11 environmental 26:16,23 27:1,19 28:3,7,8,13,13 54:19 56:3 80:14 81:9 88:14 101:25 102:5 environmentalist 82:17 epidemiological 154:24 155:1,3 epidemiologist 147:23 epidemiology 19:9 75:11 76:24 150:5 150:22 episodes 147:15 equally 153:24 equation 142:13 equipment 21:3 72:1 124:3 equivalent 58:25 163:2,4,12,13,20 163:21 164:9,15 164:16 165:9 error 92:6 122:2 155:11 errors 139:17 especially 58:1 essentially 6:3 126:16 Est 27:21 establish 19:5 136:23 148:5 154:17 established 80:8 83:3 estimate 10:19 81:15 84:7,14 85:18 94:23 100:4 152:16 168:3 180:9,24 estimated 15:23 105:20 127:11,18	129:12 134:16 172:16 estimates 103:11 103:12,24 110:23 151:6 152:22 162:15 163:19 172:12 estimating 105:23 175:25 et 46:9 50:21 71:13 European 154:9 evaluation 157:10 157:11 evaporating 47:18 99:14 evening 178:2,15 evenly 168:16 event 17:12 39:14 82:1 99:16 100:21 115:23 116:3 117:20 141:15 events 45:25 everybody 180:22 evidence 1:13 2:18 3:20 4:13 5:9 8:1 17:14 18:21 19:6 26:13 30:14 31:3 31:6,8 32:17 33:15 34:13,14 35:7,17 38:9 39:9 40:4,13 54:18 55:17 57:11 59:11 59:14 63:11 65:18 66:19 67:20,22,23 69:12,15,16,21,24 70:11 71:11 72:15 74:10 76:18 79:6 79:6,6 80:2 87:9 88:21 89:14 92:14 92:16 99:9 102:14 102:22,25 104:19 104:25 105:2 114:11 115:25 116:1 121:1,13 126:13,15 135:18 136:23 140:14	141:12 143:1 146:4 152:20 155:18,24 156:5 156:16 181:24 exact 52:4 exactly 5:13 45:20 56:18 63:9 67:24 115:14 116:5 124:6 132:20 157:5 exaggerate 131:17 examination 94:1 137:18 examined 94:17 143:24 examining 18:19 example 9:8,24 12:8 16:8 17:18 17:23 18:3 25:4 28:16 31:3 33:1 39:13 46:19 59:1 69:18 73:4 80:9 107:6 140:17 145:2 153:12 154:7 157:5 158:3 159:5 166:15 169:24 174:22 examples 7:5 9:22 exceeded 5:8 exceedingly 40:12 exception 10:21 70:21,23 169:11 excess 73:8 145:10 145:17,19,20 147:19 excesses 149:22 excessively 105:9 exchange 157:12 exclude 150:22 exercise 85:24 86:3 86:16 102:4 105:12 117:17 132:16 138:9 exhibited 83:5 existed 6:11 104:7 existence 107:17	expand 85:25 116:21 122:1 150:10 152:16 175:15 expanded 129:13 132:19,22 expect 13:7 17:1 37:20 40:8 51:5 51:24 53:20 59:17 70:16 72:13 84:20 100:22 106:8,9 expected 12:21 33:17 37:18,23 38:9 66:23 71:2,8 experience 17:18 31:5 49:15 118:2 experienced 12:15 107:12,23 125:24 126:1 137:22 experiencing 120:16 experimental 28:21 98:7,8 137:22 experiments 89:6 expert 4:2,13 33:23 53:21 100:4,15 110:1 158:9,10,12 158:23 159:19 160:23 174:18 175:7 expertise 2:13,14 3:18,19 6:4,8,10 7:3 26:8,14,17 27:16 29:24 56:3 58:11,12 60:17 62:10,10 80:10,14 81:7,8 82:1 95:19 98:2 99:11 101:19 101:23 108:19,23 109:19 111:1,19 113:10,24 114:5 126:6,9,19,20 127:2 130:7 135:15 137:16,19 137:21 142:12 149:2 150:5
---	---	---	---	---

151:11 152:1,6,25 157:17 162:9 167:10 168:11 169:8 170:24,25 172:6 174:14 176:2,15 177:13 experts 30:6 175:6 experts' 2:13 explain 75:14 104:4 110:15 122:8 147:16 148:7 162:20 explained 88:23,24 105:8 107:15 156:19,20 157:21 explaining 179:15 explanation 121:12 148:14,17,20 149:10 explanations 76:20 148:6,13,25 explore 77:24 144:17 148:1 151:22 explored 126:12 exploring 162:17 explosion 4:7 5:22 111:18 122:13 123:22 128:14 136:3 140:2 169:3 explosions 140:19 170:8 expose 41:8 exposed 9:17,20,23 15:14,15 19:12,13 36:25 38:23 47:11 75:24 76:3,5,14 109:9 135:6 165:15,16 168:10 168:13 exposure 9:19 12:20 13:22 15:19 15:24 19:6 32:12 102:5 108:18 109:5 130:15 133:4,14 135:25	143:22,25 145:22 146:6 160:1 exposures 103:2 express 43:16 73:2 expressed 53:5 72:24 expressing 45:19 expression 5:23 26:25 142:2 expressions 96:7 129:15 extend 130:9 133:8 extended 76:4 128:17 129:14,15 130:3,4,13,14 extensive 98:4 102:7 extent 3:16 102:13 112:17 122:16 174:7 external 9:19,23 12:10,20 15:13 68:25 69:1 extract 32:21,23 extrapolation 168:10 extreme 58:22 103:20 107:2 118:15 119:1,4 120:1 121:17 131:10 extremely 27:1 92:5 107:19 138:21 165:12,13 eye 65:18 eyebrows 82:25	85:3 89:16 92:11 92:13 104:16 115:18 120:14 122:22 131:19 132:12 134:5 147:12 151:1 158:9 160:22 164:14 170:11 172:7 177:10 183:17 factor 39:18 58:7 58:15 59:3 81:16 81:23,25 83:23 84:15 85:25 86:21 86:24,25 87:3 88:25 89:19 90:17 91:2,12,15 152:12 161:23 163:6,7,8 163:17,22,23,25 164:4,5,11,18,25 165:8 171:17,18 171:24 172:21,22 175:10,11 factors 26:16 90:8 156:10 164:3 172:11 175:25 facts 114:24 failure 15:3 faint 117:4 fair 4:4 7:1 14:5,14 14:25 15:2,20,22 30:1 51:20 62:13 72:17 105:4 107:11 131:24 145:12,13 146:9 156:1 167:6 180:18,20 182:1 fairly 10:8 159:3 fall 85:19 98:11 99:20 112:18 131:21 fallen 27:10 125:1 126:23 127:5 falling 38:16 84:1,2 96:14 99:16 111:17 114:2	fallout 4:21,23 9:25 13:9,24 24:21 33:15 47:9 48:1,7 48:8 50:10,23,24 52:4 53:9,12 55:13 60:12,13 62:17 64:7 71:9 71:17,21 73:14 76:4 114:21 115:4 115:6,24,25 116:1 117:24 118:3 120:6,7,25 fallout/residues 13:22 falls 27:8 false 131:1,1 familiar 25:2 48:13 81:10 149:5,14 far 11:15,16,21 21:12 24:24 26:2 31:8 44:9 46:8,10 50:3 55:24 59:25 60:5,17 67:1 79:20 86:11 93:5 94:9 108:24 116:5 116:11,13 120:13 120:14 122:4 133:14 145:8 164:22 166:25 faster 99:20 favourable 139:21 features 5:16 23:25 February 54:25 175:18 feel 142:14 176:18 177:11,12 feeling 95:18 129:24 feet 99:4 129:24 fell 5:24 55:7 61:18 felt 6:3,8,9 89:21 111:1,4 113:1 115:23 127:15 175:21 fewer 166:4 field 12:15 24:12	24:19 25:7,9 107:23 137:16 figure 80:19 88:1,3 99:5 103:5 109:4 109:8,12 110:16 124:4 151:18 164:24 figures 94:2,3 123:18 151:18 files 1:25 film 8:9 10:3,4 12:23,24 13:10 16:16,21,25 final 52:25 142:3 158:11 163:18 finally 142:16 find 11:17 12:23 13:11 31:19 34:19 34:23,24 35:1 44:13 54:24 64:23 69:21 77:24 78:19 83:19 87:11,12,15 88:22 99:19 101:8 112:23 129:3 142:13 178:14 181:5 finds 11:25 fine 6:7 74:7,7,12 91:8 142:2 177:19 178:5 179:4 finish 126:10 149:9 176:9 179:2 finished 45:14 131:7 finite 167:23 firing 41:11 firm 31:23 first 3:3 7:6 22:1 23:3 26:7 30:5,7 31:18 32:18,18 34:20 36:9,11 39:2 41:18 45:21 47:3 48:10 49:17 51:1 52:12 58:10 62:14 63:3 68:8 68:23 69:4,23
	F			

81:25 83:16 85:1 85:14 97:23 101:11 104:15 105:15 108:3,12 115:13 117:20 118:4,11 119:1,18 119:19,25 122:10 124:7 126:13 128:1 136:12 138:14 140:25 147:23 149:14 155:2,9,10 159:2 162:20 167:13 171:10 182:16	following 29:6 34:24 36:5 41:11 50:25 52:2 95:9 118:21 follows 15:13 foot 36:14 footage 100:20 forensically 92:5 Forgive 38:6 40:22 form 17:11 21:14 21:16 97:10 110:18 formation 97:2,24 formed 96:3 97:17 formula 109:15 formulae 108:20 forward 67:4,7 69:8 106:19 148:14 149:14 forwarded 41:20 found 64:12,24 66:15 70:1,5 83:19 98:11 113:17 118:10 129:17 149:22 foundation 143:15 four 4:19 54:6 55:1 143:13 155:11 fraction 13:23 fragile 25:9 fragments 9:24 frank 77:16 frankly 12:23 77:15 freeze 99:15,19 freezing 99:23 French 183:11 fresh 48:25 Friday 1:14 2:11 2:19 3:12 7:12 8:1 9:14 13:3 17:17,22 23:16 74:6 182:3 183:8 friend 39:15 136:17 Friendly 136:16 front 33:16 82:5	98:8 142:17 FTT 184:4 Fuels 144:23 full 85:8 166:12 fully 176:18 function 144:17 functionality 37:11 further 11:3 19:7 21:18 36:4 40:1 64:14 92:18 97:21 98:13 118:9 148:2 165:19 fusion 52:22 futile 117:17	genetic 166:6 gentlemen 65:6 getting 39:15 74:8 74:19 86:7 108:2 145:17 146:12 150:20 160:24 177:4 gist 146:24 give 2:5 8:5,10,19 9:3 28:16 30:14 55:3 74:10 79:2 79:13 84:22 94:13 94:23 95:5 102:12 147:17 148:2 154:8 162:15 164:5 167:21,21 168:2,14 175:19 given 8:20,21 13:12 16:19 24:22 25:20 40:7 43:6,6 48:1,2 54:18 77:6,9 81:13 84:11 95:11 100:19 107:18 113:16 135:16,17 138:25 143:1 148:21 150:4 169:2 170:25 174:24 177:21 gives 39:13 52:10 52:17 64:13 99:5 102:15 167:22 giving 8:1 9:6 26:13 51:14 71:4 102:1 174:17 gloomy 182:10 go 4:12 8:13 10:2 15:9 16:15 21:22 22:18 23:9 25:21 26:19 27:18 32:9 33:1 34:16 35:21 40:18,24 46:24 47:2 50:3,8 51:4 53:6 54:21 55:4,9 56:8 57:11 61:9 77:7,17 81:5,22 85:14 89:18 93:1	93:10 95:12,15,21 104:4 107:10 108:2,24 114:5,9 136:17 142:16,24 150:2,10,17,18 151:21 152:7 155:8,9 157:18,19 158:6,11,21 160:13 163:19 167:18,19 169:17 171:23 175:8 176:7 177:20 178:17 179:3 183:20 184:6 goes 3:9 5:19 51:12 53:20 98:2 105:17 136:5,7 166:17 184:7 going 2:9,9 3:2 13:14 17:13 19:8 22:4 29:2 33:7 34:10 36:16 37:1 45:16 49:8 50:16 52:1 55:3,4 56:18 65:14 68:12 73:6 74:16,22 75:1,25 77:22 78:12,16 80:7,15 85:8 86:13 89:7 91:4 95:11 107:6 108:19,20 122:20 126:4 127:21,22 128:3 144:18 145:4 148:5 149:9 149:20,24 151:19 154:23 156:22 157:2,12 158:24 162:2 164:24 169:7 170:24 178:17 179:25 181:20 182:3,10 good 1:5 3:8 23:12 26:2 34:13 37:14 41:4 49:14,22,25 60:20 68:9 79:6 113:12,20 116:22
		G		
		gamma 8:16 9:7,23 10:7,8,9,9 25:18 73:14 115:5 118:5 120:7,9 163:7 gamma-ray 13:21 15:14 gamma-sensitive 24:20 25:12 gamma/beta 12:10 15:13 gammas 8:22 gaps 46:12 garden 55:19,22 56:11,14 Gardner 147:15 gas 25:2,3 170:9 gas-filled 8:17 24:14 gases 27:22 Geiger 62:22 66:5 68:18 78:5 79:4,5 93:23 94:17,22 140:24 Geiger-Muller 8:17 general 35:22 49:3 53:10 80:1 94:11 150:12 169:9 178:18 generally 55:14 159:2		

144:16 154:20,25 172:12,20,21 179:23 Government 14:20 18:11,20 106:3 governmental 28:10 gradually 122:23 grams 159:8 graph 167:16,19 Grapple 3:6,23 4:10,22 5:14 12:9 13:20 15:10,16 36:18 46:20 50:25 51:6 63:19,19,20 63:21 64:2,3 67:7 70:14,14 71:14,14 97:11 100:19 102:3 115:21 grass 58:5 gravity 96:22 100:17 gray 162:24 grays 182:11 great 29:7 58:19 92:19 104:1 134:21 135:18 147:16,19 greater 60:17 137:19 148:22 152:22 167:4 greatest 126:8 grid 117:5 grinding 2:17 gross 8:19 9:18 ground 5:19,21 6:14 8:5 17:4 48:7 62:24 63:9 65:21 68:22 70:9 70:13,14 73:19 80:23,25 81:13 84:1,2,4,8,12,17 84:19,19,23 85:3 85:4,11,15,19 86:5 99:14 102:16 103:17 104:12	110:14,17 111:6 112:12 114:4 142:6 group 76:2 83:3 105:14 127:19 153:11 groups 19:9 grown-in' 48:6 guess 49:20 153:19 159:7,8 <hr/> H <hr/> h 86:18 88:16 123:6 123:8 129:6 138:11,17,17,21 139:8,9,11,14,15 139:16,16 140:8 140:10,10 Haar 1:4,6,10 2:5 11:12 20:20 23:1 23:5,9,15 26:3,5,7 33:3,5,7,9,12 38:17 44:19 49:13 74:24 77:22 79:18 79:20 80:6,7 90:14,16 93:17 95:5 121:11,18 122:4 124:11 134:4 142:21,25 144:3,13 157:21 180:10,14 181:13 185:3 habit 10:16 habitation 54:17 half 10:20,22,23 11:1,6,8 48:24 123:25 138:15 139:3,4,6,15 140:2,4 166:18 180:10,11,15 181:6,8,10,12,13 Hallard 1:3,10 2:5 14:18 32:5 33:13 40:20 44:19 71:4 77:23 79:21 92:25 93:10,17 126:8	144:16 179:3 185:2 halt 2:17 hand 1:11 146:16 146:18 156:17,18 167:2 Handbook 29:17 Handed 1:23 183:21 handheld 8:18 handle 68:16 hanging 180:7 happen 19:19 happened 30:15 141:15 happening 71:16 117:19 146:15 happens 159:16 happy 74:6 79:23 97:22 183:19 184:6 hard 35:11 103:20 106:14 180:3 harmful 51:17 Harrison 160:15 172:14,14 173:1 175:9 176:4,17 Harwell 183:23 Harwell/Culham 28:1 hay 66:4 Haylock 180:4,8,19 181:6,18 hazards 12:5 head 6:18 45:21 headed 22:1 32:11 82:14 95:14 header 117:4 heading 24:11 95:15 health 70:19 143:8 157:21 hear 19:8 heard 143:18 147:17 hearing 87:2,19	heart 92:17 Heavens 33:12 heavy 66:1 110:7 height 3:6,23 4:6 4:10 6:5 98:24 99:1,3 101:13 129:18 help 35:19 39:24 55:11 81:5 83:18 94:6 116:23 151:16 153:2 162:22 helped 2:12 helpful 2:8 34:25 77:16,24 81:22 84:25 151:9 153:5 157:20 182:25 helps 182:19 hemisphere 118:19 Heppinstall 79:21 79:24 92:25 93:9 180:2 181:6,17,19 181:21 182:1,4,8 182:13,20,22 183:1,5,11,14,23 184:2,8,11,14 heterogeneity 174:4 Hey 146:18 high 5:13 10:9 37:17 38:15,23 40:5 59:8,9 62:19 64:4 65:10,12,13 72:8 84:21,22 97:12,18,25 98:17 107:14 118:5 121:8 129:19 131:23 160:1 161:8,12 165:12 165:13 166:3 168:7 183:17 higher 8:13 53:10 54:1 59:4 61:15 61:21 90:10 91:11 94:13 99:20 103:23 104:1	107:19 120:12 131:5 135:22 139:15 163:9 167:23,24 168:6 169:15 177:2,6 highest 18:16 55:6 58:16 59:1 120:16 121:16,20 160:25 highlighted 122:18 highlighting 18:21 highly 14:16 27:13 40:4 57:7 76:23 86:20 97:14 hindsight 35:16 74:15 Hiroshima 98:9 historical 5:13 18:8 44:25 51:1 historically 31:9 history 26:21 144:20 hits 85:3 HMS 113:14 hoc 72:15,15 Hogan 31:23 32:22 hold 12:15 23:1 68:15 88:17 107:24 hole-punched 1:21 homes 113:21 honest 49:18 64:24 116:23 154:20 159:8 172:23 hope 5:9 21:23 22:22 23:10 46:4 92:20 105:7 120:13 122:1 147:24 hoped 19:12 hopefully 183:7,14 hoping 180:15 horizontally 128:24 hot 34:4 47:11 49:16 57:18,18 61:12,15,20,24
--	--	--	---	---

62:4,5,8 160:20 165:23,24 168:15 169:19,25 175:3 hotness 169:23 170:10 hour 48:24 110:11 110:13 123:6,7,9 123:22 124:21,25 125:9 134:12 138:14 139:3,3,4 139:6,6,23 140:2 140:4,4,21 hour's 139:24 hours 11:1,6 47:11 49:16 99:7 122:13 122:23 123:1 129:3,17 134:7 136:13,15,21 137:3 141:8 housekeeping 1:6 1:10 178:22 185:5 Howard 159:24 huge 76:25 112:23 140:12 169:16 hugely 68:14 129:13,15 135:8 human 27:5,6 49:8 60:1 141:14 humid 47:11 49:16 humidities 98:16 98:17,19,20 hundred 129:24 148:22 hundreds 159:8 hymn 25:25 hypotheses 150:22 151:21 hypothesis 134:1 147:1,16 149:12 151:24 hypothetical 169:17	134:19 IAEA 154:7 ICRP 148:23 152:22 153:14 154:1,1,6,8,11 155:16 156:9,9,12 160:10,14 165:21 165:22 166:22,25 167:7,25 168:19 168:23 169:4 173:11,13 175:2 175:25 ICRP/103 175:2 idea 148:1 151:5 169:23 identified 12:6 49:23 53:2 62:20 64:4 identify 2:11 17:7 identifying 9:22 25:21 ignored 155:25 156:24 157:8 imagine 31:9 96:9 96:23 imminent 18:9 impacted 96:21 implication 62:6 160:2,15 imply 156:23 importance 41:10 62:4 important 12:2 17:14 26:11 27:2 29:12 51:13 67:22 67:22 75:12 98:17 98:18 115:23 132:14 141:12 146:14 147:22 148:4,10,12 153:25 174:3 importantly 62:5 impossible 44:25 97:9 131:20 imprecise 64:16 impressed 140:1	impression 101:8 improbable 54:3 57:8 in-cloud 95:25 96:4 97:1,20 in-cloud' 96:7 inaccurate 19:2 92:11 inadequate 66:17 73:25 101:25 106:11 inadequately 104:20,21 inches 36:15 include 13:8 67:18 82:16 176:3,11,12 176:13,14 included 1:24 15:23 42:2,3,7 45:5 73:11,14 97:18 172:14,15 172:17,18 174:6 including 29:8 36:24 67:14 70:9 92:3,4 97:2,25 incomplete 46:8 incorporated 96:2 175:10 incorporation 97:3 97:20 increase 72:4 115:3 120:15 increased 119:4 120:8,11,19 increases 155:4 incremental 120:20 120:21,22 127:14 127:16 indicate 38:14 90:7 90:8 124:20 indicated 10:13 112:13 116:17 118:21 121:20 132:1 133:11 135:1,12 170:23 170:25	indicates 156:21 indicating 21:16 120:11 indication 10:6 19:6 38:23 45:14 52:10 106:15 119:5 138:23 indications 63:20 102:12 indicators 62:19 individual 9:17,20 61:24 68:19,20 individuals 9:22 15:12,14 industry 144:20,22 153:13 inert 25:3 infer 8:11 10:19 38:22 inference 146:22 168:5 inform 19:7 information 4:25 5:1,2 6:22 9:4 29:2,3,8,8 37:6 38:1 48:15 51:21 53:3 72:15 82:2 87:8,16 100:19 102:15 115:17,20 115:22 127:8 138:24 172:8 informed 66:20 ingestion 8:6 11:23 95:1 ingestion/inhalat... 11:18 inhabitants 65:1 141:23 inhabited 53:11 54:2,6,13 67:19 67:20 124:17,24 125:10,18 126:23 127:6 128:17 130:4,9,14 131:13 132:5 133:8,15 134:10,13,25	135:6 137:8,13 138:2 inhalation 8:6 11:23 130:11 168:23 169:9,14 inhale 112:6,9,9 inhaled 51:14 166:16,19 inhaling 112:1 inherent 138:8 139:17 inhomogeneity 53:22 61:11,12,20 inhomogeneous 39:11,24 40:11 initial 21:4,6 initiate 14:8 initiated 100:17 inland 54:9 innate 88:20 innocently 153:10 input 132:15 inquiry 150:21 inside 68:18 75:7 121:17 159:22 insofar 26:8 60:10 79:4 121:10 instance 61:13 instructed 23:8 81:2 instruction 113:16 instrument 21:1 71:21,23 instrumentation 64:11 instruments 20:14 60:1 64:7,8 66:5 71:23,25 72:5,6 insufficient 56:25 107:16 integrated 9:15 110:22 intend 180:14 intended 130:11 132:7 168:25 intense 121:14
<hr/> I <hr/>				
i.e 28:5 101:20 123:7 128:9				

122:25	intuitive 112:4	111:17 114:22	Jolly 116:22	152:10 153:1,3
intention 117:23,25	113:23	117:6,22 118:24	joule 158:16 162:25	155:19 157:9
118:2 130:8	intuitively 37:9	119:10,19 121:2	joules 158:17 159:4	162:10,14,23
interactions 174:8	84:20	122:11 124:15,17	162:12 163:16	163:3,11,15 166:6
174:12	investigate 173:18	126:2,23 128:18	164:10	166:9 171:25
interception 96:13	investigation 5:13	130:4,5,10,14,21	judge 85:15	172:3,5 176:9
interest 18:17	invisible 155:25	131:6,13,21 133:9	judged 14:7	177:15,21 178:2,6
interested 94:18	156:25	134:11,18 135:24	judgment 6:4,9	178:9,12,17,23
interim 46:19	invite 93:25	137:7,8,10,12	11:8,10 12:17	179:5,13,15,19,24
internal 8:6 11:17	involve 5:25 35:5	141:23,24	14:10 16:25 17:15	180:6,11,17,20,22
11:23 12:20 13:1	97:5 178:19	islands 42:4	17:20,21,23 18:4	180:24 181:3,8,11
13:5,8 14:2,8,17	involved 11:9 24:7	isotope 10:19,24,25	18:5,6 19:7 72:18	181:15,18,20,22
15:19,24 18:3,25	64:25 113:15	11:5,6,8	72:19 82:2 86:23	182:2,6,9,14,21
19:6 51:15 55:4	119:11 138:16	isotopes 10:20 11:9	102:11 112:4	182:23 183:2,10
68:24 69:2 152:13	143:3 152:9	51:16 53:1	135:13 173:23	183:12,22,25
152:17,18 154:6	155:14 173:14	issue 4:1 36:10 51:4	judgments 126:16	184:7,9,12,15
159:19 160:23	involves 96:13 97:1	57:6,14 79:21	June 1:1 184:19	justification 87:7
168:23 171:12,18	INWORKS 143:17	92:17 105:17	JUSTICE 1:5,9,17	justified 105:7
175:24	iodine 183:11	142:25 149:16	1:20,23 2:3 10:12	
internally 51:17	iodine-131 10:21	154:16 157:15,23	10:18 11:11 19:18	K
international 66:11	ionising 145:23,24	179:6,17	20:1,10,16 23:3,7	keep 47:15 66:21
154:2,3,4	163:9	issued 12:10 16:16	23:13 26:1,4,6	76:20
internationally	island 4:24 5:3,4,6	16:20	33:2,4,6,8,11 37:3	keeping 41:14
154:12	6:2,12 11:19	issues 5:15 22:11	37:25 38:3,5,7	Kenneth 22:23
interplay 75:11	12:16,25 16:4,17	30:20 34:6 52:19	43:17,20 44:3,8	23:8
interpret 107:16	16:24 19:14,21	81:9 151:20	44:12 48:19 49:4	Kent 27:20
122:6 169:7	20:17,18,24 21:4	179:20,21	49:7 74:22 77:20	kept 40:15 46:4,14
interpretation	21:7,10 32:12	item 183:7	78:1,4,8,12,21,25	106:10
110:3 141:21	36:20 37:15 39:6	items 1:24 183:6	79:11,15 80:1,5	key 28:23 35:20
160:24 161:3	39:22 40:6,7,10		90:12,15 91:17,22	kicked 86:6,8,9,13
166:1 173:19	41:25 42:6,7,9,13	J	92:1,10,23 93:4	179:20
174:24	42:15 43:3,11	jet 129:21	93:12,15,19,22,24	kidney 164:1
interpreted 119:6,9	44:10 45:2,8,9	JOC 42:14	94:7,15,21 95:4	kill 169:21
140:20 155:23	46:10 50:14,21	jogs 143:21	116:15,18,22,24	killed 160:25 161:8
interpreting 127:3	53:9 54:8,11	John 172:14 173:1	117:3,13,21	161:8 168:8
153:23	55:13 56:17 58:24	175:9 176:4,17	118:18,22,25	killing 170:9,14
interrupted 45:15	59:2,5,7,16 63:18	Johnson's 4:6	119:21,23 120:4	kilogram 158:17
interrupting 74:11	64:6,12,17 65:1	Johnston 4:2,15	121:5,9,18,23	159:3,4,9 162:12
interval 120:10,10	66:5 67:11,13	22:20,23 23:7,8	123:10,14,17,20	162:25 163:16
intervals 120:9	68:5,7 69:13,19	23:19 25:16 30:10	123:25 124:2	164:10
interview 92:16	69:20 70:9,19,20	87:24 88:2 103:12	134:3 142:20,24	kilograms 159:6,11
intimidation 92:12	70:24 71:1 76:8	Johnston's 23:6	144:6,14 146:24	159:14
intolerable 89:18	76:15 90:1,4,10	51:3,23	147:1,5,8 148:2	kilometres 36:21
89:21 90:18	94:19 100:3	joint 42:6 43:3,13	149:7,9 150:2,7	39:23 43:4 50:15
introduce 59:19,20	101:16 102:2	45:5 54:14 70:22	150:10,15,20	54:5,13 67:11
introduced 161:24	104:6,8 107:18	71:24 166:22	151:1,5,15 152:3	124:17,21 125:5,5

125:7 132:21	28:1	166:9 177:22	library 93:2,4,8	165:23
133:10,12 134:10	laboratory 24:16	178:10,12	life 10:20,22 11:1,6	located 43:13
134:15,17,19	lack 53:14 59:12	let's 35:25 36:9	68:8 123:25	location 42:5 57:19
138:1	126:18	40:18 48:24 53:4	153:13 179:15	61:19 66:11
kilotonnes 98:15	land 57:22 85:7	53:6 56:8 57:10	light-scattering	logged 47:15
kind 20:16,18,25	landscape 14:18	69:4 73:19 74:5	27:24	123:21
49:11 94:12 95:2	117:3	80:5 101:9 108:24	lightly 84:23	logic 86:24 90:8
153:20 156:23	language 23:14	109:21 127:23	likelihood 17:6	91:16 166:10
160:8 174:20	111:15	128:20 134:1	60:13 110:2 160:4	logical 132:10
kinds 149:18	laptop 122:1	141:13 142:24	limit 107:5 157:11	137:25 146:22
kinetics 56:16	large 2:18 3:16,25	166:18 170:6	limitations 50:7	148:17,19 154:19
Kingdom 45:3	4:15 7:2 13:23	letter 21:15,19,20	limited 18:10 40:12	168:11
Kinlen 149:15	21:2 25:5 37:8	40:16,25 41:1,17	50:2,2 61:2 79:21	London 19:23
knew 147:12	57:23 58:1 61:23	43:7,14 70:18	107:19 149:17	54:14 65:5,11,16
knocking 150:16	96:21 114:17	leukaemia 83:4	limits 103:3 167:9	65:21,23 66:13
know 7:12,17 10:2	132:25 162:5	145:4,10,21,22	Lindahl 22:10,11	67:14,17 69:7
17:7 19:18 25:15	177:7	147:2,9,18 149:22	line 55:9 61:10	102:22 110:7
25:19 34:22 36:11	Large's 3:1 4:7 7:6	157:4,6	119:19 150:20,23	124:18 137:8
42:18 44:9,12	largely 10:1 52:19	level 17:15 18:16	151:24 167:17,17	140:17,24 141:18
45:18 46:8,13,15	146:16	38:13 39:1 40:5	167:20 171:22	141:22
48:16,19 49:19	larger 133:6 164:24	58:23,23 59:8,9	177:24	long 10:23 34:1
55:18 56:21,21,23	largest 51:5,9,23	59:13,18,22,24,24	linear 167:16	36:20 46:1 56:25
66:13 67:24 71:15	late 25:10 182:15	61:5,6 83:4 84:5	lines 15:9 96:20	76:5 94:10 144:22
71:15 79:22 80:23	laundry 69:18,19	84:21 87:23 89:10	117:6	145:7 167:5
81:7 82:18 85:5,9	69:20	89:10,17 94:3,13	linked 121:12	178:25
106:10 115:14	law 31:23	99:14 100:16,20	list 1:17,24 2:2 30:3	long-winded
116:5 122:3	lead 28:2 55:20	100:22,25 103:13	31:13,14 32:6	174:20
124:16 138:13	56:12 62:4 156:16	103:15,22,23	180:12	longer 180:12
141:8 145:8 149:2	leading 62:15 97:2	104:15 118:5,6	lit 42:4	look 2:6 6:1 35:7
150:21 155:15	leads 13:12 62:24	120:2 128:12	little 8:13 37:2	54:18 58:4 68:14
159:7,9 162:3,16	learned 157:14	134:22,24,24	68:15 107:10	77:12 79:8 90:18
164:19,20,21	learning 179:21	135:10 136:19	110:10 113:22	91:19 99:4 106:1
167:7 173:16	leave 44:24 157:13	152:6 169:5	122:11 125:5	106:13 109:21
182:6,9 183:5	led 5:20	174:12	131:22 139:15,15	114:18 115:13
knowing 13:23	left 47:10 49:16	levels 5:3,8 6:11	141:18 165:19	116:18 131:9
knowledge 6:21	143:11,12,14	20:4,6 38:15,23	liver 164:1 166:21	146:18 148:5,6
14:12 108:21	144:21	53:10 54:1 62:8	lives 10:23 11:8	155:4 167:2
151:2	left-hand 55:5	65:10,12,13 70:23	138:15	168:25 171:7
known 12:6 24:22	155:10	70:24 72:8,8 73:9	loath 77:7	173:24 178:24
29:4 145:22 146:5	legal 14:18	97:18,25 103:3	local 24:21 54:15	181:3,22 182:4,6
knows 79:24	legitimate 53:6	104:7,8 105:13	131:6 135:17,23	looked 2:11 7:12
krypton 25:4	88:13,17 103:8	110:14,16 116:9	161:6 163:9 168:4	32:2 56:4 69:15
KW 28:19,21	151:14,24	116:13 118:10	169:20	87:14 137:17
	length 111:14	120:22 121:8,8,21	localised 50:9 73:3	149:3,16,18,19
	114:13	123:4,6 124:9	73:6,8,11 137:6	156:12,13,13,14
	lengthy 34:25	135:2 151:3,15	137:11 160:1	looking 4:22 20:5,7
<hr/> L <hr/>				
laboratories 20:24				

27:4,7 29:24	84:24 98:16 99:18	118:3 136:20	maximum 103:18	28:21 35:8,8,14
35:15 45:22 54:24	100:20,22 110:3	157:10 166:14	104:16 125:11,12	47:22 51:19 52:9
93:1 101:3 108:11	129:23 145:12	man 107:12	127:14,16	55:21 56:13,25
111:10 125:21	146:17 157:7	management 5:4,5	mb 98:21,22	59:22 62:14 63:25
146:7 148:24	161:9 167:1,15	12:16 16:17 21:4	mbq 109:12	64:3 66:4,14
149:17 168:4	169:25	manager 21:15	mean 38:12 46:14	81:20 89:3,5
177:16	lower 5:17 90:9	map 24:20	48:14 56:20 58:21	97:10 98:7 105:3
looks 26:1 177:4	91:15 100:10,16	maps 56:20	78:13 90:6,21	115:21 116:5,7
183:2,20	100:25 101:12	Maralinga 11:19	93:6 94:8 97:23	118:3 119:18,20
Lord 1:6,13 10:15	120:17 124:9	22:7	109:8 111:23,24	119:23,25 120:1
19:24 37:7 38:2,6	128:12 131:14	margin 125:8	113:20 138:17	127:11
43:19,23 48:20	132:24 135:2	169:16	145:2 153:18	measuring 14:23
78:3,7,18 79:18	138:20 139:16	maritime 119:11	156:3,7 166:12	21:3 45:1 62:17
79:19,20 80:4	169:10 170:3,5	markedly 132:13	169:24 170:16	93:21 103:19
87:18 91:21 92:9	177:3,6	marks 35:18 76:17	174:24 180:20	124:9 129:2,4
92:22 93:14 95:1	lowest 94:3	83:11	meaning 162:11	182:9
116:17,20 117:8	lunch 86:2 87:18	mass 20:12,13	179:15	medical 22:11,15
117:18 124:6	90:13 91:17 108:5	165:6	meaningless	149:4
144:4,9,13 147:4	luncheon 91:19	massive 58:19	174:11	medium 48:21,23
150:8,25 151:9,11	lung 163:25 166:16	massively 91:3	means 52:3 92:8	49:1 61:23
152:24 157:13	166:18,20	material 5:18,21	94:1	meeting 183:23
162:13,19 176:10	lymphatic 159:5,12	7:2 13:24 27:8	meant 8:12 10:15	megabecquerels
177:19 178:8,16		32:2 39:21 47:17	measurable 13:20	109:14,16
179:3,12,18,23	M	47:24 48:7 57:24	16:21	member 82:22
180:19 181:10,17	MacDougall 40:16	86:13 96:14 98:1	measure 8:15,21	membership 82:16
181:19,21 182:1,5	42:21,22 78:20,21	107:15 111:20,22	9:15 11:4 20:13	memory 1:25 29:6
182:13 183:5	machine 20:2,16,18	122:6,22 128:24	25:6 55:13 68:21	34:1,2 35:20 45:6
Lord's 23:5	machinery 20:23	136:5	80:21 85:2	78:13 88:2 89:8
lose 49:15	24:25 124:3	materials 27:24	measured 8:20 9:6	100:8 116:14
loses 37:10 39:3	machines 20:8 21:9	29:19,19 97:19	9:7 14:1 17:13	118:14 120:13
loss 37:25	magnitude 55:21	113:8	50:23 53:8,10	121:16 126:7
lost 6:18 33:2 37:22	56:13 79:13 89:19	mathematical	54:1 55:20 56:12	133:10 134:8
lot 3:25 37:10 40:3	170:5	126:21 127:4	58:4,5 59:2 66:10	143:21 145:17
52:18 60:24 75:24	main 43:5 54:13	132:6 133:18	73:9 103:16 116:9	160:12 161:19
76:17,18 83:10	65:11,25 67:18,19	135:4 174:16,16	130:19 134:5,22	169:13
105:5 107:7	67:20 110:7 120:6	mathematically	158:16 162:25	men 64:25 65:2,13
115:19,22 125:22	124:18 125:6,8	164:20	164:10,16	men's 12:8
126:4 131:11	137:7,8 156:20	mathematics 6:15	measurement 8:6	mentioned 17:22
146:10,18,19	171:20	maths 6:18 161:20	8:10 47:16 48:3	30:8 47:7 78:23
147:20 155:17	major 29:4 40:16	162:6	48:11 56:24 58:16	81:12 106:23
159:11,14 169:21	42:21,22 78:20	matter 3:11 19:10	60:7 71:12,18	met 140:24 141:24
171:5	majority 12:9,18	34:15 41:1 45:1	74:20 102:7 103:4	meteorological
lots 1:20	12:18 13:19 16:20	50:13 92:21 94:3	103:20 107:14	3:17 122:7 126:16
Lovells 31:24	43:11 52:23	167:12	117:9 118:4	126:19
Lovells' 32:22	making 32:5 40:21	matters 1:7 44:22	measurements 9:19	meteorologists 5:20
low 10:8 38:13,22	68:1 89:23 104:13	80:10	11:4 12:7,11	126:14 137:22

meteorology 26:9 35:5 56:23 62:10 133:19	41:2,16 74:7 76:21 148:11 151:5 165:14 179:4 180:6	modified 52:25	163:21	needs 93:4 103:3 107:15
meterological 4:16 5:10 26:13,14 30:17 126:25 130:6 132:8,15 136:23	mine 60:17 113:11	molecular 174:12	mushroom 97:10 99:13 100:1 101:20	negative 66:21
meters 104:10	minimal 70:3	moment 2:1,5 7:5 11:20 23:1 29:23 30:3 31:17 44:13 65:5 93:11 113:1 118:16 129:16 177:23 180:3 181:5 182:4,14	mutated 161:9	negligence 14:19 18:20
method 48:11 62:21 71:18 86:22 148:9 155:21	minimum 18:23 56:20 61:5 125:12 134:18	Monday 1:1	mutating 170:13	neither 131:22
methods 16:3 35:8 35:20 60:6 74:20	minority 161:13	monitor 17:16 18:2 68:12	mutation 160:8 161:1 165:20 166:5,7 168:14	nervous 65:9
method 16:3 35:8 35:20 60:6 74:20	minus 87:3,4,24 88:3,6,6,8,12,13 88:18,19 89:1,1,8 89:9,13,17 99:18	monitored 140:25 141:2 142:1	<hr/> N <hr/>	network 102:8
metre 81:14 84:6,9 84:13 109:14,17 142:5	minute 106:23 122:18	monitoring 5:1,2 6:10 11:17,22 13:1,6,8 14:8,17 17:16,25 24:12,18 55:12 59:25 62:21 64:6,15 65:2,8,9 65:15,19,23,25 68:3,4 72:1 78:2 111:5	N 185:1	never 20:25 49:19 87:8 111:3 184:4
metres 109:2,12 114:2	minutes 11:7 44:15 49:2 78:24 100:2 110:11 118:6,7,8 179:16 183:23	monitors 60:1 62:22 66:6 68:2 141:25	Nagasaki 98:10	nevertheless 89:21 102:13 116:1
mFISH 143:19,24	missed 30:13 32:5	month 18:1	name 28:19 65:4	new 75:19 76:13 102:6 154:7 173:15
microcurie 58:25	missing 17:14 46:3	months 18:1 70:15 78:10 112:21 122:3 179:3	nanometres 159:25 170:7,7	Nicholson 4:18 26:11 28:6,19,21 29:14 30:11,11,16 53:21 54:19 56:2 57:2 60:13 61:10 80:9 87:21,25 88:4 100:12 101:7 131:21,25 138:24
micrometer 51:7	mistaken 176:21	Mosaic 47:14	narrow 134:23 179:7	Nicholson's 26:5 29:24 39:9 55:17 62:11 95:13 109:25 111:14 113:10
micrometre 112:14 168:21,21	misunderstand 49:20 151:4	move 48:25 64:13 73:19 74:5,19 80:7 92:20 128:20 157:16 163:11	narrower 128:19 131:4	non-communicat... 80:2
micrometres 96:18 96:19	mix 52:10,15,18 176:24,25	motor 49:11	national 18:17 173:2	non-governmental 28:10
micron 51:7 161:16 161:18 165:5 166:18,19 168:19 168:20,21 169:4 169:10,11,15,15	mixed 73:17 91:5	movement 48:21 137:16,20 162:14	nature 9:5 26:15 90:21 100:23	non-homogeneous 53:22
microphone 68:14	mixing 149:13	movements 85:9	naval 75:20 76:13	non-measurable 16:24
microR 120:1	Mm-hm 152:3	moving 7:6 49:8 77:20 78:1 134:13	near 17:11	non-nuclear 149:23
mid-point 140:12	model 98:5,10 153:15 155:16,24 155:24 156:24 166:25 167:16,20 169:4	multiplied 164:17	nearby 86:8	non-uniform 53:8 53:17
middle 31:19 89:24 131:11 177:7,9	modelled 98:13	multiply 59:3 161:25 165:8	necessarily 12:13 116:25 129:4 130:23 134:6	non-zero 14:1 15:13,18
mightn't 59:14	modelling 173:15	multiplied 164:17	necessary 50:8 92:10 152:1,25 157:14 181:16	
migrate 93:4	models 168:25 174:7	multiply 59:3	need 3:3 16:15 17:24 20:8 21:21 74:22 80:23 85:5 85:9 91:19 99:1 102:7 110:16 122:6 127:6 138:3 151:7 152:16 178:12 179:7,8,16 179:20 180:18 182:3	
miles 78:11	moderate 79:6	multiplied 164:17	needed 7:1 80:2 84:11,11	
military 5:5	moderately 98:18	multiplied 164:17	needle 103:19	
millibars 98:23,25 99:2	modern 10:4 14:7 14:13,14 15:20,22 17:5,10,12 18:21 19:1,3 20:14 25:7 49:10 72:12 102:6	multiplied 164:17		
millisieverts 94:5,7 94:8,14,24,25 161:11 182:11		multiplied 164:17		
mind 36:5 40:25		multiplied 164:17		

normal 14:16 56:19	184:15	once 33:12 56:17	31:14 46:16,18	115:7,19 123:21
note 6:6 7:14 13:18	observation 148:11	73:19 79:4 180:7	originally 81:12,12	155:2,3,8,9
30:21 70:7 96:4	148:17	one's 45:21	137:2 149:20	171:10,14 173:25
114:7 183:17	observations 151:1	ones 23:21 25:7	originated 100:25	pages 28:17 32:16
noted 11:15 24:13	observed 65:12	58:6 153:23	originating 99:15	55:1,4 86:17 95:9
100:15 171:15	100:3 135:20	165:17,19	outcome 77:8 89:7	155:5
notes 61:9	148:18 156:21	ongoing 51:15	160:5	pancreas 166:24
notice 106:7 183:3	observing 120:8	open 7:24 31:18	outer 131:10	pancreatic 166:22
noticed 113:13	obsolete 68:11	47:25 54:20 68:16	outline 167:6	167:1
noting 23:22	obvious 68:21	72:19,21 76:21	outset 136:22	paper 1:25 26:12
notwithstanding	104:9	148:11	outside 3:17,19	29:14,15 35:19,25
184:2	obviously 3:24	opening 49:5	71:17 96:23 99:10	36:13,22 37:8,13
nowadays 14:8	32:19 35:13 41:4	operated 28:6	101:4,14,19,23	37:19,21 38:10,13
20:12	52:23 112:20	45:17	108:19,23 109:19	38:18 40:8 41:22
NRPB 87:10	148:13 152:9	Operations 42:6	109:23 110:25	42:3,8 43:1,6,9,11
nuclear 17:11 24:8	occasionally 77:3	43:3,13 45:5	126:6,9,19 127:2	43:15,25 45:11
31:5 98:5 143:4	occasions 10:23	54:14 70:22 71:24	133:5 137:16,20	46:5,9 49:21
144:20,22,23	70:9 107:3	opinion 72:25	142:11 149:1	59:23,24 60:15,23
148:19 149:17,19	occur 148:18	88:17 148:8	174:14	62:15,19 121:7
149:20 150:2	occurred 107:20	174:18	overall 56:15 76:16	143:6 155:1,3,3
153:13 157:6	110:4 131:3 143:7	opposed 38:5 56:24	overlap 4:19,19	155:13 160:10,14
169:3 170:8	occurs 148:18	122:19	12:1 125:8	176:17
nucleation 97:2,19	off-scale 103:15	optimistic 103:1	overlapped 125:18	papers 28:12,16,18
nuclide 52:18	104:12	order 6:23 23:17	132:5 134:11,17	40:14 41:5,8,14
164:21	offered 93:17	37:3 51:7 55:21	134:25 137:7	41:24 42:12 43:17
nuclides 28:3,8	offshore 65:2	56:13 79:13 85:6	overnight 93:3	49:12 55:16,19
53:2 172:15,17,19	Oh 31:11 55:16	89:19 100:1	oversight 64:21	56:11 60:19 87:9
177:1,8	129:20 159:7	110:23 112:14	Oxford 149:15	87:10,11 156:15
number 8:19,21	181:1	122:6 125:1,4,8		160:14 161:3
13:5 35:18 49:24	okay 11:11 33:22	125:18 126:17	P	paracetamol 158:3
56:19 70:21 92:2	34:16 35:24 44:8	132:6 133:8	Pacific 41:23 42:2	paragraph 7:25
92:4 97:12 107:1	56:9 60:9 82:20	134:10,14,15,19	42:5,7,9,11,18,20	8:14,24 9:2 11:13
114:17 117:7	88:20 94:2 109:10	135:5 136:19	42:25 45:4 78:22	13:17 24:11 26:19
119:7 122:7	114:10 123:2	137:23 138:1	78:23 90:1	27:18 28:11 36:2
127:22 148:19	127:25 128:21	143:21 148:7	page 3:8,9 7:24,24	36:12 41:5 47:4
165:15,16 168:7,9	129:7 130:2 131:8	167:4 168:18	8:14 11:12,14	48:14 49:17 50:16
168:12 172:15,17	132:17 133:23	169:1	22:1 24:10 28:18	52:1 53:5 63:3
172:19 176:15,16	134:8 136:2,25	orders 170:5	31:18,20 32:11	95:24 96:10 99:11
numbering 55:3,3	139:12 142:19	organ 158:19 159:4	33:1,7 36:1,5,6,7	100:11 102:10
numbers 16:11,13	146:10,23 151:25	160:19,20 168:2	36:9,16,17 40:24	107:25 171:22,23
117:7,8,9 161:21	153:1 159:18	organise 17:25	41:19,19 47:3,6	173:25 174:1
O	160:14 162:19	organs 159:5	50:8,16 55:1,5	paragraphs 13:13
o'clock 178:4,7	167:9 170:22	163:24	57:13 61:10 63:5	13:15
179:9,10 181:24	179:12,14	orientate 118:18	83:20 88:16 95:14	parameters 56:21
181:25 182:18,24	old 68:10	origin 167:18	95:15 101:6,7,24	175:20
	omission 105:15	original 13:18 23:1	107:10 114:9	paraphrase 148:15

pardon 4:18 38:4 64:10 99:6 121:20 165:3	20:7 41:10 51:16 53:9 61:4 66:12 86:14,18 90:20 93:9 107:6 110:19 115:23 153:13,16 155:23 156:8 177:24 182:25 183:3	133:20,23 134:6 134:22 142:4	29:15 63:22 90:20	139:16 140:8,10 140:10
part 5:12 18:20 24:1 26:20 29:12 35:17 42:9 49:4 63:8 80:13 82:4,7 98:7 102:9 111:13 114:16 116:12 121:1 125:23,25 126:1,3,5 130:3,5 130:10,14,18 131:6,10,13 135:15,23 137:6 137:11 162:1 176:13	particularly 5:1 11:5 12:18 13:10 21:2 37:14,20 46:7 47:10 49:22 51:6,17 57:4 61:2 73:15 82:7 83:4 84:16 112:13 114:2,17 124:18 152:17 160:10 168:8 175:3 177:6 181:13	peer 155:13 pending 80:2 people 7:2 12:18 16:16,17,20 17:17 17:23 18:3 19:20 25:2 41:14 59:25 60:24 62:22 65:8 65:15,20 68:3,4 69:7 72:1,6 75:18 75:19,23 89:11 92:4 128:2 133:4 137:21 140:9,24 141:23 146:16,18 146:21 149:19 151:20 152:5 155:7	physicists 70:19 physics 157:22 pick 24:10 50:9 61:8 71:19 123:14 177:19,20 picked 26:17 34:3 picking 124:3 picture 102:1 145:1 piece 37:8 67:22,23 85:7 121:7 126:15 pieces 24:25 36:13 piston 129:21 place 5:12 30:5 70:10,15 104:6 136:3 138:14 167:11	plutonium 17:17 20:4,4,6,13 24:22 73:15,16 110:18 161:17,22 164:21 165:2,4,18 166:19 169:11,13 170:3 170:11 172:18
partially 116:14 149:11	particulate 27:24 37:21	people's 3:22 135:14 140:9 162:18	placed 104:11 plan 116:15,17 117:1,5 118:18 123:21	pm 91:23,25 144:10,12 184:17
particle 26:17 28:22 29:9 50:24 51:4,5,22,23 59:19 61:24,24 112:7,10 159:20 159:22,23 160:2,7 160:9,20,21 161:6 161:18 162:4 164:19 165:2,18 165:23,24 166:15 167:3,5,11 168:15 168:18,19,22 169:17,18,19,19 169:23,24,25 170:6,19 171:2 174:5	particulates 47:20 parts 30:2 33:18 64:11,16 126:23 128:18 133:9 134:11 137:8 Pascini 31:3 pass 1:23 68:13,19 passage 41:4 passed 48:8 85:12 85:16 passing 69:16,18 patchiness 61:12 patchy 39:17 40:11 100:23	percentage 67:10 perfectly 49:14 72:25 153:22 perimeter 133:5 period 8:23 9:17 18:2,17 41:10 45:15,18 48:1,24 94:11 110:24 118:6 130:24 141:7	plane 120:3,5,24 121:2 122:10 planes 129:21,22 planning 118:13 182:25 plant 17:18,24 plants 143:4 plausible 115:10 playing 161:19 please 11:12,13 22:19 26:19 31:17 34:16 40:24 41:7 46:24 47:2 49:20 54:21,22 55:9 95:6,10,12,15 114:9 122:9 126:10 146:11 148:3 150:10	Po 8:8 pocket 181:2 point 5:6 8:1 21:19 30:20 32:5 34:14 49:13 51:8,18 52:2,6 54:16,19 60:16 61:6 67:17 88:15 89:20 90:16 92:10 102:24 104:12 106:16 107:11 111:7 113:23 121:16 122:21 124:13 126:11 127:23 128:22 131:9,16 133:20 138:20 139:19 140:9,12 142:3,23 150:9,12 155:2,14 157:13 158:11,19 167:19 176:23,24 178:14
particles 26:23 27:22 28:5,9,14 28:20 34:4 50:23 51:9,10,13,19,24 52:14,15 57:21,23 58:1,8 62:4 91:2,3 96:16,21 112:14 159:17,24 160:3 161:16 162:16 168:25 169:3 174:6,22 175:3	path 118:21 pathway 12:5 80:14 86:7 107:17 pathways 26:24 27:1,1 56:3 102:6 137:23	periods 48:3 permit 179:11 person 12:15 21:20 49:8 68:21 70:13 153:11 154:15 173:22 personal 8:2,5 9:15 148:8 personnel 9:21 13:19 pessimistic 181:23 PhD 27:20 philosophical 155:21 physical 27:19	plunge 117:16 plus 110:18,18 123:6,8,11,11,12 129:6 138:11,17 138:17,21 139:8,9 139:12,14,15,16	pointed 32:14 157:10 169:18 pointing 50:1 56:2 129:16 168:17 points 33:18 57:12 57:13 69:23 74:21 77:23 120:22 121:15 123:2 Polynesia 184:10 Polynesian 183:11 poor 38:21 105:1 population 16:23 17:1 149:13 Port 54:14 65:5,10
particular 8:7 12:8	peak 120:20,21 130:19,20 132:13			

65:16,21,23 66:13 67:14,17 69:7 102:22 110:7 124:18 137:8 140:17,23 141:18 141:22 position 15:5 47:25 96:15 154:17 positive 66:21 131:22 possibilities 76:3 111:10 156:4 possibility 14:2 62:8 76:11 100:9 111:16 128:4,15 128:16 132:2 156:3 possible 10:21 11:9 49:20 53:13,23 73:5 77:2 97:11 98:13 99:9 100:18 100:24 101:16,21 105:9 129:8 144:3 145:24 147:18 148:6,13,25 153:8 153:15 155:16 156:5 167:6 possibly 41:13 53:13 153:24 167:4 170:16 post-detonation 15:18 post-doctoral 27:23 postulating 129:10 potential 16:18 53:15 88:8 90:6 91:13 102:2 potentially 85:1 160:7 165:20 166:5 168:14 pouring 39:13 power 149:20 150:3 170:9 practical 24:21 practice 14:24	practices 147:20 pre-dating 70:20 pre-select 17:12 pre-selection 74:14 precipitation 97:17 100:16 precise 6:5 59:21 78:25 151:9 precisely 94:9 preferable 150:3 preparation 24:17 prepared 1:15,16 presence 78:16 present 9:5 10:24 15:11 35:16 41:7 42:16 47:21 52:4 145:8 151:2,6 presentation 147:17 preserving 106:12 pressure 98:23 101:12 presumably 65:21 89:20 115:19 129:1 previous 3:21 30:5 30:7 47:13 87:2 87:19 92:15 126:13 previously 47:7 primary 119:13 principal 7:13 62:21 168:19,22 principally 20:4 63:25 104:18 175:22 177:10 principle 19:17 48:16,20 57:21 80:1 print 155:6 prior 81:21 prism 153:21 pristine 93:5 private 26:22 28:6 probabilities 45:23 111:12,13	probability 50:14 76:11 128:4 131:23 probable 83:12 101:2 150:23 probably 19:15 35:23 44:7 50:3 57:23 63:19 76:14 83:6,7 86:2 149:13 160:3 177:25 182:18 probe 102:12,13,14 102:19 103:16,18 103:19 104:11 probes 24:20 25:12 68:4,5 103:14,14 104:9,9 140:15,17 probing 167:9,10 problem 16:1 98:8 104:14 138:8 153:9 155:22 179:18 problems 14:22 17:8 22:22 23:16 39:2 55:24 57:3 60:8 122:5 127:23 143:7 procedures 12:6 16:3 19:10 35:15 104:5 proceedings 91:18 178:14 183:17 process 13:2 19:20 25:21 28:14 37:5 96:15 97:4,16 133:17,18 137:14 156:22,24 179:8 processes 28:4 97:1 97:19 produce 90:17 produced 7:14 13:23 30:22 31:13 82:11 84:21 89:9 169:3 produces 15:4 producing 40:1	63:13 products 9:8,25 110:18,19 professional 68:8 Professor 7:11,21 10:10 11:2 16:11 22:1,6 25:16 30:10 47:3 48:11 48:17 51:8 92:4 114:14 149:15 157:24 158:22 159:15,23,24 181:6 prognosis 12:21 prognostication 182:11 programme 20:21 24:8 57:14 69:13 69:24 101:25 projects 28:9 prompted 177:22 pronouncing 39:10 proof 99:8 proper 87:23 88:11 properly 3:4 18:23 66:20 151:12 178:13 properties 27:24 proportion 16:23 19:4,16 25:20 39:5 proportional 24:14 25:4,8 proposing 180:4 proposition 35:22 101:11 121:13 protecting 17:10 protection 3:14 12:1 119:12 143:16 173:2 provide 17:19 provided 13:19 15:11,17 24:21 34:22 55:13 provides 50:22 Pu 8:8 13:24	published 28:12 143:6 pulling 71:5 Puncher 176:5 purely 11:10 133:17 135:4,14 149:17 purpose 21:11 29:10 78:14 85:5 87:25 pursuing 177:24 put 5:4 23:13 34:16 46:24 48:22 54:20 55:19 56:11 66:8 72:24 76:19 85:24 87:23 95:5 113:19 141:12 148:9,14 149:14 150:15 153:7 154:14 155:7,19 173:7 180:25 183:8 184:13 putting 32:19 36:22 86:12 94:16,22 117:3 puzzling 11:25
Q				
				qualification 10:10 10:12 102:11 qualifications 16:11 qualified 127:20 174:18 qualify 9:11 16:14 37:12 quantify 175:20 quantity 164:5 quarters 83:1 question 12:13 16:14 37:3,7 44:20,20 50:17 55:10,10 62:24 63:7,15,16 76:17 77:7,9 78:15 79:1 79:3,19 93:20,24

95:7 108:4 111:4 111:24 113:24 114:1,6,7 121:25 142:3 144:25 146:24 147:2,6 150:7,8,15 151:4 151:13,14,23 153:2,3,9 157:3 161:5,5,10,10 166:14 168:5 174:19 178:13 179:13 questionable 13:7 130:18 174:11 questions 7:12 35:1 35:18 75:10 80:5 83:11 87:20 105:17 114:14 121:10 144:4,13 167:10 175:18 177:12,21 179:6,6 quick 20:1 31:13 142:21 178:18 quickly 6:19 79:13 87:17 99:15 142:13 quite 3:25 7:13 11:2 17:1 19:16 20:8 21:2 23:15 25:9 34:1 40:3 49:23 52:18 60:20 61:1 67:21 68:9 68:19 76:5 83:10 87:17 88:24 94:2 100:7 105:10 107:2 110:2 115:22,25 118:5 119:7 121:4 124:6 129:23 131:5,11 139:2 142:13 144:21 145:18 146:10 147:20 153:4,10 155:15 156:14,15 159:11 159:14,19 162:18 166:9 172:19	177:21,22 180:2 180:24 182:9 183:19 184:10 quote 87:9 105:19 168:20,23 175:19 quoted 105:19 154:7,9 quotes 16:12 quoting 58:22 126:7 127:2,15 <hr/> R <hr/> radial 47:24 radiation 8:7,16,22 9:6,19,21,23 12:5 15:14,16,19 16:18 38:19 60:1,12 63:25 64:3,9 66:3 66:10 68:17 75:24 76:4,6,14 77:3,5 77:11 104:10 115:6,21 116:9,13 117:9 118:5,10 120:9 121:14,17 123:4 127:11 143:15,23,25 145:11,23,24 146:5,6 148:20,21 149:4 152:21 160:6,8 163:6,6,7 163:8,10,17 164:4 164:18,22 165:1 165:17,23,24 166:3 167:21,22 168:9 171:12 radio 28:3 radioactive 5:22,23 8:20 27:8 29:19 29:21 38:3,4,6,8 39:21 48:8 60:12 80:10,17 94:23 97:18 98:1 107:14 111:17,20 113:8 115:15 123:25 128:24 138:14 radioactivity 6:17	27:5,7 28:13 38:15,24 48:6 61:25 62:17 71:17 80:18,22 84:3,7 85:2,8,12 102:5 116:6 122:15,25 128:1,11 129:5,17 138:11 141:18 158:1 Radiochemistry 24:6 radiochemists 24:2 24:15 radioisotopes 8:8 52:4 176:25 radiological 3:13 12:1 173:2 radionuclei 9:5 radionuclide 52:3 radionuclides 25:15,17 26:23 52:11 95:14 171:19,24 172:12 radiophysicist 24:4 radius 125:19 133:10 134:9,10 134:18 135:20,21 165:5 rain 36:23 37:1,4 37:16,16,17 38:2 38:5,24 39:1,10 39:13 55:6,25 61:18 65:10,12,13 96:14 97:10,24 98:5,11 99:15 100:3,9,21 101:2 101:20 110:7,9,11 111:17,20,25 112:1 116:2 125:1 132:2,4 138:25 139:2,23 140:1 141:1,25 rain-laden 113:3 raindrops 99:13 112:6,9 114:1 rainfall 37:20 38:8	38:15 39:17 59:18 66:1 90:10 100:23 100:25 110:12 111:2 112:5 126:23 127:5 131:20 133:16,22 138:25 139:10,11 140:5,6 raining 43:8 44:1 111:24 rainout 98:12,15 rainout' 96:5 98:6 rains 41:9 rainwater 41:9 43:1,2,7,9,10,12 43:18,21 44:2,3,5 44:9 46:9 74:1,3 raise 1:8 151:19 raised 70:7 83:1,11 87:20 105:17 126:11 157:23 random 176:24 177:8 range 10:6 88:5,11 96:16 108:22 151:18 161:16 174:5 177:7,8 rapid 110:21 138:19 rapidly 97:13 112:18 118:11 138:21 rate 11:5 21:12 71:22 110:20,21 115:3 118:14 119:2,3 120:7,14 120:19 127:17 131:9 138:19 raw 46:21,22 87:16 RAYNER 22:24 rays 9:7 re-examination 180:1 re-examined 151:8 re-suspended 27:9 91:6,10,14 108:7	112:12 reaching 99:13 reactor 149:25 reactors 149:25 read 3:4 4:13 10:16 31:2 32:24 34:2 41:13 43:23 48:14 64:17 78:9 83:14 93:8 100:7 110:9 123:18 127:2,3 133:2 139:23 141:5 144:2 145:15 152:5 159:19 160:11 161:4 171:25 readily 103:14 104:10 reading 11:15 31:13 42:24 60:22 92:15 96:2,15,22 97:4 98:4,9,14,20 99:8,19,25 100:20 109:25 135:14 139:25 140:1 141:3,5,6 readings 13:22 real 35:16 60:8 115:24,25 176:22 177:3 real-time 48:4 realised 1:22 107:1 realising 184:12 realistic 136:22 167:8 179:9 really 12:24 14:11 49:19 54:4 70:8 102:17 105:1 106:1 137:15 139:20 150:9,12 152:23 153:4 159:7,9 161:5,10 166:13 169:5 170:23 175:5,7 176:2,10 177:11 177:12 reason 14:21 37:12
---	---	---	---	---

41:18 42:10,23 65:14 66:2 86:5 95:22 97:6 109:22 111:13 112:16 128:5 131:15 149:21 161:2 176:13 reasonable 13:25 14:10 25:13 45:22 49:18 56:19 57:23 68:2 72:25 97:14 99:24 102:15 109:6 132:1 137:4 140:11 146:21 170:15 176:15 reasonably 68:9 reasoning 81:22 reasons 34:9 43:25 97:12 104:19 174:15 176:14 recalculation 124:5 recall 43:2 63:23 70:12 receive 16:18 160:6 received 2:1 12:12 12:19 13:20 16:24 77:4 recognise 15:3 23:25 157:17 recognising 131:19 recollection 3:8 100:12 116:9 125:23 141:14,20 169:8 170:21 reconcile 142:7 reconstruction 29:5 record 16:21 32:3 44:25 46:7,11 63:2 70:2 138:10 recorded 3:23 15:12 69:10,13 73:9 104:21 162:10 recording 38:19 records 6:1 45:11	46:3,5,16,18,20 60:14 61:4 66:16 66:21,23,25 67:2 69:21 70:3 72:14 105:1 106:10,12 106:15 red 117:6 redone 107:3 reduced 130:25 refer 43:12,15 64:20 65:2 referees 155:15 reference 11:21 30:4 32:6,14 36:6 61:8 69:17,18 78:10,18 79:8,22 80:3 91:19 93:1 101:11 references 26:12 28:17 30:4 31:14 32:7 33:16,24 44:7 87:10 154:8 183:18 referred 31:12,14 32:6 44:6 52:17 67:3,15 170:18 171:2 184:3 referring 40:16 42:17 98:25 103:11 116:15,17 156:23 161:14 165:11 174:17 refers 28:18 29:14 42:16 48:11 reflected 120:2 132:19 reflecting 89:16 148:8 reflects 9:13 150:18 154:12 163:9,23 refused 82:22 Regan 7:11,21 10:10 11:2 16:11 22:1,6 25:16 30:10 48:11,17 51:8	Regan's 47:3 regard 4:6 6:21 18:22 173:8 regarded 14:24 18:16 69:6 111:15 regards 102:15 122:18 regime 69:5 72:11 72:13 78:23,23 register 172:25 registered 14:1 15:18 rejecting 33:20 relating 28:13 relation 3:22 14:20 26:15 33:15 56:3 83:2,17 91:3 108:12 relationship 80:16 80:24 115:14 relative 98:16,17 98:19,20 relatively 13:2 18:17 25:8 36:13 99:17 106:7 132:19 134:23 release 114:3 relevant 4:14 41:4 reliability 111:5 reliable 55:13 reliant 3:21 relied 4:25 62:16 87:16 rely 7:1 43:9 relying 45:6 104:18 121:16 remainder 42:14 remained 118:6 remaining 43:15 45:7,8 168:9 remarkable 31:5 remarkably 53:25 remember 2:20 3:4 7:9,17 16:12 45:25 65:4 76:12 79:10 82:23 88:1	108:5 117:14 132:20 140:22 170:16 remembered 2:23 remiss 77:15 remote 122:11 removing 47:19 repeat 79:12 104:22 replacement 173:14 replies 105:14,16 176:1 reply 136:25 154:20 177:12 report 3:24 4:5,8,8 4:11,12 6:15 7:6,7 7:10,13,18,20,22 7:23,25 11:13 13:18 15:23 21:25 22:6,14,19 23:6,7 23:23 26:3,5,12 29:4 32:3 33:18 33:21 34:7,17 36:1 40:1 41:25 44:6 45:10 46:8 46:20,25 47:3 49:24 50:9,21 51:21,23 52:10,16 52:17,19,20 53:1 53:3,21 63:3,13 64:1,1,3,21 66:4,9 81:18,21 82:3,4 82:11,11,11 83:6 83:14,18,20 88:23 89:2 95:3,9,13 99:1 100:5,8,15 101:6 105:3,4,16 106:16,21,24 109:25 110:1,1,7 111:14 112:13 114:9,16 115:21 116:16 121:12 125:17,21 127:3 127:11,18 138:25 139:5 143:1	145:14 152:6,14 160:11 161:13 164:7 170:17,17 171:8 172:9,13 174:25 176:4,4,7 176:20 reported 65:11 82:21 100:23 101:13 reporting 102:8 reports 2:9 3:1 4:2 4:14,16 23:18 28:15 30:2 33:24 34:20,23 42:19 46:19 51:3 63:4 69:17 78:20 100:3 110:6,9,11 113:14 133:3 135:14 152:4 represent 57:18 123:6 125:11 174:7 representative 89:25 represented 31:23 159:11 represents 129:13 reproduce 161:20 republished 107:3 requested 183:8,13 require 24:16 70:24 research 28:2 reserve 180:12 residual 37:23 46:19 63:25 64:2 66:3 105:2 115:21 127:11 respect 71:4 126:8 174:3 respectable 38:18 response 34:5 152:7 169:2 176:21 responsible 149:12 rest 42:7 61:15
--	---	--	---	--

70:23 71:1 137:17 179:25 result 21:18 47:18 59:23,24 62:20 64:4 83:5 142:15 resulting 47:20 72:3 results 8:11 16:8 42:19 61:1,20 63:24 78:22 resume 92:1 resuspension 28:22 29:3,9 77:18 80:7 80:13,19 81:3,6 81:16,17,23,25 83:18,23 84:15,15 84:22 85:25 86:4 86:21,24,25 87:3 88:25 89:18,19 90:8,17 91:2,11 91:15 95:8 retain 37:6 retained 38:1 66:23 retired 173:3 retrospective 151:17 return 141:4 returning 42:16 reveals 53:13 reverse 138:10 139:8,8 155:9 reversed 143:8 review 28:21,22 34:10,12 67:1 155:13 revise 88:16 Richard 1:3 100:5 100:15 185:2 right 2:4 5:23 6:25 13:16 22:4 23:5,9 23:24 28:23 32:8 34:8,21 35:2 36:3 36:8 44:14 47:1,5 50:3 51:11 60:4 63:1 75:5,10,13 76:2 77:19 78:4	79:8,11 82:6,8,9 82:20 83:24 85:17 93:12,15,19 94:15 95:17,23 99:6 100:14 101:10 105:14 108:2 109:17,19 112:16 114:23 118:22 123:10,16 124:6 139:7 145:18 150:2 151:4 152:11 153:6 156:11 162:19 163:11 167:13 169:6,9 171:14 172:3 173:10 175:1 177:16 178:6 180:6,11 181:14 182:2 183:25 184:9,15 rightly 2:20 88:11 rise 9:6 51:14 87:18 116:11,12 118:10 118:15 119:2,3 120:7,10,20,21,22 127:14,16 131:10 135:17 168:14 rises 128:6 rising 118:8 120:19 risk 71:9 73:10 145:20,21 152:22 155:16 156:9 160:25 163:19 167:15,17,22,24 168:3,6 169:4,13 174:9 175:25 risks 12:5 86:6 148:21 152:18 171:13 road 179:9 role 28:2 72:22 room 61:13 rotary 47:15,23 48:16,16,19 rotary-based 48:3 rough 58:5 139:12	roughly 36:20 119:18 180:9 round 20:2 32:18 49:4,8 118:16 119:3 120:18 148:18 route 118:12,23 Rowlands 75:16 royal 76:13 rub 121:7 rudimentary 12:7 rules 79:24 run 22:10 66:20 182:21,23 run-on 181:16 running 32:16 <hr/> S safe 40:21 175:8 safety 19:10 102:6 154:5,8,10 sailors 75:18,19 76:7 sample 16:8 19:21 20:2 24:16 37:14 43:12 45:13,14,15 47:9,16 48:21,23 49:2 58:21 59:1 61:4 sampled 106:14 sampler 37:19,22 38:13 43:1,1,2,7,7 43:9,9,10 44:2 46:10 48:16,18,19 58:6 59:15 60:20 73:24 74:3 samplers 36:17,25 37:6,8,13 38:18 39:19 40:8 42:2,7 42:8,8,11 43:15 45:4,7,8,11 46:5,6 46:9,9 50:14 57:19 58:16 59:17 60:11,23 samples 17:19 19:4 19:11,14,15,19,25	20:22 21:5,7 35:19,25 36:22 41:9,20 42:16 43:11,18 44:4,5 44:21 45:1 46:14 50:17 55:25 57:20 62:15 74:1 143:23 sampling 12:7 20:5 21:5,7,17 29:16 35:21 37:5 41:23 41:23 42:3,9,18 42:20,25 44:9 47:23 48:17 49:1 49:21 52:7 56:16 57:3,4,6,14 73:19 73:21 75:2,4 78:22,23 79:3 101:25 102:12,13 102:14,16,17,19 103:4 samplings 43:22 sand 76:9 86:9 satisfactory 43:22 43:22 102:18 141:17 saw 7:16 22:9 30:22 87:5 117:14 120:20,21 Sawada 159:23 saying 10:10 34:12 43:14,24 52:11,12 52:13 58:14 60:25 70:20 85:20 86:4 87:25 95:22 104:3 104:7 110:3 127:9 129:11 132:17 133:1,24 134:1 139:2 140:20 141:17 146:17,18 146:21 151:19 153:22 168:4,12 173:22 174:21 says 8:14 11:25 12:4 23:22 24:11 31:19 41:19 47:6 48:17 51:16 52:14	53:19 55:23 56:8 60:13 61:11 62:7 64:16 66:9,15 127:4 138:24 155:21,22 171:14 172:10 174:2,25 SB11 46:24 47:1 SB12 2:16 SB13 23:9 25:23 95:11 SB14 54:21 74:23 SB19 31:17 32:10 33:4,5 SB2 34:19 SB22/10 183:9 SB22/11 183:20 SB6/60 171:8,10 SB6/89 154:21 SB8 40:19,20,24 SBs 93:2,6 scale 61:22,23,23 103:21 104:1 scavenged 97:18,25 scavenging 96:1,8 96:13 97:1 scenario 40:8 181:23 182:24 scenarios 61:2 science 27:19 75:25 scientific 83:12 106:7 145:1 148:9 155:24 173:18 scientifically 66:20 scientist's 88:15 scintillation 8:18 screen 116:21 screened 15:18 sea 76:5,6,8 115:6 116:1 134:9 seafood 75:1,4 77:20 78:2 79:3 Seascale 145:5,10 147:9 seawater 75:1,4 77:21 second 7:7 8:20
---	--	---	--	--

26:19 28:11 39:5 41:19 53:25 55:10 105:16 109:3 128:22 155:3 171:21 176:23 secondly 34:10 45:25 70:2 104:18 seconds 109:5,8,9 Secretary 23:20 31:15 76:23 184:6 section 32:11 33:1 33:10 83:14 95:13 sedimenting 57:22 see 6:2,22 17:2 24:8 28:19 29:14 30:9 33:20 34:9 37:9 37:18,21 51:6,18 53:4,24 55:1 56:8 57:10 60:14 69:4 75:14 84:20 88:21 95:9,21,21 106:13 108:24 116:8 117:3 121:18 124:7 135:24 142:24 143:25 150:17,18 153:21 155:10 171:25 178:7,24 179:13 179:19 seeing 63:23 145:1 153:14,16 seek 142:14 159:1 seen 2:23,25 3:1 7:8 7:18,20,20,23 12:11 20:25 21:15 22:3,8,13,20 23:19,21 25:22 30:3,10 31:6,7 32:4 37:23 38:9 44:3 48:14,15 63:17 64:22 66:18 69:16 72:4,7 78:9 83:9 87:8 89:12 92:11 108:20 109:4 148:12 156:5 161:12	172:4,13 selection 156:22,24 157:1 self-evidently 116:2 self-induced 98:6 98:12,15 Sellafield 143:4,8 143:11,14 144:23 145:3 147:2,10,12 147:19 157:4 sellotape 37:9,10 39:3 49:15 sellotape' 47:8 send 92:5,19 senior 21:15 70:19 sense 34:13 43:8 49:14 71:6 125:10 150:20 154:13 158:1 sensitive 20:15 62:22 64:8,11 68:9 86:20 sensitivity 93:20 163:23 sent 19:22 42:11 92:3 169:20 sentence 28:11 49:17 50:5 53:25 55:10 101:4 171:25 separate 122:21 separately 14:19 September 7:21 22:2 series 11:4 34:25 56:24 106:2 132:9 serious 92:21 111:16 served 11:19 serves 88:2 100:8 118:14 145:17 160:12 170:21 serviceman 86:8 set 36:12 62:14 82:10 104:20,20	106:6 114:24 153:23 sets 41:22 95:18 setting 32:19 settled 47:9 seven 99:7 122:13 122:23,25 129:3 129:17 134:7 136:13,15,21 137:3 seven-hour 130:24 Shackleton 85:23 86:2 114:11,24 117:22 128:12 129:18 130:20 135:21 142:3 Shackletons 129:18 shape 99:22 share 93:13 shear 126:4 sheet 25:25 63:17 63:22 sheets 60:15 ship 65:1,4,15,20 66:14 113:15 141:5,22 ships 75:20 shore 76:8 shores 184:10 short 11:6 18:17 44:17 91:24 92:1 106:7 141:7 142:20 144:11 174:5 177:25 short-lived 9:24 shortly 36:23 98:11 show 6:2 33:16 60:7 75:22 81:3 showed 45:12 116:11 shower 112:20 showing 38:13 53:15 59:17 118:5 121:8 127:16 shown 40:9 60:5 135:1 150:1	shows 11:22 shrink 145:16 shrunk 133:9,11,12 135:19 side 22:15 39:14,16 92:8 116:11 155:6 155:9,10 sides 155:7 sievert 163:14 164:8 167:4 sieverts 161:11,18 162:15 sign 82:23 significance 58:20 significant 5:6,16 17:2 46:12 51:15 56:6 59:13 65:17 66:2 71:16,20 72:3,7 77:4 81:19 89:9 97:15 98:16 116:3,4 135:17 145:10 147:13 significantly 135:2 135:22 137:2 silent 40:22 similar 19:16 66:14 68:7 135:7 138:5 138:6 similarly 68:22 74:1 simple 8:15,17 24:19 25:12 49:11 114:5 125:6 140:7 simply 18:6 26:14 59:23 79:1 97:24 107:16 112:3 122:22 126:7,22 127:4,9 137:24 140:11 150:6 151:13 176:16 singing 25:24 single 11:17,22 35:17 46:10 56:24 59:15 160:20 sit 182:18 site 52:24 72:12	107:15 147:15,20 sites 148:19 149:18 149:18,20,23,24 157:6 sitting 74:8 situation 14:9,15 16:19 situations 85:1 164:7 size 50:24 51:4,13 51:22,23,25 59:19 61:14 96:16 112:7 112:10 124:12 125:12 126:24 127:7 132:23 135:7 138:1,3,4 145:15 159:4,6 165:17 166:17 169:1 sized 50:22 sizes 168:18,19,22 skin 121:3 slight 10:10 123:8 138:20 slightly 9:11 16:14 36:21 77:6 120:16 127:20 129:13 135:7 139:1 158:4 164:8,24 171:4 slim 67:23 slots 47:25 slowed 116:13 118:15 119:2,4 120:15 slower 170:4 slowing 99:23 slowly 118:11 small 13:5 17:1 20:7 28:20 36:13 36:15 52:14 61:22 67:10 70:21 81:8 91:2 106:25 132:19,23 159:17 159:20,22 162:4 162:15 164:25 165:7 166:15,24
---	---	--	---	--

167:14 170:6 smaller 50:22 51:24 57:24 112:10,14,15 131:11 135:7,8 137:2,5 145:17 smallest 51:10 smears 121:6 smokers 83:7 smooth 23:17 56:20 snow 96:3,14 snowflakes 97:3 so-called 89:5 152:18 soaked 39:15 sodium-24 10:25 soil 86:8 solution 24:22 somebody 63:13 68:12 77:4 107:23 166:19 somewhat 53:7,18 126:10 soon 99:19 111:17 sophisticated 19:22 20:8 21:3,9 24:25 sorry 2:7,20 6:20 28:25 30:11,13 32:4 33:3 34:19 42:4 63:15 64:2 68:5 75:3 117:10 121:24 125:11 131:7 146:12 149:5 155:5 156:8 159:21 161:19 164:14 168:21 sort 18:14 20:23 33:20 63:14 69:5 86:12 94:18 105:12 106:7 139:18 150:17 159:23,25 170:7 170:10 174:20 sorted 22:22 179:10 sought 106:24	110:25 175:20 sound 52:6 sounds 48:13,17 49:12 source 29:9 53:3 56:21 69:1 85:17 115:8 125:3 130:11,15 133:4 133:13,15 135:25 137:9,11,13 138:2 165:20 172:7 sources 9:19 south 54:7,9 90:1 124:14,15 south-east 124:16 southern 118:19 space 95:6 sparsely 37:15 spatial 61:20 special 6:21 specialised 26:15 137:19 specialising 26:22 28:4 specialist 27:13 speciality 3:12 24:1 27:12 101:4 specialties 56:4 specific 6:9 64:18 71:11 153:16 167:10 169:8 170:2 177:17 specifically 17:3 33:23 65:9 141:10 158:18 168:25 specification 174:9 spectrometer 20:12 spectrometry 20:10 20:11 spectroscopic 9:3 speculate 73:7 speculative 115:8 speed 99:23 124:21 spell 85:6 spelt 57:12 spend 2:7	sphere 95:19 165:4 spoken 55:24 sporadic 101:17 spot 61:12,16 spots 57:18,18 61:20 62:5,8 spread 134:20 137:3 spreading 138:7 square 39:23 50:15 67:10 81:14 84:9 84:13 109:12,14 142:4,11 stable 24:16 staff 13:4 stage 11:3 22:5 40:1 64:14 77:25 standard 14:24 15:4 69:6 78:18 109:1 110:20 154:3,12 standards 14:7,14 14:15 15:20,22 17:5,10 18:21 19:1,3 46:4 102:6 106:11 154:5,8,10 standing 39:14 112:5 start 22:14,23 35:25 36:9 55:9 56:17 114:18 123:13 139:1,5,10 140:5,10,10 144:16,19 146:7 167:19 178:4 started 45:13 68:8 118:3,10,20 119:3 139:2,3 140:3 143:14 starting 32:11 34:14 56:10 111:6 139:20 140:9 145:16 starts 3:8 55:6 95:13 140:1 182:6 state 23:20 76:23	151:2 184:6 State's 31:15 stated 101:1 statement 25:11,13 37:12 45:16 49:18 51:1 62:11 66:3,9 66:9,15 87:5 105:2 141:4,20,21 161:3 165:22 167:14 statements 2:23 30:22,24 64:19,23 64:25 66:12 141:19 station 150:3 stations 53:14 149:21 statistically 145:9 statistics 121:9 stayed 167:5 steadied 120:23 steer 80:3 stem 122:19 125:14 126:1 128:3,5,13 128:16,18,22 129:5,13 130:1,2 130:12 131:2,4 132:18,19,23,25 133:1,6,22,24 135:9,10,12,13,15 135:19,21 136:7 stenographers 44:13 step 106:1 162:19 stepped 126:19 steps 132:10 stick 39:3 49:16 136:16 stickiness 37:22,25 sticky 35:19,25 36:22 37:8,13,18 37:21 38:10,12,18 39:19 40:8,14 41:5,8,14,22,24 42:3,8,12,25 43:6 43:8,11,15,17,25	45:11 46:5,8 47:8 47:10,21 49:12,21 53:15 55:16,19,24 56:11 57:22 59:23 59:24 60:19,23 62:14,19 102:16 stop 7:25 17:3 22:24 178:2 179:11 stopping 8:24 26:25 53:17 straight 50:13 89:25 167:17,17 167:20 strange 4:16 98:23 stream 96:20 street 112:8 stress 147:23 stressing 160:22 stretch 4:17,18 30:12,16 100:5,8 100:8,16 131:19 131:25 169:13 Stretch's 26:3 99:1 110:1,7 125:21 127:3 138:25 strict 133:23 155:15 strong 38:5 128:14 structure 34:22 35:3 stuck 166:22 study 27:21 143:17 143:18 stuff 153:15 stumps 90:12 sub-micrometer 50:23 sub-micron 159:24 subject 36:7 63:5 98:7 124:4 137:18 142:16 171:8 submission 34:15 submissions 31:15 31:20,22 32:1,22 32:23 33:10 77:22
---	--	--	---	--

subparagraph 63:5	69:12 121:1	suspect 13:1 47:17	154:21 155:12	techniques 78:7,8
Subsequently	152:20 156:5	87:17 109:22	159:13 164:20	79:3 124:2
117:25	supporting 87:8,8	158:19 161:13	176:16	Technology 28:1
substantial 30:18	88:21	suspected 19:11	take-off 115:1	tell 9:7 10:8 21:12
159:3	suppose 153:7	suspended 29:19	taken 5:7 19:19	52:13,15 67:1
suck 5:18	suppressant 113:13	29:20 111:20,22	21:5,17,18 26:7	68:23,25 99:2
sucked 5:22	sure 5:2 21:21	suspension 95:7	31:9 34:6,9 44:21	139:2 142:10
suffered 15:6	23:18 44:25 62:18	108:4,4 109:21	47:16 51:17 59:1	148:15 158:13
sufficient 53:14	87:7 104:15 112:3	swam 76:8	59:11 70:10 75:14	162:3,23 180:3
96:16 169:20	117:12 144:3	swims 75:6	89:25 103:4,9	181:1 183:4
sufficiently 74:9	151:11 157:24	switching 134:3	104:2,16 111:6	telling 44:8 123:17
93:25	158:23 171:1,16	system 48:12 49:10	116:6,7 125:24	161:7
suggest 39:2 45:16	183:15 184:9	49:22,22,25 53:16	126:2,15 130:16	tells 39:23
49:21,25 54:4	surely 146:19	66:20 159:5,12	132:11,12 134:12	ten 55:19 56:11,20
60:19 61:3 75:23	surface 91:6 113:19	systematic 69:9,12	139:17 140:8,11	60:10,14 178:4,7
98:20 100:20	121:6 125:7	69:21,24 71:20	143:23 154:1,2,19	181:24 182:18
101:12 107:11	137:12	72:13,16 104:20	166:21	184:15
108:10 112:16	surfaces 57:22 58:5		takes 136:3 138:14	tend 25:5 58:7
114:16 127:22	surprised 22:9 53:7	T	139:23	96:20 112:6,10
128:3 130:18,23	113:22,22	tab 2:17,20,24,24	talk 79:21 98:24	179:3,17
131:7 137:15	surprising 12:24	2:25 3:3 7:7,10	115:10 157:22	tends 112:6
138:8	13:11 16:20 47:22	21:22 22:19,21	164:13	tens 94:11 118:7
suggested 113:6	53:18 83:10	23:3,5,11,13	talked 87:2 154:4	ter 1:4,6,10 2:5
120:15	surrounding 167:3	25:23 26:7,19	168:18	11:12 20:20 23:1
suggesting 109:1	surroundings	28:18 47:2 95:12	talking 11:2 18:15	23:5,9,15 26:3,5,7
132:11 153:19	153:11	184:1	19:17 23:14 36:11	33:3,5,7,9,12
suggests 67:20	survey 63:17,22	table 99:1 161:14	56:17 57:5 62:2	38:17 44:19 49:13
107:17 121:13	66:18,19 69:8	162:1,2 172:15	67:13 70:12	74:24 77:22 79:18
suitable 21:11	75:16,17 115:18	176:3	103:10 108:5	79:20 80:6,7
88:18	116:12 120:21	tabs 34:24	112:17 129:21	90:14,16 93:17
summaries 46:23	123:5,6 127:8,15	take 2:16 6:23 7:8	143:17 150:14	95:5 121:11,18
summarise 5:9	133:11 135:1	13:14 19:4,15	152:17 153:20	122:4 124:11
147:5	140:18 141:13	20:2 22:4 31:17	158:23 159:23	134:4 142:21,25
summarised 35:20	143:10,19	32:1,25 33:13,19	160:3 164:15	144:3,13 157:21
46:7 63:24	surveyed 64:17	33:24 35:22 39:18	173:4 177:1	180:10,14 181:13
summary 1:13	75:23 121:3	49:1 53:1 54:21	talks 43:17	185:3
46:18 66:9 100:24	surveying 69:13	58:16,22,25 60:6	tape 47:8,10,21	term 12:17 25:3
101:7,9 145:13	surveys 62:25 63:9	61:5 62:13 74:21	53:15	110:20 145:16
156:1	63:12 64:9,10	79:15 81:3,4	target 174:9	152:16 172:18
sunny 113:9	66:4,17,21,22	86:21 95:11	targets 174:8	termed 98:6
supplemental 7:22	67:2 69:16,19,21	106:18 108:15	task 151:17	terminates 182:23
supplementals 7:16	69:25 70:2 71:6	109:11 113:8	team 24:1	terms 3:13 10:11
7:19	73:3,19 104:19,20	125:9 126:18	technical 27:13	13:1 14:9 17:12
supplementary	104:25	127:23 129:9	152:2 158:4	38:12 40:10 46:22
7:10 95:3	survive 165:20	132:7 133:7	technique 47:13,14	49:3 59:21 68:3
support 15:24	168:13	142:22 144:6,8	50:6 143:24	71:15 79:13 81:9

81:23 86:13 90:21 96:6 97:23 99:2 99:13 102:1,16 106:11,13 107:16 107:21 108:22 124:12 129:2 148:4 153:25 159:6 162:6 173:8 174:17 175:3 176:11,14 territory 8:2 22:12 22:16 96:23 101:14 109:23 test 3:11 15:10 17:21 18:5,9,24 24:8 36:18 41:11 65:2 76:12 78:13 102:3 107:10 111:23 129:11 156:7 tested 19:25 69:7 testing 14:20 19:20 19:23 20:21 71:6 71:18 109:6 113:15 tests 9:21 12:9 13:23 17:5 18:9 18:11 29:7 47:14 47:23 50:25 59:2 70:10 106:2 thank 2:3,4,8 11:11 33:8 62:12 74:12 74:25 77:14 80:4 91:21,22 92:22,23 95:4 121:9 144:9 144:14 151:11 178:6,9,16,20 184:12,15 themes 28:8 theoretical 98:10 theoretically 53:12 100:18,24 theories 137:17 theory 126:9,11 147:18 thermonuclear	52:22 54:7 they'd 20:22 83:7 87:13,13 120:15 141:25 thing 3:4 30:21 32:25 76:15 94:12 105:11 125:15 146:16 148:4 151:23 158:24 159:25 168:22 170:7 182:16 things 2:10 60:21 66:8 82:25 93:8 97:5 112:9,18 142:10 153:14,16 think 1:21 2:2,24 3:3,12,25 6:7,13 7:1,22 8:11 9:13 10:5 13:3,10 14:5 14:7,9,14,16 15:8 16:13 17:4,6,16 17:22 18:8,11,24 19:3,24 20:11,25 21:3,10 23:23 25:10 29:6 30:1 30:15,19 31:12 32:3 34:2,4,5 35:23 36:14 37:7 37:9 38:2,10,12 39:9,23 40:20,22 40:25 41:16 42:21 45:5,18 46:5 49:2 49:9,11,23 50:3 51:4 52:11,12 53:20 55:16 57:6 57:12,17 58:10 62:3,5,7,18,21 63:20,24 64:1,21 64:22 65:1 66:2 68:1 70:20,22 72:1,14 74:18,24 74:24 78:15,15 81:11 82:5,19 83:9,19 84:20 85:1,20,24 87:6,9 87:10,13 88:2,7	88:23 89:4,12,16 90:10 91:4 93:17 93:20,24 98:2 99:10 100:10 101:14,18 102:9 103:7,10,11 107:21 109:4 111:19 112:16 113:10,14,23,24 113:25 114:8 115:2,17 116:2 117:11,12,19 118:1,7 119:6,25 120:19 121:25 123:14,17 124:21 125:21 126:3 127:10,19 129:11 129:23 131:16,20 131:21,23,25 133:10 134:8 135:12 136:1 139:1,5 140:3 142:2,8,21 143:12 144:4 145:13,14 145:15,25 146:2 146:12,14 147:5 147:22 148:2,4,10 149:13,19 151:8 151:13,25 152:1,4 152:7 153:3 154:20 155:2 156:2,19,22,25 157:9,14 158:21 159:18 160:2,4 161:15,15,18 162:8,15 165:10 166:10 167:13 168:5,17 169:12 170:17,23 171:15 173:3,11 174:5,18 175:7 176:1,5,5,7 176:10,10,20 177:11 178:2,19 178:25 179:5,11 180:18 181:8,11 182:21,24 183:14	thinking 40:18 78:4 164:14 third 29:14 176:24 Thomas 92:4 157:24 158:22 159:15 180:13 thorough 156:14 156:16 thought 2:25 20:22 21:13 43:21 57:7 90:2 119:15 127:13 131:19 133:17,18 137:14 172:8 179:2 180:2 180:4,11 181:3 183:12 thoughts 146:12 three 28:18 143:12 threshold 167:16 throw 91:1 throwaway 87:5 thrown 90:19 Thursday 181:16 181:25 thyroid 183:11 Tier 30:5 32:18 126:13 time 8:21,22 9:17 14:10,12,25 18:10 18:17 21:13 32:18 34:1 36:14 45:12 45:12,13,13 46:1 46:21 47:11,15 48:1,2 49:16 62:16 64:22 93:13 94:18 99:25 102:4 104:6 106:11 108:18 109:5 110:24 115:18 116:7 117:10 119:7 120:9,10 123:7 124:4,19 128:16 129:23 138:20 142:20 144:21,22 145:3,7 157:25 162:10	173:4 177:16,18 180:3,18,20 181:3 181:24 times 148:22 152:22 184:4 timetable 180:25 181:4 timing 178:18 tiny 39:5 51:19 52:13 tip 54:8,10 tissue 158:15,18,19 159:3,12,17 160:17,22 161:6,7 163:22,25 164:4 164:11,19,22 165:4,6,9 166:1 167:3 169:20 170:11,13 tissues 163:24 174:4 today 7:14 18:22 31:13 40:19 told 35:4 93:10 142:1 143:6,21 144:5 tolerated 89:11 tomorrow 78:16 177:18 178:3,4,7 178:24 180:5 182:15 184:15 top 22:1 36:17 41:19 50:16 55:5 57:13 101:24 117:5 126:1,3,4 128:9 topic 77:17 79:15 114:8 topics 28:12 57:11 total 9:16 110:23 totally 24:17 39:16 touch 92:13 touched 74:1 trace 21:21 track 37:3 trading 28:6
--	--	--	--	--

transcript 54:25 60:22 61:9 110:1 123:15	87:11 143:22 148:7,15 150:15	<hr/> U <hr/>	understands 158:24	unwise 92:5
transcripts 30:7 74:23,25	trying 2:10 4:23 6:22 10:15 15:5	UK 44:21	understatement 59:14	upper 106:25 107:4
transfer 26:24,25 28:4,14	49:21,24 60:6,19 60:23 72:11 76:20	UKAEA/AEA 28:1	understood 55:12 94:15 147:24	uranium 20:6 24:23 110:18
transferring 65:1	80:21 85:2,14,18 106:13 116:24	ultimately 105:4	undertaken 28:9 102:4	161:17,22 162:16
transit 99:25 119:1	141:12 148:4 173:16,17,17	unaware 83:13	undoubtedly 4:11	166:15 167:3
translate 127:7 129:9 162:8	178:14	uncertainties 59:21 77:6 105:18,19,20	unexplored 93:6	169:12,24 170:3,6
transparent 105:9	tube 68:13,18,18	105:20,23,23	unfortunate 126:10	172:19
transporting 141:24	Tuesday 184:19	106:23,25 107:5	unfortunately 78:10 79:9 87:12	urine 12:8 16:7
travel 115:16 164:22	turbulent 97:14	140:13 152:12	uniform 40:6,9 58:24 59:4,7,12	17:19 19:4,11,15
travelling 124:20	turn 3:21 11:12 40:18 95:7 171:10	171:12,19 172:10	59:13,15 60:12	19:19 20:1,5,21
tray 47:24	turned 118:16 119:2 120:18	172:16 175:19,21	uniformity 53:20 59:13 60:10	21:17
treaty 18:10	Turner 89:4	175:22,25 177:2,5	uniformly 160:21 166:4	use 8:9 12:17 19:7
trials 13:20	turns 47:25	uncertainty 4:21 76:25 105:13	uninhabited 53:10 54:1	20:12 24:19 25:8
Tribunal 1:8 3:21 3:21 16:2 30:5	twice 79:5 127:16	111:2 171:5	unit 84:7 158:16,17	25:12,18 39:20
32:18 35:4 61:8	two 2:10,23 4:14 10:23 18:1 30:25	172:21 173:1	162:24,24 163:13	41:25 43:25 44:2
63:7 72:23 76:10	34:8,24 39:2	uncontrolled 70:10	164:9	47:8,10,16,21
77:10,24 111:9,9	41:22 43:24 54:8	under-read 58:8,8	United 45:3	48:22,23 71:21,24
126:13 143:19	54:8 57:13 64:19	under-reading 58:14,19	units 84:6 164:7	71:25 84:2,16
144:18 146:15	64:24 65:6 66:8	underestimate 47:20 88:8 131:18	university 27:20,21	85:25 88:25 89:14
158:12,24	66:11 69:23 73:17	undergoing 13:5	144:21 149:15	99:1 106:22 109:2
Tribunal's 34:11	76:2 85:1 87:9,10	underlying 24:18	unknown 171:3	110:20 149:6
tricks 161:19	87:11 91:18 117:8	underneath 83:8	unpacking 121:9	154:1 156:9
tried 49:19 85:23 105:8 106:21	120:21 123:2	understand 2:15 10:14 12:24 21:6	unquestionably 77:1	172:18 182:10
126:18,21,25	137:7 140:21	24:18 29:11 42:10	unrealistic 18:15	useful 9:18,22 48:4
137:24 142:9	141:8 142:7,11	60:16 76:22 80:16	unreasonable 125:14	66:12 172:7
147:5 161:22	148:12 155:7	82:19 86:17 107:7	unreliable 47:13 50:5	usefulness 50:2
tries 155:4	164:3,5 183:6	108:13 111:8,11	unspecified 110:13	useless 36:23
tropical 47:17	type 8:16,21 17:24 48:18 60:20	111:23 114:22	unsuited 24:17	uses 89:1
tropics 128:7	155:11,11,11,11	117:18 121:11	untrue 159:10	usual 91:18 106:3
trouble 76:1 103:25 105:22 141:9	155:12,19,21	124:8 126:12	unusually 62:19	usually 8:22 9:15
true 8:9 11:24 17:9 62:18 131:3	156:22 163:2,18	129:10 142:10		9:18 96:4,5
144:20 152:15	types 8:18 9:3 10:6 42:3 47:22 58:6,6	143:12 145:13	<hr/> V <hr/>	163:19
157:4 169:12	155:11 166:13	147:4 150:1,16	valid 153:22,24	
170:1 175:5	typically 164:21	162:6,7	validate 98:10	
try 35:7 37:13 63:8	typically-sized 94:5	understandable 80:16	value 8:19 61:1,3 89:8 104:3,5	
		understanding 45:4 108:21	152:15 176:22,23	
		130:13 141:3	177:3,8	
		153:9 165:21	values 58:4	
		176:18	vanishingly 166:24 167:14	
			various 28:9 30:6 42:4 61:19 62:2	

97:1 117:6 133:2 vary 56:18 62:1 79:5 88:5 172:10 varying 62:8 125:22 Vaskess 64:5,15 65:19 67:3 69:8 velocities 85:9 108:22 velocity 58:2 80:24 81:4,6,7 83:22,24 84:2,9 85:6 108:16 109:2 142:8 version 116:20 vertical 138:7 vertically 128:23 veterans 11:18,24 12:9,19 13:8 14:1 15:11,17 17:3 19:5 29:5 83:5 vets 156:7 view 12:14 38:18 53:4,6 54:19 73:25 75:22 88:13 88:15,24 103:8 113:23 131:16 153:14 160:10,14 169:18 viewed 88:14 viewpoint 107:23 views 3:22 60:21 villages 149:23,24 Violet 183:8 visit 70:13,20 71:3 volume 23:3 32:1 109:17 165:9	79:15 84:18 87:18 90:12 95:7,21 108:2,4 114:7,8 142:16 144:16,19 144:25 150:10,18 155:19 158:21 179:12 wanted 77:21 147:25 155:15 157:18 172:25 183:15 wants 1:8 79:21 92:25 93:10 warm 99:17 170:18 171:2 warn 180:4 washout' 96:6 wasn't 38:23 40:17 84:10 87:7 92:12 124:2 141:10 150:9 153:4 157:17 water 75:6,7 112:24 113:12,19 way 6:14 8:12 9:11 10:8 25:18 29:25 33:22 37:14,19 38:19,21 44:24 45:15 46:13 57:1 63:9 70:10 72:24 74:16 76:4,5 77:3 85:24 86:6 87:23 91:1 98:23 109:6 111:21 112:1,12 113:20 114:18 115:25 119:6,8 126:9 127:9 137:3 138:7 148:24 151:25 153:7,14 153:16,22 157:18 158:22 167:7 169:7 174:20 183:19 ways 27:4 145:1 153:8 157:19 we'll 4:11 7:5 27:12	44:7,14 59:12 91:17,17 93:12 114:7 144:6,8 159:14 160:13 176:7 178:2 179:5 183:5 we're 34:10 36:11 45:22,25 70:12 74:19 84:25 94:18 157:11 158:23,24 162:2 164:15 173:24 177:1 we've 4:14 26:7 40:19 44:1 55:24 59:18 69:22 80:8 102:9,17,19 104:14,19,22 137:17 143:18 149:7 152:10 154:4 156:1 157:14 weakness 37:24 weaknesses 37:16 37:16 weapons 52:21,21 52:22,23,23 54:7 54:8,9 wear 16:25 Wednesday 54:25 181:15 182:16 week 79:5 weekend 1:15,16 2:7 7:16 weight 163:25 weighting 163:6,7 163:8,17,22,22 164:3,4,4,11,18 well-known 183:16 184:5 well-written 172:8 went 5:14 45:6 63:12 65:4 150:13 158:22 166:12,16 166:19 weren't 20:21 46:14 66:24 75:18	west 54:7,10 64:5 118:9,17 120:5 124:14,15 125:25 126:2 western 116:11,13 118:12,15 119:1 121:15,23 wet 37:10 38:19 39:20 95:16,25 101:20 110:4 111:21 whatsoever 69:24 111:4 wheels 183:2 whichever 35:14 whilst 3:20 76:6 wholly 18:15 widely 12:25 100:22 wider 68:15 widespread 40:5,9 71:20 72:3,16 104:7 137:13 wind 125:22,24 126:1,4 127:1 136:10 182:1 window 68:16 wishing 104:22 withdrew 178:21 witness 30:22,23 31:1,8 64:19,22 64:25 65:18 66:11 70:11 91:21 92:14 100:3 105:2 141:4 141:19,20,21 155:20 157:9 178:8,10,16,20,21 178:23 181:18 witnessed 65:3 witnesses 30:24 92:7 woefully 19:1 66:17 wonder 42:17,23 wondered 147:25 wondering 1:12	143:2 word 84:18 159:13 words 96:3,15,22 97:4 98:5,9,14,20 99:8,20,25 100:21 work 2:12 4:23 17:6 27:23 28:7 38:11,25 57:25 63:8 65:14 75:11 106:24 109:15 119:12 138:10 143:22,24 144:19 170:9 worked 27:25 42:1 68:2 144:22 153:12 workers 9:21 17:10 143:23 workforce 147:11 147:12 working 17:17,23 33:9,12 81:10 108:6 115:9 143:14 146:8,19 works 83:24 world 12:1 90:18 128:9 153:21 worn 10:3 worried 25:22,24 worry 147:20 worrying 147:14 worse 90:3,6 worst 89:15,22 106:22 130:11,16 131:15 132:7,11 182:24 worth 127:21 168:17 worthwhile 37:1 117:19 would've 90:2 wouldn't 14:6 15:1 18:5 37:20 46:15 57:4 60:17 68:23 69:6 71:1 74:15 101:23 142:14
W				
Wahab 75:16 waiting 180:7 walk 112:8 walked 112:20 walking 112:5 want 19:3 37:13 48:24 74:21 77:17				

150:2 154:14 158:11 169:7 180:2,3 writing 43:20,21 117:4 155:14 written 28:14,17 42:19,20,22 52:20 69:17 81:21 152:5 155:13 172:13 wrong 32:3 153:17 155:16 177:14 180:16 wrote 21:20 173:4	0 138:17 139:14 0.001 109:2 0.1 96:16 0.5 139:9 168:18 00 167:18	114 15:9,10,12 12 2:16,17,20,24,25 3:3 23:13 120 132:21 13 2:24 7:7 11:12 23:13 54:25 95:24 155:8 173:25 131I 9:8 133 40:24 137Cs 9:8 14 7:10 11:1 41:10 96:12 144 185:4 14A 21:23 14B 22:6 15 1:21 22:10 96:25 1500 58:21 16 7:21 22:10 27:25 36:1,9 97:8 109:12,14 160 109:16 17 22:10 36:17 98:3 184:1 178 185:5 18 22:14 55:9 63:3 19 171:22,23 1950s 21:2 25:10 1951 183:24 1977 27:20 1985 27:22 1986 27:25 1995 29:15 1998a 28:20 1998b 28:22	2.17 35:1 20 1:1 22:2 61:10 94:8,8,9,25 124:21 163:8 164:18 165:8 20,000 142:5 20/25 100:2 200 94:12,21 2002 28:5 2006 29:6 2010 143:14 2011 7:21 2012 22:2 2013 54:25 2015 143:6 2016 1:1 184:19 21 55:5 184:19 210 8:8 22/11 184:7,8 23 22:24 61:10 239 8:8 13:24 24 22:19,21,24 23:3 23:5,11,13 47:11 49:16 25 144:8 253 47:4,6 254 50:16 255 50:20 52:12 256 52:1 257 53:5 27 32:11 28 33:1,7,8	3.3 43:18 3.30 180:8 3.35 144:12 30 49:2 110:11 161:16 165:5 30-micron 164:23 300 58:17 78:11 35 68:3
<hr/> X <hr/> X 185:1 xiv 63:5	<hr/> 1 <hr/> 1 51:7,7 63:21 67:13,16 112:14 115:7 123:6,7 129:6 138:11,17 138:21 139:8,16 140:8,10,10 155:11 161:18 162:25 163:7,25 166:18 168:18,20 168:21 169:4,10 169:15 176:14 185:2,3 1-micron 168:24 169:1 1,000 161:23,25 1.0 96:17 1.08 91:23 1.5 139:12,16 10 28:18 33:1,10 36:17 39:22 44:15 50:14 55:16 87:3 87:4,24 88:3,5,6,7 88:12,13,18,18,25 89:1,8,9,13,16 94:13,21 152:12 171:10,12,17,18 171:24 172:22 10,000 99:4 10.00 184:19 10.30 1:2 100 62:3 94:8 98:14 109:5,8,9 152:21 159:25 170:7 11 47:2 173:25 174:1 11.45 44:16 11.55 44:18 112 11:13 113 13:17	<hr/> 2 <hr/> 2 27:18 43:4 47:2 114:2 115:10 155:8,11 159:11 171:14 172:11,16 172:21 175:10,11 2.05 91:25 2.14 34:20	<hr/> 3 <hr/> 3 15:10,16 23:23 24:10 28:11 43:4 59:3 87:4,24 88:6 88:12,13,18 95:14 155:11,12,19,21 156:22 159:11 172:11,17,21 175:10,11 3,722 15:11 3.00 180:8 3.2 41:5 43:17 3.25 144:10	<hr/> 4 <hr/> 4 3:8 23:22 59:4 87:4 88:19 89:13 95:15 114:25 144:8 155:12 4,000 67:10 4.30 182:18 4.35 184:17 40 36:21 54:5,13 124:17 125:7 400 39:23 50:14 430 58:25 45 25:23 26:1,3,7 45(vi) 36:6 46 25:23 26:1,5,11 26:19 36:5,7 95:12 47 36:7 50:8 63:5
<hr/> Z <hr/> Z 63:21 Z1 63:19,20 67:7 70:14 71:14 Z4 63:20 70:14 71:14 Zealand 75:19 Zealanders 76:13 zero 70:9,13,14 125:7 137:12 161:1 167:22,22 zone 40:21	<hr/> 0 <hr/>	<hr/> 5 <hr/> 5 36:2 58:7,15 59:3 88:3,6,8 89:1,1,9 89:17 115:2 123:11 169:10,15 5-micron 168:24 5(a) 36:12 5.8 54:22,23 50 28:12 94:8,8 98:19 125:5 133:12 134:15,19 141:14 170:7 50-plus 16:4 500 152:21 51 8:14 52 9:2 10:13 53 9:13 54 9:14 10:14 47:3		

55 7:25 138:13
5D 123:11

6

63:9 36:15 89:8
60 32:16 125:5
133:10 134:9,15
134:17 135:20
171:9
60Co 9:9
660 119:25

7

77:24,24 24:11
115:5
70 28:15 99:18
133:10 134:10,17
70-kilometre
135:20
700 98:21,24 99:2
72 95:9 114:9
72(ii) 114:19
73 115:7
75 115:19 116:15
123:21

8

8 101:6
80 98:18,21
81 83:20 86:17,18
82 86:17,18 88:16
89 154:22

9

9 57:13 107:10
96 15:12