Tuesday, 21 June 2016
(10.00 am)
MR RICHARD HALLARD (continued)
MR TER HAAR: My Lord, before Dr Busby's cross-examination of Mr Hallard continues, could I raise a question?
On the first day of this hearing the Tribunal, through you, my Lord, indicated that you might be helped by a document you described as a Scott Schedule. I'm afraid, having thought about it, I'm not entirely sure, speaking for my appellants, I'm entirely sure what it is would be of most assistance to the Tribunal.
I wonder if it's possible at some point to give a little bit more clarification of what you have in mind.
MR JUSTICE BLAKE: It's possible.
MR TER HAAR: I'll just leave it there for the moment.
MR JUSTICE BLAKE: Yes.
A. My Lord, I've produced an expanded version of the aircraft survey of the Shackleton which I think is rather more legible than the original version which was in my report.
MR JUSTICE BLAKE: Yes. Thank you. That's your figure 6, isn't it?
A. My figure 6. I've actually referred to this as figure 3, unfortunately, because that's the figure from

the original reference.
MR JUSTICE BLAKE: Right.
A. Which is how I tend to think of it. So I've called it figure 3, but you're right, it's my figure 6.
MR JUSTICE BLAKE: Thank you very much.
A. Shall I pass them up?
MR JUSTICE BLAKE: If you could. (Handed)
A. I have also indicated --
MR JUSTICE BLAKE: Do you have one of these?
DR BUSBY: No, we haven't. (Handed)
MR JUSTICE BLAKE: Right, can we just have a few moments just to have a look at this to see. Right, it's also a little clearer as to the trajectory of the aircraft which I was trying to improve with your evidence.
A. Yes, I should have put this in the original report, my Lord, or something like it.
MR JUSTICE BLAKE: Yes, it's useful to have. Right.
(Pause)
A. I've also -- I think I may have said the units were milliR. The units are actually microR, as I've indicated in the key at the top, and I've also given an approximate conversion that 100 microR is approximately equivalent to 1 microsievert in the modern units.
MR JUSTICE BLAKE: Right. They were using Rs rather than

SVs?
A. Yes. Sieverts and grays have only been introduced in the past 15 to 20 years, from memory. I can't remember exactly when they came in. Prior to that there were three units that were used, all of which unfortunately began with R -- a roentgen, a rem and a rad. There is no modern equivalent to roentgen but it's approximately equivalent -- 100 roentgen would be approximately equivalent to a sievert.
1 rad is the equivalent unit to a gray, where again 100 rad is 1 gray.
And a rem is the equivalent unit to a sievert, where 100 rem is equivalent to 1 sievert.
In the original AWE references most of the units that they would use -- most of them, not all -- would refer to R.
MR JUSTICE BLAKE: All right, thank you very much. Yes.
Cross-examination by DR BUSBY (continued)
DR BUSBY: Good morning.
A. Good morning.
Q. Well, as I recall, we had just finished off yesterday looking at the CERRIE report and what I was going to go on to, just briefly, was to ask you -- I asked you about the dose from -- whether it was meaningful to, or how meaningful it might be to consider a dose from

a particle to local tissue and compare it with the ICRP way of diluting it into kilograms of tissue.
Now I'm going to ask you if you think -- whether an internal radionuclide which binds to DNA might be considered to represent a similar problem for dosimetry.
A. Right. I need to stress, of course there was quite a lot of discussion about the issue of nuclides binding to the DNA last week and I need to stress that I have no expertise in that area.
Q. It's just the dosimetry. I'm not asking about the biological plausibility or anything to do with chemistry, just if the DNA is a target, first of all. Do you accept that the DNA is a target?
A. The DNA is the principal target.
Q. The principal target?
A. There will be other targets --
Q. Of course.
A. -- similar to that.
Q. Of course.
A. The DNA will be the principal target.
Q. So my question just to sort of simplify it then is that the effect of a nuclide that decays bound to the DNA would not be the same or would be very much greater than the effect of a nuclide that was not bound to the DNA, that was just in the cytoplasm somewhere else far away

from the DNA?
A. I would think that would be true.
Q. Thank you.
A. As I said, I don't have that detailed expertise in internal dosimetry modelling but I would think that would be true.
Q. So you haven't included -- I mean the ICRP doesn't include any way in which doses from nuclides that bind to DNA, for example strontium 90, would be distinguished from nuclides that don't, for internal radionuclide dosimetry?
A. That's true, I don't believe ICRP do that. I did read two papers, one by I think Tanner and Harrison and another by Eakins, both from Public Health England, who looked at the issue of what I think you referred as to the photoelectric amplification --
Q. We'll come to that. That's a different matter. I'm just talking about binding to DNA now.
A. Okay, right.
Q. Now, in your report you use the ICRP risk model -- we have already said that -- and you've used the ICRP dose co-efficients in order to get from the internal dose, which you derived through various steps, to the overall doses, the internal doses which you produced in your report.

Now my question is: why did you use the ICRP dose co-efficients? Why did you not consider dose co-efficients from the European Committee on Radiation Risk? It's not the only model around at the moment, is my point.
A. No. But I think as I said last night, the ICRP model is the international standard, it's the international benchmark, it's the one that is used almost universally to my knowledge. If you look at the International Atomic Energy Agency's basic safety standards -- I think I said some of this last night -- that document which was issued, I think only about two to three years ago, actually contains the current ICRP inhalation and ingestion dose co-efficients in a table.
The European Union Basic Safety Standards Directive --
Q. Could I just stop you? I'm sure all of that is true. It's not really my point. My point is that --
MR JUSTICE BLAKE: It may be relevant to the answer to the question that you posed, so that's why we've got it in.
DR BUSBY: Well, if you wish -- I don't want to stop you but I just want to point out that that wasn't really where I am going with this.
A. Okay.
Q. What I wanted to ask you is if you were aware of the

rules for experts and for expert reports that they should review alternative approaches to what it is that they're being asked to do and explain why it is they didn't use them. You're explaining that now, of course, but you didn't seem to do this in your report.
A. Okay. I think two points perhaps to make on that. The judgment that I made was not a technical judgment. I don't believe that I have the appropriate internal dosimetry expertise in order to make a technical judgment. The judgment that I made was based on what is the international standard.
I was not --
MR JUSTICE BLAKE: Sorry to interrupt you, but are you aware of any other safety dosimetry exercise which uses the European Committee's model opposed to the ICRP model?
A. I'm not, my Lord.
But I have to say, to answer your question fully, that I was not aware of the ECR/210 model at the time that I wrote my report. I have read it now but I read that rather later in the process.
DR BUSBY: Could I take you to SB10/163. If we go to page 244.
A. This is the ECR/210?
Q. That's right, yes.
A. And page what, I'm sorry?

Q. Page 244.
A. Okay.
Q. Well, you have looked at the ECRR report.
A. I have.
Q. So you will know that the ECRR -- the committee attempts to resolve this problem of particles and also the problem of binding that I just put to you.
You can see here there's a list of risk co-efficients that you might have used, if you had decided to just write down that there was an alternative approach.
Is that correct? You could have used these to produce a different set of doses?
MR JUSTICE BLAKE: You weren't aware of these at the time you wrote your report?
A. I wasn't aware of these at the time I wrote my report, my Lord. I read this document rather later.
MR JUSTICE BLAKE: Okay, so you have given that answer. You have explained why the ICRP is the international model that you used.
Now you have had a look at these, do you have any comment to make upon them as an alternative dose co-efficient?
A. If I recall from the document it uses a modification of the ICRP risk model in that it introduces two additional

weighting factors and I assume that they've been used in this table.
DR BUSBY: This is just a list -- that's right, it's a list of the ones that have come out of using those weighting factors which are described in the text but we don't need to go there.
A. Not all of the isotopes which I've used would be listed here. The list of isotopes came from the Carter report. Quite a number of them are here, but not all.
Q. No, but some are.
A. But some are, so from that point of view --
Q. My question is that if you had used these, I think, would you agree that your doses would have been higher?
A. Yes. They would --
Q. Right. So now my final question in this area is -- well, not quite final -- is it possible -- do you think it's possible -- because the argument in this Tribunal is about reasonable doubt.
A. Yes.
Q. So my question is, is it possible that the ECRR model is closer, and possible now, not that it is or it might, but might it be that the ECRR approach would give you a better dose in the sense of the way in which you would relate dose to illness ultimately? Is that possible?
A. I don't have the expertise to be able to make a judgment

on that. The only comment I would make -- I think I'm repeating a statement I made last night -- is that the COMARE response to the CERRIE document, because obviously the approach which you've described was considered I think at some length in the CERRIE Committee --
Q. No, it wasn't --
A. Okay, well, it's referred to in the CERRIE Committee -- perhaps I could put it like that --
Q. Yes.
A. -- that the COMARE response to that committee said -- I do actually have a page reference if that would help.
MR JUSTICE BLAKE: Just give us your answer and then --
A. The COMARE response said that it did not consider that the members of the CERRIE Committee who had suggested that the risk from internal emitters was between 100 and 500 times greater than the ICRP risk estimates, that the -- that COMARE did not consider that they had justified their views. And it then went on to discuss where ICRP currently -- or the years that ICRP have been working on its current values.
MR JUSTICE BLAKE: Now you've given us that answer. You've explained that you don't think your expertise is at the field of whether ICRP is to be replaced by ECRR.
A. Yes, my Lord.

MR JUSTICE BLAKE: But can you help us? What kind of expertise and what kind of people who have addressed this issue would have the relevant competent skills and expertise to --
A. They would need to be a specialist in internal dosimetry, my Lord, and there were such specialists, two or three, I think, without naming anyone, who were on the original CERRIE Committee.
MR JUSTICE BLAKE: On the CERRIE Committee.
A. Yes, my Lord.
DR BUSBY: Can I take you to page 247 of the same tab number. This a statement that was made by a number of very eminent radiation biologists and other experts. I was included there but I don't say that I am one of those. There were some very eminent people there.
It says at item 2 on page 247:
"Assert that employing the ICRP risk model to predict the health effects of radiation leads to errors which are at minimum 10 fold while we are aware of studies relating to certain types of exposure that suggest that the error is even greater."
At 5 they:
"Urge the responsible authorities and all those responsible for causing exposures to adopt a precautionary approach, and in the absence of another

workable and sufficiently precautionary risk model, to apply without undue delay the provisional ECRR 2003 risk model which more accurately bounds the risks reflected by current observations."
Do you have any comment on that?
MR JUSTICE BLAKE: Were you aware of this?
A. The Lesvos Declaration, yes, I have seen it. I think it's quoted in -- I think it's actually in the ECRR/210 document, if I remember correctly. Sorry, that's what this is.
DR BUSBY: Yes.
A. So, yes, I'm aware of it.
MR JUSTICE BLAKE: Were you aware of it at the time you were writing your report last year?
A. I don't think I'd actually read the Lesvos Declaration at the time. I don't think I had.
MR JUSTICE BLAKE: It may be that you've already answered this question. Are you aware of any responsible authority who had adopted these measures?
A. I'm not, my Lord. It might help to expand on that answer slightly, unless you would rather I didn't.
MR JUSTICE BLAKE: Well, if you're not aware of a responsible authority adopting it, that may be sufficient.
A. Okay.

MR JUSTICE BLAKE: If someone else wants to ask you questions about it, we can go there.

Right.

DR BUSBY: Thank you, that's all I need to talk about on that item.

I'd like now to ask you about Mr Ken Johnston who you rely upon in your report to some extent.

A. I use some of his expert evidence, that's correct.

Q. You consider him authoritative and dependable as a source of information then?

A. I believe so. He has expertise which was valuable which I don't have, particularly in nuclear explosions.

Q. Such expertise to the extent that you relied upon it is -- I won't say critical, but fairly pivotal to the decisions that you made, the assumptions that you made in making your calculations?

A. Some of them, I think, yes.

Q. Yes. Can I take you to SB13/24.

A. I'm sorry, which tab?

Q. SB13/24.

A. 24.

Q. This is one of the first, if not the first --

A. Yes.

Q. -- report by Mr Johnston. I just want to take you to the subscript, the little note which has a (i) next to

it at the bottom of page 3.

A. Right.

Q. In which he says, and I read:

"For example, uranium is present in most soils at a hu(?) ppm level and also in coal deposits. Fallout, particulate and fly ash from coal-fired plants therefore contains uranium and its daughter products. It is, however, absent from coral."

Would you agree with that?

A. The environmental survey, or one of the environmental surveys -- I think it was the New Zealand environmental survey, the NRL survey, but it might have been the Washington survey, one of those two -- does refer to levels of natural uranium on the Island. It doesn't quantify that. I think it refers to two natural isotopes. So from that point of view I'm aware of the survey which makes a qualitative statement that there is natural uranium on the Island which presumably means in coral.

Q. But this survey was done after the --

MR JUSTICE BLAKE: Are they coral islands?

A. They are, I believe, coral islands, my Lord.

MR JUSTICE BLAKE: Entirely coral?

A. I couldn't answer that, to be honest, but I believe it's a coral atoll, so some of the soil on it will be made

from coral. I honestly don't know whether it's all of the --

MR JUSTICE BLAKE: I know the Maldives, for example, are entirely made up of coral, aren't they?

A. That could well be the case here as well.

MR JUSTICE BLAKE: I just don't know whether there's any topography or volcanic activity or anything else --

A. I don't know. It could well be that it's entirely from coral.

MR JUSTICE BLAKE: Right. Anyway --

A. Certainly it is surrounded by coral in the sea.

MR JUSTICE BLAKE: You are just answering Dr Busby's question by reference to what you've read --

A. Yes.

MR JUSTICE BLAKE: -- that other surveys found some natural uranium in Christmas Island?

A. Yes, my Lord.

MR JUSTICE BLAKE: Whether that's from coral, which is a possibility, or otherwise, you can't say?

A. No, I can't. But they found it.

DR BUSBY: But these surveys were carried out after the testing?

A. Yes, they were. In the 1970s, 1980s and 1990s.

Q. So if Mr Johnston is right and that there's no uranium in coral, then we surely conclude that the uranium that

was found -- I am going to go there too -- in the McEwan report, the New Zealand report, arrived there afterwards?

A. Well, I would assume that there's two possibilities. (1) that Mr Johnston may have been incorrect in what he says, or the other, if he was correct, then I suppose that would be a reasonable assertion but I don't know if there's any others. Again, you are going outside my expertise.

MR HEPPINSTALL: My Lord, I rise because this is something of a fantasy discussion. Dr Busby is well aware from his involvement in the Upper Tribunal that Mr Johnston conceded Dr Busby's point that there was uranium in coral --

MR JUSTICE BLAKE: So we are going down a wrong turning.

MR HEPPINSTALL: Yes, and Dr Busby is fully aware of that from the proceedings before Mr Justice Charles.

MR JUSTICE BLAKE: Thank you.

DR BUSBY: I'm not sure the extent to which it's fair for Mr Heppinstall to jump up in the middle of my line of questioning --

MR JUSTICE BLAKE: It is if you are going to be going off and putting questions on a false hypothesis.

DR BUSBY: He doesn't know where I am going with this, my Lord.

MR JUSTICE BLAKE: Wherever you are going, you can't make a question asking a witness to comment on something where, if you have the information, you know that may not be a secure foundation.
DR BUSBY: But Mr Johnston never conceded --
MR JUSTICE BLAKE: No, Dr Busby, you've got to manage your time -- by the way, I'm giving you whatever you need to do, but you've got to manage this process so you can extract the points where you disagree with this witness, where you can put a positive case to this witness that you rely upon, and if you are asking a question based upon something which is contained elsewhere in this mass of papers, try to make sure it reflects at least the consensus or the legitimate differences of opinion, if it's opinion-based. Yes?
Okay, let's go on.
DR BUSBY: Right, we are still on uranium.
There are two papers that are relevant. One is the one that you've already mentioned. There was another report that was made from a survey by the University of Washington in Seattle which we've put in which we'll talk about later.
A. Which was the other one I referred to.
Q. Before we go there, you were informed on 18 May that you might be asked some questions during this hearing.

There was a list of questions sent to you, wasn't there?
A. Yes.
Q. You got those. Right.
Since much of our concern is in our statement of case and in this discussion generally, we flagged up that we would ask you to tell us how much uranium is in the bombs by mass rather than by activity. I mean of course I can do that but I'm not allowed to be an expert and you are an expert, and it's a fairly simple calculation. So perhaps -- and you did in response to a question about the total activity calculate that. If you could just convert that into mass for us in the Grapple Y I would be very grateful.
A. Oh, just Grapple Y?
Q. Well, all of them would be nice but I think we can more or less approximate -- if we know what Grapple Y was, in terms of the amount of UT-38 in terms of kilograms, tonnes, whatever, then I think we can assume that we can get an overall amount of uranium as a sort of rough --
A. I've got an overall breakdown but the total mass of uranium from Grapple Y from memory was about 3.3 tonnes based on what is called the -- or what I've referred to as the AWE gist document. It's known as "the Bevis Parker gist". That's a one-page document which quotes extreme upper limits of a number of nuclides of

particularly uranium and plutonium.
MR JUSTICE BLAKE: Yes, as I understand it, you mention in your report because of the classification issues they have given a gist of a conservative or an upper estimate.
A. That's correct, my Lord.
MR JUSTICE BLAKE: You've taken that upper estimate?
A. Yes. It's up to a factor of 10 greater.
MR JUSTICE BLAKE: So this may not necessarily be what was actually there?
A. No.
MR JUSTICE BLAKE: But if the upper estimate is to be taken at face value then you can do a calculation to tell us what that means in weight?
A. Yes, my Lord, and that's what I've done.
MR JUSTICE BLAKE: And the answer was 3.3?
A. Yes, from memory Grapple Y was 3.3.
I have notes, my Lord, which I'll try not to refer to, but if I do need to refer to the notes would that be in order?
MR JUSTICE BLAKE: Yes, as an expert you are not meant to keep everything in your head.
A. Thank you, my Lord.
MR JUSTICE BLAKE: You are entitled to refer to your notes, particularly if you've been asked to do a calculation to

assist us.
Is Grapple Y sufficient for your purposes?
DR BUSBY: It probably is but since he has done the sums I thought we may as well hear what the answers are for the other ones.
A. The total mass, these are the three alpha emitting nuclides. They were all obviously beta emitting nuclides as well and I have actually done a calculation for those but the half lives are so short it's not relevant.
Q. All I want is the total mass of uranium 238 that came from all of the bombs, because one of our appellants is Mr Smith, who was there much later, and we are trying to get to some idea of the amount of uranium that was exploded over the islands in total.
MR JUSTICE BLAKE: Pause there. It is total mass of uranium 238.
A. The total mass of uranium 238 for all of the weapons that I calculated was approximately 8,000 kilograms, that's 8 tonnes.
DR BUSBY: 8 tonnes. Right. That's very helpful. Very helpful.
Now --
A. That was uranium 238.
Q. Yes, yes.

MR JUSTICE BLAKE: And this is Christmas Island?
A. This is Christmas Island, yes.
DR BUSBY: So we have 8 tonnes of uranium 238 turned into particles over Christmas Island.
Do you know what the density of uranium oxide is?
A. Oh, is it something like 11 grams per millilitre or what would that be?
Q. 11.
A. So uranium oxide did you say?
Q. 11 is right, roughly right. I'm not allowed to say that. I would agree with you if you were to say --
MR JUSTICE BLAKE: Come on, just ask the question. Keep out the comments, please.
DR BUSBY: 11?
A. 11, I believe, yes.
Q. So it's a very heavy particle then?
A. It would be a heavy particle.
Q. We have 8 tonnes of heavy particles micronised into nanoparticles over Christmas Island over a period of time.
A. Yes, they would be vaporised in the detonation, of course, and then they would condense out in the cloud.
Q. So do you think it's possible that this material would have contaminated Christmas Island to some extent?
A. To some extent. I mean clearly, as I was saying in my

evidence yesterday, I have assumed quite a significant level, quite a high level, of fission product contamination, widespread contamination over the Island and a proportion of that would be from uranium. From the calculations which I did, the becquerel proportion is very low from that.
Q. Yes. Well, do you know what the surface area of Christmas Island is, roughly?
A. Well, you quoted it in the questions at 388 square kilometres, and then asked if I could estimate the activity falling over that area. I do have a difficulty with that calculation. Because for the cloud, the nuclear cloud, to span from the surface zero where the weapon exploded to the populated areas, the radius of that cloud would have to be about 40 kilometres in which case the area of the cloud would be about 5,000 square kilometres so approximately one order of magnitude greater than the area of the Island.
So I felt it would be misleading to assume that all of the activity fell just on 388 square metres. So I've done the calculation for 5,000 square kilometres which would be the area of the cloud.
Q. Well, we'll come to this later, but if you've done the calculation for 5,000 square kilometres, which is what you assume it will fall on, what was the answer?

A. Well, I have done that calculation but there is a difficulty with that too, in that if all of the uranium were to fall on the Island, which clearly is a huge assumption, all of the fission products which would be associated with that would also fall on the Island. Everything would have to fall at that time.
I would say first of all that I don't believe there's any evidence to support that assertion but we can perhaps come back to that.
But if all the fission products fell on the Island, just for Grapple Y I calculated that the external dose alone will be several tens of sieverts which would be a fatal exposure.
Q. But that wasn't my question.
MR JUSTICE BLAKE: Sorry, what was the question?
DR BUSBY: The question was: what would be the concentration of uranium on the Island, not fission products?
A. Yes, but what I'm saying is that the two would be associated and therefore you would need to look at the whole situation and what I'm saying is that the fission product component of that question would result in fatal exposures for everyone on the Island by some margin, and therefore, taking it one step further, I don't believe that it's reasonable to assume that all of the uranium or all of the fission products fell because it would

create a situation which clearly did not happen.
Q. Okay. Fair enough. I won't take that any further.
But you say that it fell over a larger area and presumably then into the sea?
A. Yes.
Q. Right.
A. Some of it would have fallen on the Island, given the scenario you've asked me to look at, and the rest would have fallen in the sea.
Q. Okay. If there was rain -- and I think we are going to bring in a number of witness statements to say there was rain -- and entrainment of seawater too, which produced -- we will argue, then precipitation out of the cloud or through the cloud is much more quantitative, is it not? I mean it brings down all the stuff that's up there, or how much would you say it brings down?
A. Well, I don't believe I can answer that question. I haven't got the relevant expertise, but we did discuss, or we did touch on this yesterday as well, particularly the witness statements of Dr Nicholson and Mr Stretch and the transcript of Dr Nicholson's evidence. I think the conclusion from that was -- if I can paraphrase, and again stressing that I've no expertise -- that even Dr Nicholson with his expertise felt that it was probable but not definite that there

may have been some scavenging of activity from the cloud by rainwater.

I am certainly not in a position to be able to quantify that, which is why I've not tried to do that. I've tried to remain within my expertise, and that is why I remain -- that I looked at the evidence for contamination on the Island and took what I believed was an upper limit of the levels of widespread contamination on the Island. That was what I based my report on.

Q. Yes. But if rain occurs, do you agree that it would bring down a significant amount, much more of the material, than if it were just coming down on the basis of gravity?

A. Than dry deposition?

Q. Yes.

A. Yes, I do.

Q. Yes.

A. Indeed, in my report I'd assumed that the contamination -- I had taken it that the level of contamination which I'd assumed, which is significant, was likely to have arisen from some scavenging due to rain rather than dry deposition.

Q. Is it possible, do you think -- is it possible now -- that the levels -- I mean the levels that you used for your calculation were the highest levels found on

various sticky filters?

A. They were more than that actually.

Q. But not a lot more?

A. No, they were about 50 per cent more than the very highest and I could go through my reasoning if that would help.

Q. But in fact we have heard already -- I don't need to bring the memorandum, but there was a memorandum that says that the sticky filters were to be taken in -- or if they were left out they wouldn't work because the rain would wash it all off.

So my question is: is it possible that the levels of contamination were significantly higher in places, not everywhere, not over the whole Island, but in places where there was heavy rain, that there might have been very much higher contamination than you assume in your analysis?

A. We did discuss this yesterday and I did discuss that in my evidence yesterday, that it's possible that you could get localised areas due to rainfall which could have been higher, but I believe that the most reliable form of direct contamination monitoring would have been to use instruments held by people, monitors, and we discussed yesterday the evidence which I have seen which indicates that there were certainly surveys done by

people using contamination monitoring instruments in certainly the southern part of the Island, that's around Vaskess Bay -- the south western part of the Island I should say -- in Port London, on the ship, and I also said I think that my deduction would be that if there was that kind of monitoring going on in Port London because of rainfall there would have similarly been monitoring going on in Main Camp which was also the main inhabited area, which was only anyway a few kilometres from Port London.

Q. But these are Geiger-Muller counters?

A. Yes.

Q. Yes, and they are not responsive to alpha emissions.

A. Those particular ones wouldn't be. Some modern Geigers are actually very responsive to alpha. It depends on the thickness of the window.

MR JUSTICE BLAKE: What were they using at the time?

A. What they were using at the time, no, would not have responded to alpha, my Lord.

MR JUSTICE BLAKE: So this line of questioning, as I understand it, is that you draw attention to and rely upon the Geiger-Muller monitoring on the Island?

A. Yes, my Lord.

MR JUSTICE BLAKE: Dr Busby has put to you but that doesn't pick up -- is it all alphas?

A. It wouldn't pick up any alphas, my Lord, because the tube is simply too thick.

MR JUSTICE BLAKE: Right. So logically I would imagine the next question is, well, then can you draw any information from the use of the Geiger-Muller counter as to alpha radiation?

A. I believe you can, my Lord. There was quite a lot of discussion in the previous First Tier Tribunal, particularly between Mr Johnston and Professor Regan about the appropriateness of using beta and gamma measurements to calculate alpha.

The reasoning is -- and I think it was accepted at the end of this discussion -- the reasoning is that when the activity is condensing in the cloud, the nuclear cloud from the detonation, that you will get a mixture of what are called refractory materials and fission products together in a fairly uniform mix, along with the materials from the bomb which would have been originally aluminium which effectively would dissolve some of the other materials within it.

MR JUSTICE BLAKE: So you are referring to the evidence in the previous hearing?

A. I'm referring to the evidence in the previous hearing.

MR JUSTICE BLAKE: In a sense, it's probably not a useful use of your time to summarise that all but you've

identified it and I think you have referred to it. You agree with that? Or what's your position?
A. I have no expertise in that, my Lord, I'm afraid.
MR JUSTICE BLAKE: So you simply note that.
A. But I've noted it and I have accepted particularly because -- if my recollection serves me correctly -- I think it was broadly accepted in the end by both that there was likely to be -- that use of beta and gamma measurements as an indicator of the presence of plutonium was a reasonable thing to do, until the fission products had decayed to such a point that they would no longer be detectable.
MR JUSTICE BLAKE: I suspect that Dr Busby is interested in the uranium.
A. The same would be true of uranium.
MR JUSTICE BLAKE: And although this is not an area of expertise of yours, you don't have any adverse comment upon that?
A. No, just applying --
MR JUSTICE BLAKE: The debate or the reasoning or the conclusion or whatever it is?
A. No. Just applying logic, it appeared to be reasonable from what I could understand.
MR JUSTICE BLAKE: Yes.
DR BUSBY: So if we take a situation where there was

torrential rain and someone was there with a Geiger-Muller counter, and presumably they were because they would have been quite nervous and I think in our witness statements we see there were a lot of people with radiation suits running around with Geiger-Muller counters.
A. I've never actually seen a witness statement.
Q. We are going to go to one. Where was I? Oh yes, the beta emissions from these materials in the water would not make it out of the water, would they, because of the stopping power of the water? If there was a pool of water, very little beta activity would emerge from the water because betas don't have the energy to penetrate more than half an inch of water?
MR JUSTICE BLAKE: Let's try and ask a question. Do I understand the question rightly that the Geiger counters would not pick up beta radiation in the water? Is that the question?
DR BUSBY: That is, yes.
MR JUSTICE BLAKE: Okay. Well, that's the question.
A. In a pool of water that might be 1 or, say, particularly 2 centimetres deep, the range -- I can't remember the exact range of beta in water, I would have to work it out, but it's probably going to be of the order of about 2 centimetres, depending on the energy, depending on the

nuclides. But of that order. But that would be in a pool. If it was simply a wet surface --
MR JUSTICE BLAKE: Sorry, I don't understand your answer.
A. Ah.
MR JUSTICE BLAKE: Can a Geiger counter pick up beta radiation in a pool of water?
A. In a pool, if the pool was deep enough then it probably wouldn't but if it was simply a wet surface from rain, then it would. So if it was a thin layer from rain, say a millimetre, 2 millimetres thick, then it would be able to detect the beta and the gamma.
MR JUSTICE BLAKE: At what point of thickness or depth of water do you think that the beta radiation would not be detected?
A. I would have to calculate it, my Lord, to be sure, but I would say of the order of about 1 to 2 centimetres, perhaps. Say 2 centimetres.
DR BUSBY: So that's a partial "no", is it, do we say? Is that --
MR JUSTICE BLAKE: He said -- I've recorded the answer as the Geiger counters cannot pick up beta radiation in a pool of water deeper than 1 to 2 centimetres.
DR BUSBY: Yes, that's fine.
A. But on a wet surface they would pick it up.
MR JUSTICE BLAKE: But contrast with a wet surface as

opposed to a pool of water.
A. Yes, so simply a wet surface on a pavement or something they would pick up the beta without any trouble at all.
DR BUSBY: So the attenuation of the beta radiation by water would affect any conclusions that could be drawn about the nature of the material emitting -- you were saying earlier that there was some discussion about. But what I'm saying is if it was a wet surface or if it was a pool of water those considerations would be invalid?
A. If it was a deep puddle of several centimetres then, no, I don't think the betas -- or there would have been very limited beta, obviously from the very surface, but from a normal wet surface, which most of it I think would have been, then yes, they would detect the beta. They would certainly detect the beta on the people and of course they were monitoring people as well.
Q. I would like to now go to your report. I have down here it's SB2/2.17. But I'm not sure.
A. I've got 2.14. Is this my original report?
Q. No, it is the 2.17 one on uncertainties. (Pause)
MR JUSTICE BLAKE: I think you are being asked to look at tab 2.17, page 130 of 151, table 4.1, "Comparison of uncertainty factors for dose co-efficients used to protect adult members of the public."
Is that what you want?

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

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

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

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

that anybody received. I think you've said that, that you have chosen to contaminate the whole of Christmas Island at some high level, you have made all sorts of other subjective choices which tend to make us think that you are looking to make these doses as high as possible and yet we find that you've ignored the CERRIE report which says they could be out by a factor of 10 for some radionuclides and you've ignored the Lesvos Declaration which says the same, but possibly even higher, and now we have the Environmental Protection Agency here, which you yourself quote as saying that there could be an uncertainty of almost 10 times, and even this study you write "three times".

But you now tell us that you haven't used any of those numbers and that in fact if you had, the answers you would have given the Tribunal -- and if nobody had asked this question about uncertainties those would be the numbers everybody would believe were the correct numbers. I am at a bit of a loss to know why, you know, you made this subjective decision not to include these uncertainty values.

A. The reason was because I don't believe that that area is within my expertise. I have said that several times. I've said it in this report and in others.

MR JUSTICE BLAKE: So when you did your report, you used

what uncertainty values?

A. I didn't use the uncertainty -- I didn't use any uncertainty value for those dose co-efficients, my Lord.

MR JUSTICE BLAKE: Any uncertainty values?

A. Not for the dose co-efficients, my Lord, no.

MR JUSTICE BLAKE: Because?

A. Because ICRP themselves say that the dose co-efficients are intended to be used as point values, i.e. as they are.

MR JUSTICE BLAKE: And you had confidence in that?

A. I used that -- I relied on that statement. I may have been in error, but that's the judgment that I took.

MR JUSTICE BLAKE: Yes.

DR BUSBY: So, Mr Hallard, we received a first paper from you, a very large, 250 pages paper, which gave answers for each of these individuals from all sorts of exposures that you decided that every exposure they could have received from different routes. That gave an answer, you know: A, B, C, D, dose, dose, dose, dose.

Now if nobody asked any questions, if we here on this Battersby/Smith team hadn't said "Can you answer this question about uncertainties?" those numbers would have remained, nobody would have questioned them, they would have been used as the basis for the argument by Dr Haylock and Professor Thomas that the doses were too

low to cause the cancers.

That's the case, isn't it, if nobody had asked any more questions, if we'd just left it at that?

A. Yes, I think that's probably true.

Q. But we did ask questions and as a result of that you said, "Yes, there are some uncertainties" and you'd missed out a few dose routes as I recall it, and produced another very large paper, 185 pages, in which all of the doses had changed. Is that right?

A. Actually I think the final dose estimates for most of them didn't change. The only one that changed significantly, from memory, was the dose estimate for Mr Battersby. That did change significantly by about 30 per cent. But I think the -- I would have to go back and look through the dose estimates.

Q. I'm not arguing about the actual doses, which we don't accept anyway. That's not the point. The point is that we now learn that if we had asked -- and we didn't know that you hadn't. It's not clear here that you hadn't used any of these uncertainties. It actually says in column 1:

"This study. 3, 3, 3, 3."

But now you tell us you didn't use the 3, 3, 2 and whatever it is. The uncertainty factor.

A. I think I've made it -- well, certainly I sought to make

it clear. You're talking about the replies that I sent to you?

Q. No. No.

MR JUSTICE BLAKE: What does this study mean at page 130, table 4.1?

A. I'm sorry, my Lord, I can't find the statement.

MR JUSTICE BLAKE: "Uncertainty factor", the last column.

A. Yes.

MR JUSTICE BLAKE: Subheading: "This study".

A. Right.

MR JUSTICE BLAKE: What does "This study" mean?

A. "This study" refers to the paper that this table was taken from. So "This study" refers to the paper by Harrison and Puncher.

MR JUSTICE BLAKE: Right, as footnote 3 explains?

A. Yes.

MR JUSTICE BLAKE: Right. It's not the study that you have performed for us?

A. No, I've simply extracted this paper and I've tried to explain that on the previous page.

MR JUSTICE BLAKE: Okay.

DR BUSBY: Right. So if we were to let's say approximate, we could argue that you had used the uncertainty factor of the USEPA your doses would have been multiplied by a factor of about 10. Is that correct?

A. Yes. The figures in that final column I think are used in a slightly different way to the way that Harrison and Puncher used them. Again I looked at them and tried to convert one to the other and I wasn't sure I could. But either, yes, you would use a factor of 2 to 3 if you took the Harrison and Puncher figures or the others for nuclides which have got a good body of evidence.

Q. So quite apart from any considerations of the CERRIE Committee or the Lesvos Declaration or the ECRR risk factors co-efficients that we looked at, quite apart from any of those, if we just take the United States Environmental Protection Agency, do you consider that to be an authoritative body, firstly?

A. It's -- it's an authoritative body. As I say, the paper felt that the Harrison and Puncher paper which this table came from, felt that their estimates were better because they used more up-to-date data and there were a number of other reasons why they felt their estimates were better.

Q. Harrison and Puncher are, if I could put it like this, the National Radiological Protection Board?

A. Or Public Health Protection Agency, I think they were at the time.

Q. But the United States Environmental Protection Agency is not a radiological committee, it's a committee that has

to do with a wide range of concerns relating to environmental protection; is that correct?

A. I don't know.

Q. No. Anyway, to get to the point here, had you used this factor of 10 -- we can say that just as yardstick, a factor of 10 -- Mr Battersby's dose which you produced of, as I recall, almost 40 millisieverts --

A. Yes.

Q. -- let's say, it was a bit less, but let's say 40 millisieverts, would become 400 millisieverts, is that right?

A. If you used a factor of 10 it would. If you used a factor of 3, obviously it would have been lower.

Q. If you used a factor of 3 it would be 120 millisieverts?

A. Yes.

Q. These are significant doses, aren't they?

A. Yes.

Q. So if your report had used these, our appellant, Mr Battersby, would have received a dose which nobody would say was insignificant.

A. No, I think that's true, but again I would be using numbers in a way that they were not intended to be used from my reading of ICRP, from my reading of CERRIE and others. COMARE also comment that they believe that the true value of the dose coefficient is more likely to be

close to the centre of the range than at the outside. The uncertainties will be plus or minus. Particularly taken over a range of nuclides there would therefore have been some balancing of those so that the final number over a range of nuclides would not be likely to be as great as that.

But at the extreme, then yes, the numbers could have been higher by that value.

Q. The decision of this Tribunal will be based on an interpretation of the law which involves reasonable doubt, and so would you agree that it would be fair to use the highest figure possible that one could obtain taking all the uncertainties into consideration, especially uncertainties published by an agency as authoritative as the US Environmental Protection Agency? It would be better to use that high figure if we were talking about doubt?

A. Well, again, I'll not go back to comment --

(Overspeaking)

MR JUSTICE BLAKE: Let him answer the question, please. You posed the question.

DR BUSBY: Sorry.

MR JUSTICE BLAKE: What's your answer?

A. Again, it comes back to my feeling that I simply don't have the expertise to be able to understand the

uncertainties adequately.

MR JUSTICE BLAKE: My understanding that the context for this sub-question is the wounds; is that right?

A. Particularly for Mr Battersby it would have been a wound, yes.

MR JUSTICE BLAKE: I mean all this comes in response to question 2.2:

"ICRP 72 is ...(Reading to the words)... dose co-efficients."

Et cetera.

A. Yes.

MR JUSTICE BLAKE: I understand from your answers that you have used ICRP figures because COMARE and others indicate that that's the most reliable.

A. Yes.

MR JUSTICE BLAKE: When you were asked these questions you provided other information about others with greater error margins and that information is put in table 4.1.

A. Yes.

MR JUSTICE BLAKE: You did not use any of those uncertainty factors in your reports because you had confidence in ICRP because others were telling you about that?

A. Effectively, yes, my Lord.

MR JUSTICE BLAKE: And the question is now being put that if you had used the range of uncertainty factors between

those two columns, "This study", which refers to Puncher and Harrison and USEPA, then for example in Mr Battersby's case the millisievert exposure would go up from 40 to 120 to 400?

A. In essence, my Lord. There is a slight qualification I would make, that the wound dose co-efficients which I calculated were based on themselves a very pessimistic model for calculating the wound dose. So there would have been some factor effectively built in for that. But --

MR JUSTICE BLAKE: Well, I am trying to work out the relationship between the factors that you did use in your original report --

A. Yes.

MR JUSTICE BLAKE: -- and the uncertainty factors that you told us about in answer to a question.

A. I think I can't really quantify the uncertainties in the method that I've used. So I think I would have to say in answer to your question that, yes, you would apply this uncertainty perhaps of a factor of 3 if you used the Health Protection Agency values, a slightly higher value if you use the USEPA values.

MR JUSTICE BLAKE: And do you think that is a reasonable approach to dosimetry in Mr Battersby's case?

A. You mean to use the factors or not use them?

MR JUSTICE BLAKE: To have used the risk factors which seem to increase the dose estimates?

A. So to apply a factor of 3 or 10 or whatever?

MR JUSTICE BLAKE: Between 3 and whatever it is, yes. We have the things in the table. I don't know which one you want to have a look at. But I mean if we're interested in 238 uranium it's 3 and then 5 to 6, whichever one.

A. Yes.

MR JUSTICE BLAKE: Do you understand the question?

A. I do understand the question.

MR JUSTICE BLAKE: Well, is that a reasonable approach to this form of dosimetry assessment?

A. It would not normally be done.

MR JUSTICE BLAKE: Because?

A. Because ICRP themselves say it's -- the CERRIE Committee also says that the way that it would -- that the way you should use the dose co-efficients is to use them as point values as they say, simply to use the value.

In the context of whether I should use them, whether I should have used them in this calculation in order to remain beyond reasonable doubt, it's still a difficult judgment. I think perhaps the answer is yes. But again -- sorry, I'm not trying to be evasive or awkward. I am just trying to give you as honest an answer as

I can.

MR JUSTICE BLAKE: That's all we are asking of you, but since the topic has arisen I would just like to know where you end up on the question.

A. I have used them as point values because that's what ICRP recommend, it's what the CERRIE Committee says should be done.

MR JUSTICE BLAKE: Has anybody, ICRP or CERRIE or other agencies that you consider authoritative, responded to the risk factor, uncertainty factor?

A. You mean have they multiplied any of the values by these factors?

MR JUSTICE BLAKE: Have they responded saying that that's asking the wrong questions or "We disagree with it" or "We agree with it" or is it just ships sailing through the night not communicating with each other?

A. Dr Harrison is actually a member of ICRP so obviously there is a communication link there.

MR JUSTICE BLAKE: Well, maybe, but I mean --

A. But I'm not aware of any response to this particular paper. I don't think the paper was written for that purpose. Or it may indeed feed into the calculations of the revised dose co-efficients which is currently going on at the moment.

MR JUSTICE BLAKE: Right. Yes.

DR BUSBY: Just one final point on this issue. I would just like you to confirm that these are uncertainty factors over the ICRP risk co-efficients. That is to say the USEPA doesn't have their own risk model. They all use the ICRP model and what they are saying here is that it might be out by a factor of whatever it says in this column, 5, 2, 8 or 3 or whatever?

A. That's my understanding of it, yes.

Q. So there's no alternative risk model in this table. It's not about any other risk model --

A. No, both papers were about estimating the uncertainties.

DR BUSBY: Good, thank you.

Well, my Lord, I don't know whether you want to -- I mean my next line of questioning might take some time. I could start it now and continue. But I just mention that if --

MR JUSTICE BLAKE: Well, we've got to have a break in the next 15 minutes. If you would prefer to take a break now ...

DR BUSBY: It might be better to take a break now and then I can take the next line of questioning through continuously. Of course it's your --

MR JUSTICE BLAKE: Well, no, you probably have an idea of what you are going to go to next. Right, we'll take a break.

25 past. We'll continue then.
(11.12 am)
(A short break)
(11.25 am)
MR JUSTICE BLAKE: Yes.
DR BUSBY: Right. Well, we are going to look at re-suspension factors. Before we do so, though, if I could just finish off -- I have a little extra bit to finish off on the uncertainties.
Could I take you to table 4.1 on page 130 of your second report, the 2.17 report, the one we've been looking at.
A. So we are looking at this table from the Harrison and Puncher.
Q. Yes, we were.
MR JUSTICE BLAKE: You cut and pasted from that?
DR BUSBY: In the same tab.
A. Yes.
MR JUSTICE BLAKE: Yes, the question?
DR BUSBY: In the same tab there's a table 3 on page 106.
A. Yes.
Q. Right. Now, if we go down the first -- this says: "Source of dose", "Co-efficient", "Estimated potential uncertainty"?
A. Yes.

Q. It goes down here:
"Overestimate to estimated dose, per cent."
If we go down to number 4 here, where it says:
"Activity of cloud in inhabited areas of the Island."
I see it says "factor of 20".
A. Yes.
Q. What I don't understand is did you use that factor of 20 or are you pointing out that that factor of 20 might be possible to be used?
A. These are the ranges of uncertainties that I believe exist in the calculations.
MR JUSTICE BLAKE: In your calculations?
A. My calculations, my Lord.
MR JUSTICE BLAKE: Yes.
A. So what I'm saying with that is that I believe that the calculation which I've done is an upper level, which is the final column, but that that could overestimate the dose by up to a factor of 20.
DR BUSBY: So you did use the factor of 20 in that -- you are saying that that factor of 20 was incorporated into your --
A. No, what I'm saying is that the calculation I did I believe was an upper estimate using the numbers which I used in the report. But you could interpret the

numbers in a less conservative way than I did, perhaps a more realistic way, if you like, a balance of probabilities-type way, and had you done the calculation that way you would have got a number which could have been up to a factor of 20 less.
Q. I see, good. That's all, thank you. I was a bit confused by this table. I wondered what it was it was saying.
MR JUSTICE BLAKE: Thank you for drawing it into the discussion. I had asked you a question before the adjournment, and I don't know whether the reference to that table 3 helps at all, as to what is the relationship between table 3 and table 4. Do your uncertainty estimates incorporate any of those at table 4.1 or is it a different approach to the same issue? Is there double counting if one takes yours and then multiplies by 3 or 5?
A. It's a different approach to the same thing. What I've done in table 3 is just quote factors, but on their own that isn't terribly helpful because they could be misleading, so what I've done is then converted those into what the equivalent uncertainty would be in millisieverts in dose.
So again it's the same approach that the far column, so the column to the far right, is showing the --

MR JUSTICE BLAKE: Of table --
A. Of table 4.
MR JUSTICE BLAKE: Table 4, yes.
A. Yes, is showing the potential underestimate. So that if there were uncertainties which had not been fully included in the calculation they would be shown in that final column as an underestimate and you'll see that most of the values shown there are described as "upper levels", that is I believe that they are upper levels, upper limit values, based on very conservative assumptions.
MR JUSTICE BLAKE: Sorry "upper levels" we get from table 3, page 106, final column; yes?
A. Yes, it's the same description here.
MR JUSTICE BLAKE: And toggling between, as I am trying to do, 106 and 130, just describe to us the relationship between the two tables.
A. Between 106 and 130, my Lord?
MR JUSTICE BLAKE: Yes.
A. The only relationship between those two tables is that -- if I can just find 130 again -- the only relationship between that is that if you look on -- so if we're on table 4 again, if you look under item 7 there, so this is on page 117 --
MR JUSTICE BLAKE: 117.

A. This is on table 4, my Lord. Sorry, I thought this was the table you were referring to.
MR JUSTICE BLAKE: No, I was referring to your table at page 130, table 4.1. But never mind.
A. Right.
MR JUSTICE BLAKE: You have introduced table 4 as well, yes?
A. I'm sorry, my Lord, I thought that's the one you were referring to.
MR JUSTICE BLAKE: Right.
I am going to make one final attempt at this.
A. Right.
MR JUSTICE BLAKE: Is there any connection between your uncertainties for each dose co-efficient in table 3 and the table you put in table 4.1?
A. The only relationship, my Lord, if you look on item 7 -- that's effective dose -- an example would be item 13.
MR JUSTICE BLAKE: At table 4 you are now on?
A. No, I've gone back to table 3. So this is page 109.
MR JUSTICE BLAKE: 109.
A. So item 13, which it says at the end of the row:
"Estimation of the uncertainty of the ICRP dose models is beyond my expertise."
And it's discussed in my response to question 2.2 on pages 129 to 132.
MR JUSTICE BLAKE: So the estimates you've made in table 3,

Mr Johnston's reports for some of the bases of your calculations?
A. Some of them.
Q. And that you see him as a dependable authority, although recently perhaps not in the case of uranium.
A. I think particularly in terms of the nuclear weapons expertise that I've relied on his nuclear weapons expertise, yes.
Q. Right. In your report, the first report on page 81, SB2/2.12, can we just have a look at that?
MR JUSTICE BLAKE: This witness' first report?
DR BUSBY: Yes.
A. Do you mean 2.12 or 2.14?
DR BUSBY: I have 2.12.
MR JUSTICE BLAKE: His first report, page 80?
DR BUSBY: Page 81.
MR JUSTICE BLAKE: 81. 81 of 285. That's 2.14. Yes.
DR BUSBY: Yes, "Re-suspension factor," here we are.
A. Right.
Q. You actually ended up using a re-suspension factor under (h). This is page 82, not page 81, I see here. So at (h) you say here:
"Hence a re-suspension factor of 10 to the minus 4..."
So 10 to the minus 4 is what you use?

if one was to -- applying a precautionary approach, would one then modify the calculations by the table 4.1 uncertainties? That's what I'm trying to get at.
A. Right. I can make a judgment here, my Lord, and I hope this helps.
It would not normally be done for the reasons that I said, that ICRP themselves say that it should be used as a point value and there are other documents which we've seen which make a similar comment.
If you wanted to estimate the highest possible inhalation dose, taking account of the uncertainties, so right at the extreme end of perhaps a 95 per cent probability or something like that, then it is possible that you would use those uncertainty values.
MR JUSTICE BLAKE: Right.
A. But that is not the way they're intended to be used, my Lord.
MR JUSTICE BLAKE: Yes. We're moving on.
DR BUSBY: Well, we can leave that now.
So you have made a number of subjective judgments about all kinds of questions coming to the results that you came to for the doses, is that correct?
A. I've made judgments and assumptions. I hope I've explained the basis for them in the report.
Q. I think you've already said that you rely upon

A. Yes.
Q. Right. So having accepted that now, can we please go to Mr Johnston's report, which is SB13/36.
Now, in this report on page 11 -- where does he say that now? He uses -- I can't quite find it, but he uses a re-suspension factor of 10 to the minus 3, Mr Johnston says?
A. Yes.
Q. You agree that that was his assumption?
A. That's what he's used here. In a later report he corrected that and used a value of 10 to the minus 5.
Q. But he did use it here, 10 to the minus 3?
A. He used 10 to the minus 3 here and then changed it later.
Q. I think Mr ter Haar asked you about this before but is there not a report from the National Radiological Protection Board where they calculate dose constraints, collective effective limits for isotopes of uranium, plutonium, radium and so forth, where they use the factor of 10 to the minus 3 for dusty conditions due to ploughing fields?
A. I haven't seen that report. If that's the one I was looking for I have sought to find it and I looked on the relevant websites including I sought it from the archive and I could not -- there were actually two reports that

are referred to. I simply couldn't find them, so in the end I relied on the information which I think included those because they were referenced in the Carter report and in the end I used the information in the Carter report.

Q. But had you used the factor of 10 to the minus 3 which I think you agree might -- well, has been cited by many people as being in these reports which you couldn't find, the doses would have gone up significantly?

A. Any inhalation dose based on deposition would have gone up significantly, yes.

Q. 10 times?

A. It would have gone up 10 times, but there was a lot of discussion in the Carter report about re-suspension factors which we discussed yesterday. Carter used a re-suspension factor of 10 to the minus 5, which he considered to be conservative, based on experiments which have been done in Maralinga. So he used 10 to the minus 5 which he considered to be very conservative. He said the range effectively was from occasional values at 10 to the minus 4 up to about 10 to the minus 6 or above. So I used 10 to the minus 4 on the basis that that was the highest level which had been seen in their measurements and therefore I considered that to be highly conservative actually.

Q. Do you concede that the NRPB actually gave a figure of 10 to the minus 3 for dusty conditions?

A. I've not seen that.

Q. So you say it didn't happen?

A. No, I mean I haven't seen that report. I haven't seen that value used.

Q. We have the report but not here unfortunately. So I guess that's as far as I can go with that.

MR JUSTICE BLAKE: Do you know when they did?

DR BUSBY: Yes, it was in --

A. I'm sorry, my Lord?

DR BUSBY: Oh sorry, the witness. Yes.

MR JUSTICE BLAKE: I was asking do you know when the NRPB, in the report that you haven't been able to track down, used 10 to the minus 3?

A. No, my Lord, I've not seen that report.

MR JUSTICE BLAKE: I appreciate you haven't seen it. I just wondered whether you knew what era the report was from.

A. I see, what the date was? I could probably find out from the Carter report.

MR JUSTICE BLAKE: The citation?

A. If my memory -- yes, there was a citation. I'm pretty sure there was.

MR JUSTICE BLAKE: If it's NRPB, it's before they became Public Health England.

A. Before they became Health Protection Agency and then Public Health England. It's quite an old report.

MR JUSTICE BLAKE: Yes.

DR BUSBY: Could I suggest to you that it was about 2002? Would that seem reasonable?

A. I can't remember. I don't know. I was disappointed not to be able to find them and I did try very hard to find them but in the end I concluded that since the Carter report had cited them, that therefore the information in the Carter report would be based on that, and would have taken account of that and therefore it would be reasonable.

Q. There are various kinds of dust, do you agree? So the concept which I think was raised earlier in these discussions about intolerable levels of dust would have much to do with the particle size, would it not?

A. It's a subjective statement. Perhaps it might have some relation to particle size. I wouldn't have thought it would be dependent on particle size. It's simply dependent on the fact it was a very dusty and therefore highly unpleasant environment.

Q. But the ultra-fine particles, if you like the nanoparticles that generally are conceded are the consequence of the condensation of the plasma from the explosion, those particles are essentially an aerosol,

are they not?

A. Well, the very fine particles, particularly if they were taken down to earth in rainfall, which is what I assume because if they were that fine actually it's very unlikely that they would be deposited on the ground by dry deposition and pretty much the only way that small particles like that -- from my reading of Dr Nicholson's report particularly and Mr Stretch's report, the main way for very small particles to be deposited on the ground would be if they were taken down in rain and that's what I've assumed in my report. Therefore, they would be distributed on the ground.

Q. I think my question is about this question of the tolerability of very dusty circumstances.

So what I am trying to ask you is would you consider that if the dust particles were so small that they were almost an aerosol they could be present in the atmosphere at very high concentrations but not considered to be intolerable because they were not clearly sticking to things and covering surfaces and generally kind of making people cough?

A. Well, we're perhaps going beyond my expertise. As a comment, I would had said that it would depend on the mass in the air rather than the particle size. But if there was a certain mass as grams per metres cubed or

whatever in the atmosphere that that mass -- and that was considered intolerable at one particle size I would have thought as a judgment -- although I don't have expertise in this area -- as a simple judgment I would have thought that would be intolerable for any particle size, within reason.

Q. We are going back to uranium. Can I take you back to the Washington report which is SB6/79.

MR JUSTICE BLAKE: So we've finished with SB13, have we?

DR BUSBY: Yes, we have, yes.

A. Which tab?

DR BUSBY: SB6/79.

This is a paper which we obtained from the archives of the University of Washington. It's a survey of Christmas Island and various other places.

A. Yes, I've seen this.

Q. I want to take you to the Christmas Island table which is one of these. Page 7 is Christmas Island.

MR JUSTICE BLAKE: 7?

DR BUSBY: And page 8. Yes, so page 7 talks about Christmas Island and it says the sites where the analysis was done in 1975.

Over the page we have table 3. Now where is the uranium stuff? (Pause)

MR JUSTICE BLAKE: Yes.

DR BUSBY: I think maybe this is a different paper, my Lord.

In this report there is a report in which they say concentrations of uranium found --

MR JUSTICE BLAKE: You had better put the right document --

DR BUSBY: -- on Christmas Island, but this doesn't seem to be the one. Unless I haven't got the right table.

MR JUSTICE BLAKE: Mr Heppinstall is giving you a prompt.

MR HEPPINSTALL: That one? So that's in 77.

DR BUSBY: 77, sorry, I gave you the wrong --

MR JUSTICE BLAKE: Leave 79.

DR BUSBY: SB6/77, not 79.

MR JUSTICE BLAKE: Delete 79, put in 77. Right.

DR BUSBY: Right, here we are.

So this is table 1 in that report on SB6/77.

A. Which page is that on?

Q. It's quite a short report --

MR JUSTICE BLAKE: Page number?

DR BUSBY: It doesn't have a page number, my Lord. It's sort of --

MR JUSTICE BLAKE: If you go in --

DR BUSBY: It's the eighth page into the --

MR JUSTICE BLAKE: Into the tab.

DR BUSBY: -- tab. It's called:

"Table 1. Radioactivity of the three most abundant gamma-emitting radionuclides in selected samples from

Christmas Island."

MR JUSTICE BLAKE: Have you got it there?

A. Yes, I have.

MR JUSTICE BLAKE: Right, well done. We have the table.

DR BUSBY: This is one of the few reports that we have which actually lists concentrations of uranium. As you said, the McEwan report mentions it but doesn't give any numbers.

So if you look on the right-hand side, the third column of this is uranium 238. It gives the concentrations in picocuries per gram?

A. Yes.

Q. Can you say whether these are significant quantities of uranium 238? Whether you would expect to find them on a coral island, given Mr Johnston's remarks about concentrations of uranium on coral islands?

A. Well, this is outside my expertise in terms of environmental concentrations of uranium on the Island. I have looked at this.

MR JUSTICE BLAKE: You've looked at this report before, have you?

A. I have looked at the report before, yes.

MR JUSTICE BLAKE: So it's not something you are having to deal with fresh.

A. No, and --

MR JUSTICE BLAKE: What was the question again?

DR BUSBY: Would you consider these to be normal levels of uranium in the environment on a coral island?

A. Okay, I'm going from memory.

MR JUSTICE BLAKE: Can you comment upon that?

A. Yes, I can from memory, my Lord.

MR JUSTICE BLAKE: Right. Okay.

A. So I may need to confirm this data and come back to you. It was a little while ago that I did this, but I looked at -- ah yes, I looked at typical levels of uranium just from doing a Google search and found some papers which appeared to be authoritative, from good sources. If my memory serves me correctly, these levels were -- and I will need to confirm this, so please understand that these are based on memory -- that these levels, that the level in soil, and we see that there are not many values for soil, there's only two or three values for soil, everything else is from animals, but that these were actually fairly consistent with typical levels of uranium in Britain, and in the United States and particularly in Canada the levels tended to be rather higher.

DR BUSBY: That's very helpful, thank you, yes.

If we look at this table on the right-hand side of 238-uranium, the highest levels are in fish, would you

say that? Is that correct?
A. Goatfish, mullet -- yes, they appear to be.
Q. We have three fish here, Milkfish, mullet and goatfish and I know there are hardly any -- it's a very, very -- you know, but it's all we have. It's all we have.
A. (Nodded assent).
Q. So there does seem to be more uranium in the fish than there is on the Island?
A. Yes.
MR JUSTICE BLAKE: In the soil.
DR BUSBY: Thank you.
A. But then there's uranium in seawater.
DR BUSBY: Of course, of course. But then the seawater also lands on the land, doesn't it? I mean it's a coral island.
A. I mean, I say there's uranium in seawater because I know there's uranium in seawater. I could not make any quantitative association between what appears in the fish and what's in the uranium. I simply don't know.
MR JUSTICE BLAKE: When you say uranium in seawater do you mean as a naturally occurring --
A. Yes, my Lord. You get natural uranium in seawater in the same way as you get natural uranium in soil.
DR BUSBY: There is no way we can tell from this table if this is natural uranium, is there?

A. It's uranium 238, which is the principal constituent of natural uranium. Apart from that, no. It's simply a statement of how much uranium was measured.
Q. We would need to have other uranium isotope measurements in order to see whether it was from the nuclear explosions or whether it was from the -- yes, thank you.
A. Yes.
Q. Can we just go now to SB7/110.
Have you read this paper before? Have you seen this paper?
A. I don't recognise it. I have read papers from Professor Sawada on black rain and I've read one of his references but I'm not sure this is the one I've read.
Q. This is a different Sawada, this one.
A. Oh, is it? In that case I won't have read it.
Q. But it was cited by Professor Sawada. Essentially you can see if you can just have look at the abstract I guess -- and I'll just let you look at that. (Pause)
A. Okay.
Q. These people then, would you agree that these people were measuring uranium in the black rain at the areas where the black rain fell after the Hiroshima --
A. As far as I can tell. I mean I've only read the abstract and of course, as we discussed the other day, that could be misleading.

MR JUSTICE BLAKE: What's the question? Because let's see whether this witness can help upon this topic at all. If he hasn't read the paper I rather doubt it but what's the question?
DR BUSBY: The question is: do you agree that the rain would have contained -- that the rain at Hiroshima, the black rain at Hiroshima contained uranium?
A. I can't comment. I really can't.
Q. We'll leave it in that case. It's not really your area of expertise.
So we'll leave that altogether now. It was just to draw attention to the presence of uranium on Christmas Island from the Washington report.
MR JUSTICE BLAKE: Right. So we aren't going to pursue that one.
DR BUSBY: We can now go to SB7/96.
A. SB7 again.
Q. Yes.
A. And which tab?
MR JUSTICE BLAKE: 96.
DR BUSBY: 96. Yes.
Have you seen this paper before?
A. I have. I've looked at it briefly. I haven't studied it in detail. I only received it quite recently, so I just did some preliminary calculations on it and

that's all.
Q. You are a health physicist?
A. Yes, I am.
Q. Are you aware of the studies that have been carried out of doses at the Marshall Islands by the Health Physics Society, a very large paper by SL Simon and various other people?
A. I'm not aware of that particular paper. I mean I know a lot of work has gone on in the Marshall Islands but I'm not aware of that particular paper.
Q. Earlier on you said that you used the dose -- that the distribution of radionuclides in your calculation and you took -- which would have occurred after a bomb test, and you took that from the Carter report.
A. Yes, subsequently modified in my supplementary report. In the supplementary report I discovered that the information in the -- well, perhaps we'll go into that later but with that qualification then yes, I used the Carter report.
Q. Now, when a bomb explodes and produces all sorts of fission products and activation products and residues from the bomb casing and whatnot, the actual concentrations, the immediate concentrations or the concentrations after one hour or whatever, 10 hours, 15 hours, days and so forth, they depend greatly on the

spectrum of radionuclides that are there; is that correct?
A. Well, the rate of decay of the mix of nuclides for both fission weapons, that's atomic weapons, and thermonuclear weapons, there is an approximate relationship and that same relationship is being used for both types of weapon. It's the so-called -- the relationship is T, which is time, to the power of minus 1.2. Now it's an approximate relationship but it's quoted in Carter, it was quoted in quite a few of the papers from Christmas Island, it's quoted in "The effect on nuclear weapons", the book called "The effect on nuclear weapons" by Glasstone.
So the indication from that is that regardless of the precise mix of the nuclides, that the approximate rate of decay -- of the mix, not the individual isotopes, of the mix -- is roughly the same.
Q. Yes, but to calculate the actual internal doses you rely upon the concentrations of the specific nuclides because then you have to go to the ICRP risk co-efficients for those nuclides, is that correct?
A. Yes, and largely I've used the mix and the internal dose co-efficients that were in the Carter report.
Q. The internal dose co-efficients are not so important as the actual concentrations of the substances which are in

the people for which those co-efficients are applied -- to which those dose co-efficients are applied.
MR JUSTICE BLAKE: Is that a statement or a question? I've lost this. What questions do you want to pose about this document?
DR BUSBY: I am saying that the --
MR JUSTICE BLAKE: Ask him a question.
MR TER HAAR: I thought I did, my Lord. But the results of the internal dose calculations for different spectra of radionuclides would be different, is that correct?
A. Yes. Yes. There would be some isotopes which would tend to dominate but yes, it would vary depending upon the precise mix.
Q. There are different isotopes in a fusion, in a thermonuclear bomb to the ones that are produced by a fission bomb, is that correct?
A. Yes, and I discussed that at some length in my report.
Q. In fact, principally you used the data from Carter which was for a fission bomb; is that correct?
A. Yes, but I then modified it in my supplementary report to take account of three additional nuclides, which was uranium-240, neptunium-240 and plutonium-240.
Q. Where did you get the information for the concentrations of those?
A. Of those three nuclides?

Q. Yes.
A. From the gist document, the Bevis Parker document.
Q. But you could have gone to this -- this is the standard work on the distribution of radionuclides from fission fallout and from thermonuclear fallout?
A. Okay.
MR JUSTICE BLAKE: Is that a question?
DR BUSBY: Why didn't you?
A. Well, because I wasn't familiar with this paper. I've only seen it relatively recently -- very recently in fact -- and prior to that I wasn't aware of the document.
Q. But, Mr Hallard, you hold yourself out to be an expert in this area.
A. My expertise is in health physics, rather than nuclear weapons and the precise mix, which is why I've used the data from Carter because it was authoritative. I can also explain why I think there were certain --
Q. So is it fair to say that your expertise is not in the health physics relating to the assessment of risk from nuclear weapon fallout?
A. Not specifically. It's general expertise in health physics.
Q. So your report is written by somebody who you now tell us does not have expertise in the analysis of fallout

from nuclear weapons; is that correct?
A. Er --
Q. Or not fully, perhaps? I mean perhaps I am being too cruel here.
A. I'm not an expert in nuclear weapons, no, and I've said that before, I think. And I did discuss in some depth, I think, the data that I was using from the Carter report and why I concluded in the end that it was reasonable to do so.
Q. I think what I am asking you to agree is that the inputs to your calculation in terms of the -- yes, the inputs into your calculations were not inputs that would have been used by someone who was an expert, like Professor Simon, in the doses from nuclear weapon tests.
A. I think the Carter data is generally taken, certainly from the information that I have, as being good data and amongst the best data available which is not classified.
Q. But -- yes.
MR JUSTICE BLAKE: If you want to make a point about this document you'd better make it because we've had it open for some time and we haven't gone beyond the title page and we're going to have to put it into a question or abandon it.
DR BUSBY: Well, I have made all my points about this, my Lord.

MR JUSTICE BLAKE: If you are asking questions of this witness, Dr Busby, I want you to ask a question.
DR BUSBY: The Carter data then you agree was the best data available for fission bombs, but your report is about exposure to fallout from thermonuclear bombs which is not the same. If you look in this report you can see data for both fission bombs and thermonuclear bombs, which are different, is that correct?
A. I've not studied the report in that much detail. There will be variations between individual weapons. The data, I mean I --
MR JUSTICE BLAKE: Look, I'm sorry, I'm going to cut across this. This is just getting nowhere.
You have explained in your report how you have used Carter.
A. Yes, my Lord.
MR JUSTICE BLAKE: And you have modified it for the nuclear devices.
A. Yes, my Lord.
MR JUSTICE BLAKE: And because of different radionuclides an you made calculations.
You are familiar with this document?
A. I have seen it, my Lord, recently, but I've not had time to study it in significant detail.
MR JUSTICE BLAKE: From what you have read is there anything

in this report which suggests that what you were doing in modifying Carter was wrong or inappropriate?
A. I've looked at the decay rate in this report, my Lord, and I was finding similar decay rates.
MR JUSTICE BLAKE: Yes.
A. I've looked at the gamma levels, this is the gamma levels at 1 metre height from the deposit of the radionuclides contained in this, and the numbers were similar. I think these numbers were coming out to be slightly higher, less than a factor of 2. So the Carter report data was within a factor of 2 for gamma of the data here. I've done no other analysis of this.
MR JUSTICE BLAKE: Are you still comfortable about your modification of Carter to get the results that you produced to us in the light of this report or do you think anything you have read would require you to recalculate?
A. I haven't studied the specific nuclide mix in this, my Lord. The data that I've used was the best data that I had available, frankly, and I still believe is reasonable and actually pessimistic because the use of data from a fission weapon -- fission weapons actually have a higher proportion of plutonium in them than the fusion weapons because there is residue from the core of the fission weapon so therefore you get a higher

proportion of plutonium and that in itself will lead to a degree of pessimism.
In terms of the other short-lived isotopes I simply haven't done enough or I haven't looked at that in that depth in this report.
MR JUSTICE BLAKE: Okay. Pause there. Now if there is anything you want to develop in that answer or challenge or point anything else out, now is your chance, Dr Busby.
DR BUSBY: Do you consider you are expert enough to have made the modifications that you made to the Carter fission spectrum?
A. In the supplementary report?
DR BUSBY: Yes.
MR JUSTICE BLAKE: The modifications you made.
DR BUSBY: The modifications you just told us you made?
A. In the supplementary report, I believe so.
Q. I take it that's a "yes"? yes?
A. Yes, I had a short conversation or a conversation with somebody in Aldermaston to confirm that my interpretation of that gist report was the correct interpretation of it and he confirmed that it was.
Q. You've just told us a minute ago that you had a look at a couple of things here and you said "less than a factor of 2", so in other words, it wasn't the same, was it?

A. In terms of the gamma levels. No, but there will be variations -- I mean there will be variations between individual weapons, let alone between different reports.
Q. Of course. So if you had used this authoritative data from Lawrence Livermore, you would have got a different result, would you not?
A. The external result might have been slightly higher. I haven't done that. I mean I would need to do the full integrations, et cetera, to be able to compare them. But I think they broadly would be at least within a factor of 2.
Q. Right. So that's another factor that we have to consider in terms of increasing the dose, apart from the EPA factor of uncertainty and all the other stuff, is that correct?
A. A small factor, difference between them, but I would need to look at the --
Q. Of course.
A. I would need to do the calculations to be sure.
Q. Of course.
A. But a small factor. As I say, there will be variations between individual weapons. It depends on the design of the weapon in terms of -- well, the weapon design.
MR JUSTICE BLAKE: At the end of the day we're looking at specific issues about specific weapons.

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

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

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

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

A. I don't.
Q. So would you disagree if I were to say it was about 20 times U-234 to U-235?
A. I would take your word for that if you tell me that that's correct.
Q. All right. So it's possible that what Dr Morgan was talking about here was the fact that not only was it more radioactive but there was a lot more of it in the enriched uranium.
In fact, if you look at the Bevis Parker, you've analysed the Bevis Parker gist and you find that there is a -- I mean, did you find that there was a lot of U-234 in the weapons' residues, that it represented quite a significant proportion in terms of its activity?
A. Yes. There was significantly more in terms of total kilograms. So I'll just read out the figures which I think is probably the simplest way of answering your question.
Q. That would be helpful.
A. So this is total kilograms for all weapons based on the Bevis Parker data, which of course was an upper limit.
So for uranium-238 it was approximately 8,000 kilograms; for uranium-235 it was approximately -- well, about 400 kilograms; and for uranium-234 it was approximately 10 kilograms.

Q. Could you just tell us what that is in activity? Is that possible?
A. In terms of total activity?
Q. Well, if we could do the same for one bomb, I mean it would give us the same --
A. I've got it in various units, kilogram per metre squared and things like that.
Q. Becquerels is what we want.
A. In terms of total becquerels the simplest thing might be if I just do that calculation.
MR JUSTICE BLAKE: Well, if you haven't done it, don't do it now. You may have to do it at a later time.
DR BUSBY: It would be unfair to ask you to do it now.
MR JUSTICE BLAKE: I am not going to do it in the witness box.
Do you really want that calculation, the total becquerel activity?
DR BUSBY: Yes, we would like the total becquerel --
MR JUSTICE BLAKE: Is that a calculation that you can perform for us if you are asked to do it?
A. I can, my Lord.
MR JUSTICE BLAKE: Can you do it over the short adjournment or something like that? Is that possible?
A. It wouldn't take very long. I have all the data I need.
MR JUSTICE BLAKE: Don't try and do it now.

A. I won't.
MR JUSTICE BLAKE: Yes, can we move on to another topic?
DR BUSBY: Yes, we can.
There's one thing I want to go to which is the various routes that there were for exposure.
MR JUSTICE BLAKE: You've finished with this document now, have you?
DR BUSBY: Yes, I have, yes.
MR JUSTICE BLAKE: We can close that one up. Pathways to exposure?
DR BUSBY: Pathways to exposure, yes.
MR JUSTICE BLAKE: Right.
DR BUSBY: I don't intend to take you to any documents on this one. But I just want to go to some missing exposures and in particular one missing exposure.
MR JUSTICE BLAKE: Right. So your report deals with pathways, I think, from page 16 -- well, you are dealing with various sources of information, aren't you?
A. I am, and I discussed the various pathways which I've used in the report.
MR JUSTICE BLAKE: Yes, right. Well, with that in mind I think it's going to be suggested that there's a pathway that was missing.
A. Okay.
MR JUSTICE BLAKE: Right. Which is that?

DR BUSBY: Right. We were talking earlier about where all this stuff fell, and there's a lot of speculation about how much of it fell on the Island and how much of it fell in the sea and so on. But would you agree that a significant amount of it fell in the sea?
A. That seems likely from various mechanisms, yes.
Q. In fact, it's the Secretary of State's position that most of it fell in the sea.
Now, you work at Sellafield and you've been involved in health physics at Sellafield. There have been a lot of papers and a lot of concerns about what's called sea-to-land transfer; is that right? Have you been involved in that at all?
A. I've never been -- no, I've never been involved in that.
Q. But do you agree that there is such a phenomenon and it's well characterised, well described?
A. Yes. I mean I'm assuming what you mean is a combination of silt coming back or perhaps activity dissolved or suspended in seawater being what is called blown off the surface in terms of air activity, that kind of thing. Is that the sort of thing?
Q. Yes, it's quite a specific phenomenon called sea-to-land transfer.
MR JUSTICE BLAKE: Have you heard of this phenomenon called sea-to-land transfer?

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

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

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

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

Q. Just a general statement, yes.
Your response was not an expert response, you would agree, it was just your opinion?
A. Yes, it's an opinion.
Q. Right.
A. And it's an opinion made in the witness box in the space of a few minutes.
Q. And your opinion is also that this enormous amount of radioactivity from the explosions, including 8 tonnes or up to 8 tonnes of uranium as particles that would fall in the sea, they would just be dissipated and diluted and generally of no importance with regard to exposure at Christmas Island? That's your thought, your opinion?
A. That's my first reaction. I mean, the activity from the detonations would clearly go -- from any large detonation, thermonuclear detonation, a lot of that activity is transferred into the stratosphere or into the high troposphere. These are layers in the atmosphere. From there they are dispersed over very large parts of the globe -- over the whole globe, in fact, and I'm sure that you are familiar with that principle.
Some of that activity would presume -- well, it would have fallen in the sea, because of course we know from the experience with the Shackleton aircraft that

that aircraft flew through activity which was falling in light rain. But the distance, that was already many tens, over 100 kilometres I think from the Island, and therefore again we're talking about significant distances and huge bodies of water.
That's what I have in mind when say that I wouldn't have thought as an initial reaction that it would be a significant pathway.
Q. Would you agree that the Pacific Ocean has currents?
A. Yes. I don't know anything about the currents but I would agree it's got currents.
Q. A current means the water moves either to the west or the east or somewhere?
A. Yes.
Q. And if the material falls in the sea then the current will take it towards the land?
A. I don't know enough about the currents in the Pacific.
MR JUSTICE BLAKE: Depending which way the current is blowing, I would have thought. That's somewhat abstract, I'm afraid.
DR BUSBY: We can --
MR JUSTICE BLAKE: Well, no, if you have a particular question to put, put it.
DR BUSBY: Is it possible that a current would have brought that material that fell in the sea ashore on

Christmas Island? Is that a possibility?
MR HEPPINSTALL: I am not going to let Mr Hallard answer that question.
MR JUSTICE BLAKE: Yes. You are being asked to speculate upon an unknown premise.
A. I just don't know would be the answer.
MR JUSTICE BLAKE: Right.
DR BUSBY: Have we got the --? No, in that case we'll leave that.
MR JUSTICE BLAKE: Yes.
DR BUSBY: But you do -- well, we can leave this with what you've said so far which is that that was just a pathway --
MR JUSTICE BLAKE: We have what he said, so if you want to move on to another topic that he can help you with.
DR BUSBY: So that pathway wasn't one that you considered.
Yes, there was one point about that before I leave it.
Do you agree that that pathway has been suggested as a cause of the increase in childhood leukaemia near Sellafield? Do you remember that as a possible cause?
MR JUSTICE BLAKE: Do you know about that?
A. I think I couldn't comment on that, my Lord. I don't think I know enough about it. It would be well beyond my expertise. Any information I have on that would be

general and it would be based on memories from years ago. I think it would be --
MR JUSTICE BLAKE: We don't want to do that.
DR BUSBY: Fair enough, okay.
Now, there was another pathway that was used by the Simon study of the Marshall Islanders and that was inadvertent ingestion and actually I think Mr Johnston in one of his reports uses an inadvertent ingestion of 1 gram of material per day. This is just people, you know, biting their fingernails and --
MR JUSTICE BLAKE: Well, what is inadvertent ingestion?
DR BUSBY: Inadvertent ingestion is where you bite your fingernails or suck your lips or use teaspoons that are contaminated or whatever, and therefore you swallow soil or other material?
A. Well, I have included an assessment for eating soil.
Q. Oh, you have?
A. Yes.
Q. Oh, that would be inadvertent ingestion. So I must have missed that. Okay, sorry.
We'll leave that one now.
I'd like to now take you to the question of rainout and seawater entrainment because I think you have assumed that the -- well, I'm not sure if you're the right person to talk to about this actually -- perhaps

you are not -- but if I could ask you to look at the statement by Archie Ross at SB9/140, and comment on -- right we haven't got it. Okay. (Pause)

It rather has to do with this business of running about with Geiger counters and so forth.

A. Okay. 140?

Q. Have you seen this document? Have you read this?

A. I don't believe so. I've seen that diagram.

Q. Right.

A. Now whether I've seen it -- or I've seen a similar diagram, an equivalent diagram, whether I've seen it in this or somewhere else. I don't recall this document but I've read so many documents that I may have seen it and simply forgotten.

Q. I deeply sympathise. Can I just go to paragraph 9 and he says: .

"... about 20 minutes or so we returned to the Main Camp ..."

A. Yes.

Q. "... changed into shorts and went to pick up the transport."

Then he goes on to say that the port area where he had been had been under torrential rain from the very same clouds produced by the bomb.

So do you accept that Mr Ross actually saw that,

that this is evidence that there was torrential rain produced by the bomb or not?

A. Well, I mean, I think it's accepted that there was torrential rain.

MR JUSTICE BLAKE: Well, I think that may be the point. What's the question?

DR BUSBY: Does he accept that that is evidence that there was rain at the --

MR JUSTICE BLAKE: Well, I think his report deals with rain.

A. Yes, and Mr Stretch's report contains several eye witnesses' evidence. In fact, that may be where I've --

MR JUSTICE BLAKE: I think you do, about the chap who went to dig a trench or something.

A. Yes, and that's in Mr Stretch's report.

DR BUSBY: So this was 20 minutes after the bomb.

MR JUSTICE BLAKE: Why don't you go to his report because that may be a more useful starting point on this topic to see whether you have anything new on this document than was contained in the report?

DR BUSBY: I think probably in that case everybody has accepted that there has been torrential rain --

MR JUSTICE BLAKE: Well, his report is based upon that. I think you've really got to bring this to focus upon what this witness has told you about in his report. I think I was reading it -- isn't it paragraph 14 at

page 29, from recollection? As it happens, a topic I've marked up, by some extraordinary coincidence?

A. Yes, thank you, my Lord. Yes, that's exactly it.

MR JUSTICE BLAKE: Yes, right.

So do we get anything more from this document, Dr Busby, than we have in that report?

DR BUSBY: Yes, well perhaps not this one. I was going to go to the entrainment point, Mr Fiddaman. I was going to start with this one and then go to Derek Fiddaman's witness statement from HMS Cossack, which is at 139.

MR JUSTICE BLAKE: We move on from tab 140. Right.

DR BUSBY: Well, it's one back from that, 139.

MR JUSTICE BLAKE: 139. When I say "move on", we go to a different tab, perhaps, if that's better. Yes.

DR BUSBY: Yes.

MR JUSTICE BLAKE: Tab 139.

DR BUSBY: Well, I clearly didn't need to take you to the Archie Ross statement because you accepted that.

The arguments have been put forward that that rainfall was a result of --

MR JUSTICE BLAKE: Well, I don't think Mr Ross or anyone else is going to be able to tell us that, others will, but rainfall you have. Now, what do you want from 139?

DR BUSBY: I want to go to the third bullet point here on the second page.

MR JUSTICE BLAKE: Page 2?

DR BUSBY: The first page is "I Derek Fiddaman", dah-di-dah. Over on page 2 there are a number of bullet points, and I want to go to the third bullet point.

MR JUSTICE BLAKE: Have you read this one?

A. I have, my Lord.

MR JUSTICE BLAKE: Good.

DR BUSBY: Fiddaman was on a ship --

MR JUSTICE BLAKE: Yes, well, what's the question?

DR BUSBY: The question is it says in this bullet point:

"The cloud was boiling red and black, and it seemed as if the stork was sucking up the Pacific Ocean."

Then various other things he said, terrifying, and so forth.

MR JUSTICE BLAKE: What's the question?

DR BUSBY: Do you accept that this particular explosion resulted in the entrainment of seawater?

MR JUSTICE BLAKE: Can you comment on that?

A. I can't, my Lord. I mean, I've read a considerable amount of debate about that, particularly Mr Johnston's reports.

MR JUSTICE BLAKE: Right. You've seen the debate about it. Can you add to that debate from your own personal expertise?

A. No, my Lord.

MR JUSTICE BLAKE: Right. I don't think we are going to get any information from the witness on that topic.
DR BUSBY: Right. I asked a question, did I not? No.
A. Sorry --
MR JUSTICE BLAKE: His answer is he can't assist you on the question of entrainment by rainwater.
DR BUSBY: No, all right.
MR JUSTICE BLAKE: He's seen the information by the experts on that topic and he can't add to it.
DR BUSBY: Okay.
MR JUSTICE BLAKE: Have we finished with SB9?
DR BUSBY: Yes, we've finished with that now, thank you.
We'll now go to photoelectrons, Professor Howard's report, SB1/2.4.
MR JUSTICE BLAKE: SB1/2.4.
DR BUSBY: SB2/2.4?
A. SB2 or SB1?
MR JUSTICE BLAKE: No, it's SB1, it's 2.4 (Pause) It's SB1, tab 2.4. For some reason we have a number of tabs in bundle 1 and there they are.
Which page of Professor Howard?
DR BUSBY: Page 6, my Lord.
MR JUSTICE BLAKE: Right. Do you have page 6?
A. Yes, my Lord.
MR JUSTICE BLAKE: Fig 1, "photoelectron tracks"?

A. Yes.
DR BUSBY: First of all, you were trained as a physicist?
A. Yes.
Q. So you understand the photoelectric effect?
A. I understand the photoelectric effect.
Q. You understand that elements of high atomic number have a much higher ability to intercept radiation?
A. That's why lead is a good shield.
Q. Exactly, and in fact uranium is used also as shielding?
A. Uranium is a good shield as well.
Q. Yes. So if you had uranium inside you or lead inside you and you were X-rayed that would intercept the radiation, so you could see that as an image; correct?
A. Yes.
Q. That's why if you have --
A. If --
MR JUSTICE BLAKE: Yes.
A. -- to qualify that slightly, if you had a large enough piece to be able to see it on an x-ray then you would see it, and clearly it would stop the X-rays and therefore it would be visible. If that's what you mean, then the answer is yes.
Q. Yes. So where does the energy go when the X-ray or the gamma ray hits the piece of uranium or lead that's inside you? What happens to the energy?

A. It's emitted in the form of a beta particle. Well, to all intents and purposes, it's a beta particle. It's actually an electron from the atom, from the outer shells of the atom, which is ejected from the atom.
Q. It's not a beta particle?
A. It's not a beta particle, because strictly beta particles are produced in the nucleus but, unless you knew what the source is, you would not be able to distinguish it from a beta particle.
Q. Well, perhaps we could call it a photoelectron?
A. Yes, okay, call it a photoelectron, yes.
Q. But it is indistinguishable from a beta particle?
A. Yes, but --
Q. So its effect on tissue would be the same as the effect of a beta particle on tissue?
A. A beta particle of the same energy.
Q. Identical, in fact, yes.
So if you had, instead of one safety pin or a large item of lead inside you that you could image, you had lots of small items, the same effect would occur?
A. Yes.
Q. Correct? In fact, it would occur to a greater extent, the smaller the size of the piece of material; correct?
A. Are you talking about small particles now?
Q. I am just trying to ask you if some of the energy --

let's put it like this -- some of the energy would be lost because the beta particles or the photoelectrons wouldn't get out of the --
A. Ah, yes, if the piece of lead or piece of uranium in this case was big enough such that the beta particles couldn't get out then that's true, but if it was at micron levels, or whatever, or smaller than that, then I don't think the size of the particle would make much difference.
Q. No. So in fact all of the energy that's absorbed by these particles of lead, shall we say, would come out as beta particles?
A. Yes.
Q. So somebody standing in the environment and receiving a gamma radiation dose from natural background would have more photoelectrons or beta particles, if you like, in their body than if they didn't have these particles inside them?
A. Sorry, can you just repeat the question?
Q. The hypothetical person that has these smaller pieces of lead inside them now, and who was just living, like all of us, being exposed to background radiation, gamma radiation, they would have a bigger dose from photoelectrons inside them, or beta particles inside them, there would be more beta particles inside them

than if they didn't have the lead particles inside them?
A. Yes, but the extent of that enhanced dose clearly would depend on how much uranium there was.
Q. Or the number of particles there was?
A. Yes, that's what I mean.
Q. Yes. Yes. Of course.
Is it fair to say -- I mean, can you tell me if the ICRP risk model takes into consideration any of these effects relating to particles of uranium or lead or platinum, or any highly-absorbing or radiation-blocking material?
A. Again, you're going beyond my expertise because you are getting into the internal dosimetry. I'm not aware that it does, and from general comments I've heard, I think -- I'd better not because I'm getting into a field which I think is going beyond my expertise.
MR JUSTICE BLAKE: You can't comment.
A. I can't comment on the internal dosimetry aspects, my Lord. So I cannot answer that specific question.
DR BUSBY: But as a physicist do you agree that all of the things that I've said so far you would agree with?
A. Yes.
Q. About the beta particles being the same as the photoelectrons --
A. Of the same energy.

Q. -- and the gamma radiation background causing some increase in beta particles, if you like, than there would be if there was nothing inside you?
A. Yes.
Q. Yes. So we can't quantify it, but the general effect is acceptable physics in your --
A. Yes. The photoelectric effect is one of several means in which gamma is absorbed by atoms.
Q. Yes. In fact, that is -- yes.
MR JUSTICE BLAKE: Right. We have that answer.
DR BUSBY: Now, if we look at this picture, figure 1 here, which was provided by Professor Howard, the consequence of research that he's carried out at the University of Ulster. Have you seen this picture before?
A. I have, yes.
Q. Yes. So what this picture shows are three types of photoelectron emissions from water on the left, gold in the middle and a uranium particle on the right-hand side.
A. Yes.
Q. Do you accept that the results of this -- you know, that this shows approximately the kind of thing that we're talking about? Let's not get involved in qualitative, but just qualitatively is it what you would expect as the atomic number of the element that we're talking

about went up?
A. That you would get more beta particles --
Q. Yes, more beta particles --
A. Yes, I would accept that.
MR JUSTICE BLAKE: Give him a chance to answer. Yes. What's the answer? Because I haven't got an answer now.
A. The answer is yes, my Lord.
So that you would expect to see more photoelectrons, as Dr Busby refers to them, you would expect to see significantly more photoelectrons from uranium than you would from gold, than you would from oxygen, the last one.
MR JUSTICE BLAKE: Yes.
A. It's a light element, anyway. I think it was oxygen.
DR BUSBY: Yes, oxygen would be the component of the water that would be mostly responsible, you agree?
A. There is a specific relationship between what is known as the atomic number, which is the number of protons in the nucleus and also the number of electrons orbiting the nucleus. That's called the atomic number.
MR JUSTICE BLAKE: Yes.
A. And the probability of a gamma ray being absorbed by the photoelectric effect is approximately the atomic number raised to the power of 4.
MR JUSTICE BLAKE: Yes.

A. It varies slightly, but what that means is that you then get a significant higher absorption of gamma in big atoms like uranium or like lead than you get in small atoms like oxygen.
MR JUSTICE BLAKE: And does this phenomenon have an impact upon your calculations?
A. I don't believe so, my Lord.
MR JUSTICE BLAKE: Why is that?
A. I've read a paper -- again, we're getting into the internal dosimetry, and in terms -- and the dose co-efficient that I've used is the ICRP dose co-efficient for uranium, for example.
MR JUSTICE BLAKE: Well --
A. But two more specific answers to your question, I think.
I've read a paper -- two papers -- produced by Public Health England looking precisely at this effect. Although it's a while since I've read them, I think their final conclusion was they concluded that the dose from the alpha emissions from the uranium was more important than the beta emissions from this.
MR JUSTICE BLAKE: Yes.
A. But I think the other thing -- this more a qualitative statement -- it does very much depend on the -- in this case it would be the mass of uranium in the body rather than the activity.

Now, I'm not going to the point here of the uranium sticking to the DNA because that's beyond my expertise, and there's obviously been a debate on that. So I'm just talking about the uniform distribution of uranium throughout the body. There would need to be a lot of uranium in the body for the number of beta particles emitted from the uranium to be more than the other carbon and oxygen atoms in the body, because although the number of beta particles from those atoms is a lot less, in this relationship to the power of 4, because, for example -- perhaps I'll not go into the maths.

MR JUSTICE BLAKE: Right, okay. That completes your answer, does it?

A. Yes.

But in general terms my feeling is that there are so many more atoms, that the proportion of the oxygen atoms in the body are so much higher than the proportion of the uranium atoms, unless there was a lot of uranium, that the oxygen atoms would still tend to dominate.

MR JUSTICE BLAKE: Yes.

DR BUSBY: But you agree that you're not an expert in this area?

A. I'm certainly not an expert on the dosimetry side of it.

Q. I just wanted you to agree that the process itself, as you very --

A. The process itself and the relationship, the power 4 relationship, approximately, power 4.

Q. -- you very helpfully answered that question with regard to the general process as a physicist.

A. Yes.

Q. Thank you.

Just to be sure, the reason that you didn't -- I thought you said, but just to be sure -- the reason that you didn't use any consideration of this photoelectron effect was because you used the ICRP model, which doesn't consider it at all?

A. Yes, I used the ICRP model, which I think I said I couldn't answer the question on whether it actually includes this or not, because I'm not sure and I would have to speculate, effectively.

MR JUSTICE BLAKE: Well, don't do that. Anyway, that's your answer. We have the answer.

A. That's my answer.

MR JUSTICE BLAKE: Okay.

A. And the papers by Tanner and Eakins also indicate that alpha is more important.

MR JUSTICE BLAKE: Right.

DR BUSBY: Right. I think that's all we need to do about photoelectrons.

I just want to ask you now about carbon-14.

A. Okay.

Q. You didn't include any estimation of the doses from carbon-14. Why was that?

A. I felt it was outside my expertise to too great an extent.

MR JUSTICE BLAKE: When you say it's outside your expertise --?

A. Yes, my Lord, and I couldn't find any information which I felt was helpful enough. Perhaps more recently --

MR JUSTICE BLAKE: Information on what?

A. Carbon-14.

MR JUSTICE BLAKE: And its relevance to these calculations?

A. Yes, it's relevance to -- I haven't produced any assessment of dose based on carbon-14. I looked at it. I have produced one for tritium, which has very high levels of uncertainty, but when it came to carbon-14 I looked at it and just felt that I couldn't produce an assessment of the dose.

I have seen more recent information --

MR JUSTICE BLAKE: But did you -- is that fact a fact you have mentioned in your report?

A. Yes, my Lord.

MR JUSTICE BLAKE: Do you think that invalidates your report in some respect?

A. Well, it means that there a nuclide for which I've not

felt able to estimate a dose and I was disappointed by that. But I just felt that I didn't have sufficient information or sufficient expertise to be able to make any kind of assessment on it.

MR JUSTICE BLAKE: Right.

DR BUSBY: Would you agree that carbon-14 is an extremely important radiological hazard?

A. It is. It's perhaps worth mentioning, I mean I nearly mentioned it a moment ago but I thought better of it. There is information on carbon-14 in one of the -- well, two of the annexes to an UNSCEAR report, the UNSCEAR 2000 report, if my memory serves me correctly. I think it's annex A and annex C, which I've read quite carefully.

MR JUSTICE BLAKE: Well, as a result of reading those reports, does that give any information about the answer you've just given us?

A. There is a figure in annex C -- and again I need to be very careful here because I've already gone beyond my expertise --

MR JUSTICE BLAKE: Well, at the moment the topic of carbon-14 has come up.

A. Yes.

MR JUSTICE BLAKE: The answers I have from you: "I didn't consider it. Outside my expertise. Yes, it is

an important radiological element."
A. Yes.
MR JUSTICE BLAKE: I sort of rather tried to draw your answers on the relevant questions before us as to whether that weakens, invalidates, your report in some respect. To which the answer is?
A. It certainly weakens the report because there is a nuclide which I've not attempted to estimate a dose for. There is a figure.
MR JUSTICE BLAKE: Yes.
A. There is a figure, I think in the UNSCEAR annex C, a figure -- two figures, in fact -- figures 10 and 11, if my memory serves me correctly. With a great deal of caution about my lack of expertise in this area, which is considerable, there is an implication from those figures that the short-term dose from carbon-14 may be a factor of 2 to 3 greater than tritium.
That, I'm afraid, is the absolute best that I can do, and even then I've gone well beyond my expertise, so I do that with some considerable caution.
MR JUSTICE BLAKE: Right. Well, do you want to ask any further questions on this topic?
DR BUSBY: Well, you said that it weakens your report. You accepted that it weakens your report because you left out one of the nuclides that you could possibly put in.

But it's not just any old nuclide, is it? It's generally conceded. Because we are all made of carbon, I think, that's the point, to be an extremely, potentially, serious exposure.
A. Again, with the caveat that this is well outside my expertise, and I'm relying really on the information from the two UNSCEAR annexes in this, I believe that the dose from carbon -- the half life of carbon-14 is long, about 5,700 years. Approximately 6,000 years. The dose from carbon-14 is actually accumulated over long periods rather than short periods, because of the half life and the way that it's dealt with within the body.
But I really don't feel I could go beyond that because, again, I feel very uncomfortable about my lack of expertise in this area and therefore drawing specific conclusions.
Q. There was an awful lot of carbon-14 produced in those explosions; correct?
A. There was a significant amount. It's actually contained in the -- there was a gist -- another gist, agreed between Mr Johnston and Professor Regan, and that has an estimate for the amount of carbon-14 produced from the weapons. I think it said that there was something like 1500, plus or minus 500 moles. Now, I'll just explain the term "mole" because it's not a commonly

understood term.
MR JUSTICE BLAKE: M-O-L-L?
A. M-O-L-E.
MR JUSTICE BLAKE: Oh, L-E.
A. Yes, like the animal.
MR JUSTICE BLAKE: Like the animal as opposed to something else. Mm-hm.
A. Yes. I think the simplest way to explain it -- it's a concept that causes a lot of confusion -- that there is a number, so-called avogadro's number --
MR JUSTICE BLAKE: Well look, I don't particularly want to receive a general lecture on this at the moment.
A. I beg your pardon, my Lord.
MR JUSTICE BLAKE: I am just trying to see how far this relates to the issues in your report that are relevant to our case.
A. Okay.
MR JUSTICE BLAKE: You have a gist from Johnston and Regan --
A. Yes.
MR JUSTICE BLAKE: -- 1500 plus or minus mole. Is that a quantity?
A. That's a quantity.
MR JUSTICE BLAKE: You understand what the quantity is?
A. Yes, my Lord. So it's about -- so the upper limit would

be 2,000 moles, from memory.
MR JUSTICE BLAKE: Upper limit of?
A. Of the carbon-14.
MR JUSTICE BLAKE: Released by one explosion, or a whole lot?
A. I would need to check on that, my Lord. I think it's the whole lot, but I would need to check on it.
MR JUSTICE BLAKE: Perhaps you could check. I mean, is this an irrelevant question? Is this is a line of inquiry you are pursuing?
DR BUSBY: I think we've got all we need out of this, my Lord.
MR JUSTICE BLAKE: I am just trying to find out what you are pursuing and what the answer is.
DR BUSBY: I only had one more question on this, was whether it was included in the mix, in the Carter table that you used for your mix of nuclides that emerged --
A. No, it wasn't.
Q. So Carter didn't use it either?
A. No. I think it's principally -- no, no, he didn't use it.
Q. Did Carter use tritium?
MR JUSTICE BLAKE: It's one o'clock. Is this the last question on this topic?
DR BUSBY: Yes, it is.

MR JUSTICE BLAKE: Right. So Carter didn't use --
A. Carter didn't use tritium because tritium is mainly produced in thermonuclear detonations.
DR BUSBY: I have one more question and then we can leave it at that, my Lord. If that's all right with you? If I can creep over the line by --
MR JUSTICE BLAKE: Ask your last question. I thought I'd identified that was the last question, but it was the penultimate one, was it? What's the last question, then?
DR BUSBY: Well, is this on this subject or generally?
MR JUSTICE BLAKE: On the topic before we break for lunch.
DR BUSBY: Oh, I see, right. Yes, it is. We can break for lunch.
MR JUSTICE BLAKE: I'm sorry, I'm losing the sense of whether we're having a sensible exchange here. I thought we were just bringing this topic of carbon to a close, and you said you had one last question and then another last question. But have you concluded the topic of carbon?
DR BUSBY: Yes.
MR JUSTICE BLAKE: And tritium?
DR BUSBY: Yes, my Lord.
MR JUSTICE BLAKE: We'll leave it there. Thank you. We will come back at the two o'clock. I'll just have

a quick conversation about timing now. So please go. I think -- was there anything that we wanted to calculate? The becquerel --
THE WITNESS: Ah yes.
MR JUSTICE BLAKE: -- of uranium?
THE WITNESS: The total number of becquerels of uranium.
MR JUSTICE BLAKE: I think that remained a potentially relevant answer.
THE WITNESS: I will do that, my Lord. It won't take very long.
MR JUSTICE BLAKE: Thank you.
(The witness withdrew)
MR JUSTICE BLAKE: Right. We are going to have to stop this afternoon at 4.15. You will have completed your cross-examination by then?
DR BUSBY: I'm very nearly finished, my Lord.
MR JUSTICE BLAKE: The whole cross-examination?
DR BUSBY: Yes.
MR JUSTICE BLAKE: I see. I mean, I was asking about questions to find a convenient moment to pause for lunch. Okay. Well, then let's see how we go.
DR BUSBY: I will just be discussing some issues --
MR JUSTICE BLAKE: Fine, fine, fine, we'll take the lunch break and see how we go.
DR BUSBY: Yes, my Lord.

(1.05 pm)
(The short adjournment)
(2.00 pm)
DR BUSBY: After some discussion over lunch, my Lord, we've decided that we won't have any further questions for Mr Hallard.
MR JUSTICE BLAKE: Oh right.
DR BUSBY: I think Mr Hallard was going to tell us the result of some calculation.
MR JUSTICE BLAKE: I think he was. I am anxious with anticipation. You've been doing some calculations?
A. I have.
MR JUSTICE BLAKE: Right. So what do we have?
A. Right, these are the total activities for the three nuclides. Uranium-238, the total activity -- these are approximate -- total activity is about 1 times 10 to the 11 becquerels.
MR JUSTICE BLAKE: Yes.
A. Uranium-235 is about 3 times 10 to the 10 becquerels, and uranium-234 is about 2 times 10 to the 12 becquerels.
MR JUSTICE BLAKE: 2 times 10 to the 12 becquerels?
A. Yes, my Lord.
MR JUSTICE BLAKE: Thank you.
DR BUSBY: Good, thank you.

MR JUSTICE BLAKE: Right.
DR BUSBY: Thank you for your patience.
A. I'm sorry?
DR BUSBY: Thank you for your patience.
MR JUSTICE BLAKE: I think that completes -- we had a nice photograph but we didn't go there.
MR HEPPINSTALL: We didn't get there.
MR JUSTICE BLAKE: Right.
MR HEPPINSTALL: Does the Tribunal have any questions before I re-examine?
MR JUSTICE BLAKE: We did have some. Would you prefer us to put those now?
MR HEPPINSTALL: Yes.
MR JUSTICE BLAKE: Sometimes it may be and sometimes it is not.
Let me just deal with one topic and then my colleagues can decide.
Questions from the Tribunal
MR JUSTICE BLAKE: Yesterday, we were dealing with the Shackleton results.
A. Ah yes.
MR JUSTICE BLAKE: And you helpfully took us through the chart and explained that. I began to understand that. You provided the blow-up chart.
A. Yes.

MR JUSTICE BLAKE: You cite reference 14 for information at the time about the Shackleton results in your evidence.
A. Ah yes.
MR JUSTICE BLAKE: Yes?
A. Yes.
MR JUSTICE BLAKE: You are looking very blank there.
A. I was trying to remember what reference 14 was, but I think I can remember.
MR JUSTICE BLAKE: I'll tell you what it is, if necessary. Well, I will tell you what it is. Let's turn it up now. Well, let's turn up your report on it. It is easier to pose the question when we have the report in front of us.
A. I think I actually have that reference with me, my Lord, if you wish me to get information out of it.
MR JUSTICE BLAKE: That might be helpful. I am setting the scene but I will pose a question.
A. Yes.
MR JUSTICE BLAKE: It's Jones and others and the reference is at page 280 of the paper. You deal with it at page 72 of 285, yes? Let's go to page 72.
A. Right, yes, and I have actually got that reference with me if we need it.
MR JUSTICE BLAKE: Okay, (iv). You tell us here, and it was the topic that you explained:

"The aircraft is therefore assumed to have already been contaminated before take-off."
A. Yes, my Lord.
MR JUSTICE BLAKE: Now I appreciate you have got that information from reference 14.
A. Yes.
MR JUSTICE BLAKE: Jones and others, rather than -- you weren't there --
A. Yes.
MR JUSTICE BLAKE: But from what you understand, and I haven't read the reference, was the hypothesis of prior contamination a hypothesis of contamination before the explosion that was being investigated on that day? It wasn't an earlier flight, H plus three hours or H plus four hours?
A. No, as I recall it was still after the original Grapple Y detonation, but it was for other maritime reconnaissance and security operations before this specific survey.
MR JUSTICE BLAKE: Right. I mean --
A. So it was earlier in the same day, I believe.
MR JUSTICE BLAKE: Earlier in that same day?
A. Yes.
MR JUSTICE BLAKE: But I think my colleagues who have a better grasp of the chronology, there was no other

explosion -- the previous Grapple was about nine months beforehand?
A. It was. It was the previous year, the end of the previous year.
MR JUSTICE BLAKE: Yes, so question mark what might have been the source of that contamination? Let me ask the question that may be relevant to you, and it may be that it evaporates so it don't get there. But if there was another pre-existing source of contamination, is that something that you have to take into account when assessing contamination pathways on Christmas Island?
A. No. To answer that final question, my Lord, no, it isn't.
MR JUSTICE BLAKE: Right.
A. As I recall, and I can go to the reference if that would help --
MR JUSTICE BLAKE: Well, if we deal with the question then we'll see whether we need to go back.
A. Okay.
MR JUSTICE BLAKE: I've given you all that information so you have the context and then what the direct question is.
A. I think if my memory serves me correctly, my Lord, it was a similar source, they were flying earlier in the day and experienced light rain. The big difference was

that they were not making radiation measurements earlier in the day and therefore there would have been nothing to indicate that they had flown through fallout contamination. Whereas later in the day -- this was approximately seven hours after the detonation -- they were specifically doing radiation -- they were specifically measuring the radiation downwind of the detonation.
MR JUSTICE BLAKE: All right. Well, if I understand that answer then that may have dealt with a question which was in the preceding background-setting questions. Does that mean they flew out through the same explosion earlier that day or a --
A. That's my recollection, my Lord, that they flew out through a similar contaminated light rain.
MR JUSTICE BLAKE: Right. So I think when I actually put to you earlier, therefore, was the flight something like H plus 1, 2, 3, 4, 5 or 6 hours, the answer would be yes?
A. Yes, it was. It was about seven hours, I believe.
MR JUSTICE BLAKE: The one we're dealing with is seven hours. The previous contamination, where did that come from?
A. From the same detonation.
MR JUSTICE BLAKE: Right. So, after that detonation, but not seven hours after?

A. That's correct.
MR JUSTICE BLAKE: So a flight between the detonation and seven hours?
A. That's my recollection, my Lord.
MR JUSTICE BLAKE: Right. So it's the same source?
A. Yes.
MR JUSTICE BLAKE: So we don't have to therefore look for another contaminant?
A. No.
MR JUSTICE BLAKE: Right.
DR RAYNER: It will be really helpful for us if you could just go through some of your calculations to help us understand how exactly -- I am not going to go into the detail.
A. Okay.
DR RAYNER: So if we look at your revised dose assessment for Mr Abdale, for example, so this is page 67 of your revised report. Do you have that?
A. This is for Mr Abdale?
DR RAYNER: Yes.
A. Right.
DR RAYNER: Okay? So first of all if you could just talk us through how you come to those figures for the total external dose. Because yesterday I think you explained how we work out from absorbed dose to equivalent dose to

effective dose.
A. Yes.
DR RAYNER: So if you could just give us an idea of how you got to the total equivalent dose?
A. Okay. (Pause).
Sorry, I am just struggling to find the page that I was looking for. There we go.
MR JUSTICE BLAKE: The Abdale page.
A. Yes. I was just also just making sure I got all the components that went into that figure of 400 microsieverts.
The main contribution --
DR RAYNER: One minute. On page 67 I have "total skin equivalent dose" -- in the second column -- "of less than 110".
A. That's correct.
DR RAYNER: Are we looking at the same thing?
A. I was looking at the line above that where it says "total effective dose".
DR RAYNER: "Effective dose".
A. So the main component of that would be direct gamma radiation from the activity deposited on the ground.
DR RAYNER: Mm-hm.
A. And I can explain more about that, if you wish. Is that enough, or do you want to go deeper than that?

DR RAYNER: I need to know now what you timesed it by.
A. Then, right, so that is one component.
The other principal component is something -- it's not often done, but I've done it here because I wanted to make sure that I'd got an upper limit.
The other main component is I've taken the skin dose, which I've estimated to be 22 millisieverts, and I've then multiplied that by the tissue weighting factor for skin, which is 0.01, to get an effective dose to the skin. And, again, I could expand on that. That isn't normally done, but I wanted to make sure that there was no component that I'd missed here.
And that would be based on the assumption that all of the skin was contaminated rather than just a proportion of the skin which is more common.
DR RAYNER: So can I just clarify that I've understood what you've said.
A. Right.
DR RAYNER: The equivalent dose timesed by the tissue weighting factor comes to the effective dose?
A. Yes.
DR RAYNER: You agree. So what you've done is you've timesed it by the tissue weighting factor of skin and then added a bit?
A. Well, I've added that to the effective dose from the

ground deposition.
DR RAYNER: Right.
A. And then rounded it up to 400.
DR RAYNER: Yes.
A. So it would have come to 285 and I just called that 400.
DR RAYNER: That's very useful, thank you.
A. Then multiplied that by 5, because he has had five tests.
DR RAYNER: Thank you for that.
A. Does that answer your question?
DR RAYNER: Yes, that's all I had.
Re-examination by MR HEPPINSTALL
MR HEPPINSTALL: Right at the beginning of your cross-examination you mentioned that you did find that some of the arrangements at Christmas Island were satisfactory and I think you referred to the forward area health control.
A. Yes.
Q. I am just going to hand up a document which I think you will know as the Oldbury report. It's from the library, B4/19. Copies are on their way to everybody else. I'll just hand one to you. (Handed)
A. Thank you.
Q. Mr Hallard, whilst everybody else is receiving this, would you turn to page 30, please?

A. Page 30, yes.
Q. Page 30.
So just looking at page 30, am I right, were you referring to the forward area health control?
A. I was.
Q. Yes, and if you turn forward to page 45, we get some photographs, and was it images of this nature that you were commenting on to the Tribunal?
A. In terms of the forward control point?
Q. The forward control point and anything else that you have seen.
A. Ah, images of this nature, but also the video which was on the Imperial War Museum website, which was very informative, because it was contemporary video footage. And it shows the forward health control point in operation, for example, it shows the kind of monitoring that they were doing. It was a very useful video.
Q. If you could take up SB17 now, please, tab 9.
MR JUSTICE BLAKE: Are we keeping this document open?
MR HEPPINSTALL: Yes, you can put that one to one side.
MR JUSTICE BLAKE: Is this another candidate for SB22?
MR HEPPINSTALL: Yes, SB22, tab 12.
MR JUSTICE BLAKE: Is that all we need to know about it or do we need to know other things about it?
MR HEPPINSTALL: Not for this witness.

MR JUSTICE BLAKE: Just give us a moment, please.
A. So SB17.
MR HEPPINSTALL: SB17, tab 9.
A. Tab 9.
Q. If we turn to page 177, you were asked questions yesterday about radiation -- sorry.
A. 177. Is that the handwritten 177?
Q. Yes, and those who are familiar with this jurisdiction will know that sometimes numbering is only on one page. So it is 177 in reverse, the page opposite 178, 13.1.
A. Yes.
Q. The first test at Christmas Island with which this Tribunal is concerned is Grapple X. That's right, isn't it?
A. Yes.
Q. And we can see that at 13.4 it states:
"Film badge issue was restricted to selected groups as at during Operation Grapple."
A. Yes.
Q. Now, if you turn back some pages you'll see that the description of Operation Grapple, which was the first three operations, starts on the page opposite 176.
A. (Nodded assent).
Yes, I've got that.
Q. Then if you turn forward to 177, you should find 11.17

--
A. Yes.
Q. -- at the bottom. That says:
"A policy decision was taken during the planning stages of the operation to restrict the issue of [I keep putting my stickers over the words] film badges to those who could be expected to receive dose in excess of the threshold. This was in light of the situation of the Australian trials where a large number of film badges were returned with threshold doses. Accordingly, film badges were issued to personnel who handled radioactive materials, the Canberra air sampling crews and those on board ships in the targeted area. In the event, cloud tracking and monitoring indicated that no ships were exposed to fallout. Film badges issued to those on board ship were returned but not processed."
Do you understand that to be a correct description of the dosimeter issue policy at the time of the tests with which we are concerned?
A. Yes, I believe so.
This is the Woodville and Harden. Yes, yes, so that would be a correct statement.
Q. If we turn now to tab 16 in this bundle, please, we should find the Jones paper, residual radiation measurements, to which reference was made a moment ago.

A. Ah right.
Q. This is for Grapple Y, we see from the first page, which is actually the second substantive page in the tab.
If we turn to what's actually page 1 of the report, which has at the top "Introduction", we see that it records that:
"Grapple Y was planned as a moderately high air blast. Nevertheless it was highly desirable on political as well as scientific grounds to know the measured levels of fallout contamination even if these were insignificant in terms of radiological hazard."
There's A through to F; do you see that?
A. Yes.
Q. There we have a list of measures which were taken.
A being sticky paper fallout collectors at a number of sites on Christmas Island.
B:
"A ground survey of parts of Christmas Island with sensitive radiation-detecting instruments to supplement data obtained from the sticky paper fallout collected."
A. Yes.
Q. Now was that the ground survey that you referred to during your answers in cross-examination?
A. It was, and I think it's -- sorry, do you want me to go on?

Q. Well, we can just note also that samples of seawater taken. There was an aerial radiological survey. I think that was the survey that you also referred to in cross-examination?
A. Principally, yes, it's the Shackleton survey but there was actually effectively a helicopter survey done over the sea in order to take a seawater sample. The helicopter located the point of maximum radiation and took the seawater sample at that point.
Q. We also see E, and I think you referred to this during cross-examination, that there was also a separate exercise going on with sticky papers, air samplers and rainwater across the Pacific; is that right?
A. That's correct.
Q. Again also you referred to in cross-examination:
"Monitoring of fish of radioactive contamination in a number of sites in the Pacific."
A. Yes.
MR JUSTICE BLAKE: Am I right in thinking that B, the sensitive radiation-detecting instrument is a Geiger counter?
A. Yes, my Lord.
MR HEPPINSTALL: We can look at that in a moment.
Just dealing with 2.2 first at the bottom. Is this a correct description of the sticky paper method you see

there at the bottom of the page:
"Fallout trace ..."
MR TER HAAR: With the greatest of respect, my learned friend is asking if this is a correct description, it's a matter of historical record for the Tribunal to assess, not for this witness.
MR HEPPINSTALL: Does this description at the bottom of page 1 match your understanding of the sticky paper procedure that was carried out on Christmas Island?
A. It does.
Q. Then if you go over the page at paragraph 2, there's a heading, 2.3, "Results," do you see that?
A. I do.
Q. It says:
"The maximum activity detected, which was at the Decca site at Vaskess Bay, was 1.5 times 10 to the power of minus 2 microcuries per metre squared."
Then could you read out, please, the next paragraph?
A. "In addition to these measurements, surveys using portable monitors, in particular the 1320, were carried out over the Island. Activity was only detected in the area of Vaskess Bay. The level of activity at one hour was below the maximum permissible level for an uncontrolled area."
Q. Now, you referred in your cross-examination to having

read that information. Is that the information you were referring to?
A. Yes.
Q. Now, still in that document, please, to page 9.
Page 9, please. At page 9, do you find there a description of the Shackleton flight?
A. Yes.
Q. And you were asked questions a moment ago about whether or not the Shackleton was previously contaminated. The third sentence of that second paragraph, could you read that to the Tribunal, please? It starts "This can only..."
A. "This can only be justified on the grounds that the aircraft was contaminated before the survey flight, which is a possibility in view of the operations carried out by the aircraft after weapon firing. Correction of dose rate for variations and altitude ..."
I think that's not relevant. I think I've covered the point.
Q. Yes. Then further on in the next paragraph, the final sentence please.
A. Starting "The dose rates ..."?
Q. Yes.
A. "The dose rates at the maximum between B and C and at the end of the flight were presumably due to

contamination of the aircraft, the presence of which was demonstrated by monitoring when it returned to the airfield at Christmas Island."
Perhaps for clarity I'll just point out that the points A, B and C are marked on this diagram. Point A is there. These are the originals.
MR JUSTICE BLAKE: That's the blow-up you gave --
A. It's on the other one too but it's much easier to see on this.
MR JUSTICE BLAKE: If I can cross-refer that might make it more easy to understand. So point A?
A. Point A is there, my Lord. (Indicated).
MR JUSTICE BLAKE: Got it. I've found it. Yes. I have B.
A. B and C is there. (Indicated).
MR JUSTICE BLAKE: That's it there. All right.
There's no scale on this plan. Is there any description of the scale?
A. I think on the original I put a description of the scale. The scale that was marked on the original diagram is not correct. My assumption is that it probably had been drawn on A3 and we had A4. But the way that I scaled it, if I remember correctly, the --
MR JUSTICE BLAKE: I'm afraid my copy of your diagram, it suffers from the old photocopy cut-off so it says "The scale, 1 per cent and", so I'm left on tenterhooks.

A. I think if I remember correctly what I did on the original diagram you can see 1 degree and 2 degrees latitude.
MR JUSTICE BLAKE: Right. Well, I don't want to take you out of your course. I was just trying to correlate the information from the diagram to this.
A. The crucial thing is that the distance, again if my memory serves me, the distance between 1 degree and 2 degrees latitude is 110 kilometres on the earth. I believe that's the right value.
I think that's actually mentioned in the report, so hopefully we'll be able to clarify that.
MR JUSTICE BLAKE: All right, so the very informed reader can add that in when trying to --
A. Yes, because I went through the same exercise and it was obvious that what I was getting was not correct, but that was what I came up with in the end.
MR JUSTICE BLAKE: Right.
MR HEPPINSTALL: Sticking with the Shackleton topic, if you could turn to tab 13, please.
A. Right.
Q. This is the Operation Grapple Y interim report, part 7, radiological measurements.
Can you turn to page 4 of 11. The numbers are in the top-right hand corner.

A. Right.
Q. Do you have 4 of 11?
A. I do.
Q. Then there's section 2.8, "Radiological survey", and the third paragraph there, there's another description of the flight and a further explanation, which no doubt the Tribunal will note, but if you have a look at that, is that again the description you were referring to?
A. Yes, it was.
I think for completeness, and to avoid confusion, they did consider another possibility and that was that some of the radiation that they measured could have come from contamination in the sea, but they concluded that it was the contamination on the aircraft which was the principal source.
MR JUSTICE BLAKE: Contamination in the sea affecting the radiation measured by the aircraft?
A. Yes.
MR JUSTICE BLAKE: So sea rising up into the cloud?
A. Radiation coming from the sea. But that's likely to be a small component. I didn't mention that before because I didn't want to overcomplicate it but perhaps just to be clear because it's mentioned here.
MR HEPPINSTALL: If you turn over a few pages to 6 of 11, please. Under the heading "3.4. Fallout", second

paragraph, it states:
"The sticky paper fallout sampling on Christmas Island indicates a very real fallout at the Decca Master Site on the south west point of the Island and this was confirmed by a survey on foot."
Is that the survey that you were referring to?
A. Yes.
Q. "The levels were, however, within those laid down for an uncontrolled area. It is not known whether the contamination was the result of dry fallout or rainout in a light shower."
Is that also your understanding?
A. Yes.
Q. Can we just look at the Clare report that you mentioned several times when being cross-examined? It's at tab 8 of this bundle, please.
Turn to page 78, internal, the top centre of the pages. The first paragraph on that page says:
"During Operation Grapple Y the greatest and only significant measured value of 150 microcuries per square metres was obtained at the uninhabited site at Vaskess Bay. However, records indicate that subsequent surveys using handheld instruments did not confirm this high figure."
Is that also the same survey that you are referring

to?
A. I am. There's clearly an inconsistency between the two documents that this says that the subsequent survey using handheld instruments did not confirm the high figure, whereas the document we've just looked at said that it did.
I think the explanation that's been posed for that is that at the time the Clare report was written that second piece of information may have been unavailable to her for whatever reason.
Q. Page 96 of the Clare report, please. We see this is entitled "Results of local surveys for Operation Grapple Y reproduced from contemporary documents".
You were cross-examined about contemporary documents and you said you had seen compilations based on contemporary documents.
A. Yes.
Q. Is this what you had in mind?
A. Yes.
Q. And we see at the bottom there this Decca Master Site Vaskess Bay result. You also said you had seen times for the sticky papers being put out and taken away?
A. That's correct.
Q. Is this what you had in mind in those middle two columns?

A. Yes.
Q. Finally, just to complete looking at Vaskess Bay, at page 99 we find a plan of Christmas Island and I think if we look at the key, the Decca site at Vaskess Bay is number 4; is that correct?
MR JUSTICE BLAKE: At page 99?
MR HEPPINSTALL: At page 99 there should be a plan of Christmas Island.
MR JUSTICE BLAKE: I have the plan.
MR HEPPINSTALL: Underneath four, Decca Slave.
MR JUSTICE BLAKE: Decca Slave. That's Vaskess Bay, is it?
MR HEPPINSTALL: The numbers on my copy are not --
A. I thought the Decca Master Site was number 8.
MR HEPPINSTALL: Ah, you are absolutely right, which is Vaskess Bay?
A. It's very faint, it's hard to read it, but I think that is also an 8.
MR HEPPINSTALL: You are absolutely right.
MR JUSTICE BLAKE: Sorry --
MR HEPPINSTALL: Too many Deccas.
MR JUSTICE BLAKE: Yes, right, Decca Slave and Decca Monitor and Decca Master Site.
A. Yes.
MR JUSTICE BLAKE: So if one goes to the text for the key, can you just point out where the figure 8 is?

A. That one there, my Lord, I believe (indicated).
MR JUSTICE BLAKE: It looks like a 9 to me.
A. It's barely legible but I believe that is the Decca Master Site.
MR JUSTICE BLAKE: I see.
So the only numeral left of Vaskess Bay in the box actually is an 8, although I wouldn't have bet money on that if I had been asked to make that without the benefit of --
MR HEPPINSTALL: I think actually if you go back to 96 they have the same numbers, and 8 there is Decca Master Site, Vaskess Bay, so it's definitely number 8.
MR JUSTICE BLAKE: Yes, yes.
A. Number 9 is Port London, in fact.
MR HEPPINSTALL: Indeed, which is up in the north.
MR JUSTICE BLAKE: Yes, I have that. It was just the legibility of the numeral.
A. Indeed.
MR HEPPINSTALL: It was photocopied so many times.
Right, we are now going to look at something else from the library. B8B61. Copies are on their way to everybody. (Handed)
MR JUSTICE BLAKE: Have we finished with SB17?
MR HEPPINSTALL: SB22, tab 13.
MR JUSTICE BLAKE: Yes, have we finished with SB17?

MR HEPPINSTALL: Sorry, you are asking me a different question. I would keep it handy.
MR JUSTICE BLAKE: Right. I'll put it in "will return to".
MR HEPPINSTALL: We will return.
So this is two papers, I think, by the oft cited Major, Royal Artillery, MacDougall which you mentioned several times during cross-examination.
A. Yes.
Q. Hopefully this is the paper you are referring to. The first one is "Air, water and sticky paper samplings" and if we look at section 3 under 3.2, we find the words:
"This method is also fully described in the pamphlet. The paper is adversely affected by rain. It should if possible be taken under cover when rain is actually falling."
Was that the passage that you had in mind?
A. Yes. Again I'm not clear, does this refer to the Pacific? It must be because of course it's talking about rainwater sampling.
MR HEPPINSTALL: Yes.
MR JUSTICE BLAKE: We looked at another report for Major MacDougall, but that's not this one, and you made the point about you thought the context of that was the Pacific sampling rather than the Christmas Island-specific sampling.

A. I thought that appeared more logical, my Lord.
MR JUSTICE BLAKE: I remember I marked that up to think about that. But this is a different document, anyway.
MR HEPPINSTALL: If we look at the introduction we can see:
"Christmas Island has been and may again be used as a base for a task force employed on testing nuclear weapons."
I think the document falls between Grapple 3 and Grapple X.
"Although it is considered that the risk of other islands in the Pacific becoming contaminated is negligible it is necessary to collect data with which to reassure the population and AWRE."
So that may help put this document in context.
Then you also were asked questions by my Lord in respect of fish sampling and therefore the second paper is about the method of fish sampling.
Indeed, there's a section in that report called "Methods of testing fish", where a Type 1257 contamination meter is used in order to detect radiation from the fish. Is that what you had in mind when you were answering questions about how the fish sampling was carried out?
A. It was. The two main types of instrument, the 1257 and the 1320, are similar.

MR JUSTICE BLAKE: But they are both Geiger counters?
A. They are both Geiger counters. I think again if I remember correctly the 1257 is effectively a bench-mounted instrument and the 1320 is a portable one. You will able to put different probes on them, that is different types of detectors but I think they would have been -- but yes, but it would have been a Geiger detector that they were using. The information I gave you yesterday was based on a more detailed description of the limit of detection.
MR JUSTICE BLAKE: Right.
MR HEPPINSTALL: Just staying with Geiger counters, please, can you take up SB14, 5.1, page 129.
A. Which tab?
Q. SB14, tab 5.1.
This is me cross-examining Professor Regan on 4 February 2013, and in fact if we look at page 129, line 20, you'll see that actually I was going through the Jones paper, the (a) to (f), with Professor Regan.
A. Page 129?
Q. 129, they are split into four. Sorry, just wait for others to maybe catch up. (Pause)
So at page 129 I asked a question:
"I won't go through (a) to (f) because we've all just read them."

I think I was going through the Jones (a) to (f).
Then:
"Have you realised that there was a ground survey in addition to the sticky?"
His answer was:
"My understanding was that they had handheld monitors for measurement but they don't tell you the nature of what that radiation is."
I asked the question:
"No, I think the workhorse ..."
Sorry.
"My understanding was that they had handheld monitors for the ground survey so, yes. I don't know where they surveyed or over what area they surveyed but I was aware there was a ground survey."
Then on page 131 I put a question saying:
"I think the workhorse is called the 1320, which is sensitive to four counts per second. I think that's 1 microcurie per square metre. You can look at that if you want."
He says:
"I did mention that in one of my reports previously, that this ...(Reading to the words)... comments on that."
Then my next question at the end of 131 is:

"But the 4 counts per second sensitivity, would that seem reasonable given that we're talking about 1958?"
He says:
"Yes. I mean 4 becquerels, 4 clicks per second is again reasonable. That's for the efficiency."
Do you agree that that level of sensitivity for the 1320 is reasonable for the work that it was doing?
A. Yes. If you look at what the background count is likely to be based on another note from Clare on the gamma dose rate on Christmas Island, that would indicate that the background on that instrument would be, I think from memory, less than 1 count a second. And therefore I would expect that you would be able to detect 1 to 2 counts a second above that, certainly 2 counts a second above that, because the background on the instrument would be there permanently at probably about half a count a second, of that order half to 1, and there will be some movement on the needle. So any amount of contamination would have to be detectable above that background. So there would need to be enough there so you could say: yes, there was contamination there above the background. And I would say particularly at 2 counts a second it would be pretty clear, 1 count a second you maybe need to check it above background.
Q. And again on that topic if you could turn to the Carter

report, please, which is at SB10, tab 161.
MR JUSTICE BLAKE: Can we put any of these things away?
MR HEPPINSTALL: Yes.
MR JUSTICE BLAKE: SB14?
MR HEPPINSTALL: Yes.
A. SB10.
Q. Yes, SB10, tab 161. This is volume 1 of the Australian participants in British nuclear tests in Australia report, volume 1 being the dosimetry part as opposed to volume 2 which is epidemiology with different authors.
If we turn to page 182.
MR JUSTICE BLAKE: 180?
MR HEPPINSTALL: 182.
MR JUSTICE BLAKE: 182.
A. Can I just confirm, did you say tab 160?
MR HEPPINSTALL: 161.
A. 161. Turn to page 183?
MR HEPPINSTALL: 182. There's a table and halfway down the table, the 1320, what I described as "the workhorse" in my questions for Professor Regan, is there described.
Is that the correct instrument that we're talking about?
A. Yes.
Q. We see that it detects alpha, beta and gamma?
A. That would depend on the probe.

Q. Right.
A. It indicates here that it can be either used with a GM, which is a Geiger-Muller probe, so that's a probe that looks a little like this microphone.
MR JUSTICE BLAKE: Have I misremembered? Did you tell us a little earlier today or some time that the Geiger counters didn't detect alpha, you had to work back to get alpha?
A. Exactly, my Lord. The scintillation probe which they're referring to would have detected alpha. But I've not seen any evidence that a scintillation probe was actually used on that instrument. All the references that I've seen are to a Geiger-Muller probe.
The 1320 --
MR JUSTICE BLAKE: All right, hang on, I just need to get all this information together.
Carter tells us:
"In this table the 1320 battery-operated portable contamination monitor, GM ..."
That is Geiger-Muller, is it?
A. Yes.
MR JUSTICE BLAKE: And scintillation probes.
A. Yes.
MR JUSTICE BLAKE: Radiation, that's what it can detect?
A. Yes, my Lord.

MR JUSTICE BLAKE: Alpha, beta, gamma, but are you telling me that it only does alpha with the scintillation probe?
A. Yes, my Lord.
MR JUSTICE BLAKE: You don't think they used scintillation?
A. I've not seen any evidence that they did.
MR JUSTICE BLAKE: All right. Two steps forward and one step sideways.
A. The description 1320, again I've done quite a lot of research to try and understand this, but I think it refers to the box, the so-called rate meter, the thing with a handle and a dial on the front which shows you the counts per second with a needle. A simple analogue instrument. I think that is what the term "1320" will refer to.
From that you will then get a cable going to a probe, if I can just use that to imitate the probe.
So the probe, very crudely will look something like that with a handle on it. The Geiger-Muller will look like that. There will be an open window here and if you look into the open window you will see a glass tube inside and that is the actual Geiger tube. That I believe is the probe that they would have used most of the time.
The scintillation -- but there were other types of Geigers, Geiger-Mullers used on the Island of different

geometries.
It's not a particularly easy concept to think about all of these different type of instruments which is why I've tried to avoid it.
MR JUSTICE BLAKE: Mr Heppinstall will no doubt get out what he wants to. But we've gone to Carter in order to get some more information --
A. Yes.
MR JUSTICE BLAKE: -- as I understand it as to what the capacity of the Geiger-Muller probe is.
A. Yes.
MR JUSTICE BLAKE: And are we led to believe that with the scintillation probe it can detect alpha directly?
A. I think almost certainly, my Lord.
MR JUSTICE BLAKE: Right.
A. Almost certainly, I think that must be what he refers to.
MR JUSTICE BLAKE: During this report it looks as if he thought it was detecting that in Australia.
Question: is it able to detect that in Christmas Island?
Then you say that depends whether they used the scintillation probes, or otherwise doing other forms of calculation of how much alpha you've got from your gamma and beta?
A. Yes. The normal Geiger I think they would use is

similar to the one that I used when I first started in my profession and that would not detect alpha.
MR JUSTICE BLAKE: Right.
MR HEPPINSTALL: And I think you mention this in your report Mr Hallard. If we just put SB10 to one side, we'll be coming back to the Carter report in due course, but in your report at SB2/2.14, page 50, you mention the 1320 at section 2 there on page 50.
A. Yes, I do.
Q. And you give some data at the top of page 51. But then at (a) you say:
"The results above are approximate values to indicate the background concentrate on any instrument in use on the day of either GY or GZ1 and 4."
Can you just explain to the Tribunal background count rate, please?
A. Right.
MR JUSTICE BLAKE: That's the background radiation?
A. Yes.
MR JUSTICE BLAKE: Yes.
A. So --
MR JUSTICE BLAKE: I think you've attempted to give that explanation.
A. Okay, but in essence Geigers respond to gamma as well as beta. They are more sensitive to beta than gamma by

about a factor 5. But the gamma radiation will create a count rate on the instrument.

The point is if the gamma count rate had gone up significantly as a result of high levels of fallout, uniform fallout in the area where these instruments were being used, the background count rate on the instrument would rise significantly. Because the gamma dose rate from the activity deposited on the ground would be significantly higher than normal and therefore the background count rate would go up proportionately.

MR HEPPINSTALL: So at page 52(f) is that what you are explaining?

A. It is, and this is further information to comment that (f) is not just related to the background. This a contamination probe which detects both beta and gamma. It's a mobile probe, and therefore had that probe been put in direct contact with contamination of the level which I've assumed in this report, the count rate would have been above its maximum of 1,00 counts a second. And therefore it would have been very obvious, had that detector been used in the area of this contamination, the contamination level that I've assumed, it would be very obvious to anyone using it that there were high levels of contamination present.

Q. So can you explain to us, please, the link between that

and what you say at paragraph (v) at page 56?

A. Right, then that's an extension to what I've just said, that had there been widespread fallout, that is fallout over the Island which therefore would have also fallen out in the area where these probes were being used, that the increase in background, in the gamma background would have been very significant and the increase in the beta plus gamma background on the Geiger-Muller contamination probes would have been extremely significant.

Q. I promised to go back to Carter and I will. SB10/161.

You were asked questions by both Mr ter Haar and Dr Busby about re-suspension rates and you said you had used Carter. Can you turn, please, to page 70 in 161.

A. Page 70?

Q. Yes. At page 70, halfway down the page, there's a passage that starts:

"When a radioactively contaminated surface is disturbed ..."

Do you see that?

A. Yes.

Q. "... the radioactive material may be raised into the air. The re-suspension factor is the ratio of the level of radioactive material in the area above the surface to the level of contamination on the surface."

A. Yes.

Q. Is that a correct description of the re-suspension factor?

A. Yes.

Q. Unit is per metre and an example is given.

Then there's factors that can affect re-suspension and the factors that includes and there's four there. Do you agree those are the correct factors?

A. Yes.

Q. Then it says:

"Reported re-suspension factors range from 10 to minus 8 per ..."

Should that be metre"?

A. Per metre, yes.

Q. "... which is a very low ratio ...(Reading to the words)... an extremely high ratio."

Then there are three references, Turner, Lindsey, and Walsh.

Are any of those references that you were referring to when you were giving your evidence?

A. I think it is the Lindsey and the -- well, the Turner is described in the report and from memory it is the Lindsey and the Walsh papers which are the NRPB papers. We could soon confirm that from the references in the document.

Q. Yes. If you look at the references, I think the Walsh one is NRPB. I confess that I don't know about the Lindsey.

In fact, I have given my pages away because as Dr Haylock is present and is an employee of that successor body, he has gone off to find the Walsh for you.

A. Ah.

Q. We may get the Walsh.

A. The Lindsey is also referred to as an NRPB paper, NRPB/75, and Walsh is NRPB/W1.

Q. Right, well --

A. I think they were the two that I tried to find.

Q. We can add to Dr Haylock's homework.

Then you say that Turner is described. Is that what then follows in the next few paragraphs? I think you mentioned in cross-examination a dragging experiment.

A. I did, I did. Yes, this is the description from the bottom of page 70 to the first part of page 71.

Q. And it concludes:

"In this work a re-suspension factor of 10 to the power of minus 5 per meter square has been used."

Is that what you have used?

A. No. In the next sentence it says:

"It is possible that for short periods

a re-suspension factor of 10 to the minus 4 may have occurred but average long-term levels would have been close to 10 to the minus 6 per metre or less."

I've used that peak value of 10 to the minus 4.

Q. And you also told the Tribunal about decay rates. Page 188 in this paper, table A1.

MR JUSTICE BLAKE: I have lost the reference again.

MR HEPPINSTALL: 188.

MR JUSTICE BLAKE: 188.

MR HEPPINSTALL: Are these the decay rates you were referring to?

A. Yes.

Q. And we can see it's given for one hour, 12 hours, one day, two days, five days, 10 days; is that right?

A. That's correct, and that's the mix that Carter uses and I've added to that in my supplementary report by adding uranium-240, neptunium-240 and plutonium-240.

Q. Sorry, this is for the nominal atomic weapon but for the thermonuclear you've added to this mix. Is that what you're saying?

A. That's what I'm saying and that was done in the supplementary report.

Q. We can see that these decay rates fall away rapidly. Is that the behaviour that you were describing?

A. Yes.

Q. Now, it was put to you by Dr Busby that Mr Johnston had first said that there was no uranium naturally occurring on Christmas Island. Can you turn to --

MR JUSTICE BLAKE: He said in coral, that's what he actually said.

MR HEPPINSTALL: Coral. Can we turn to SB13/38, please, page 8.

If you just look at paragraph 3.9 on page 8, is it right that he there says that there is a body of evidence that coral, despite some leaching when it dies, has a natural uranium content in the region of 2 parts per metre?

A. 2 parts per million.

Q. 2 parts per million?

A. Yes, that's what it says.

Q. Right, if we just go to one of Professor Regan's reports, please, SB11/2.

A. Which bundle was it?

Q. SB11.

MR JUSTICE BLAKE: You are going to be more than a few moments with this witness, are you?

MR HEPPINSTALL: Yes.

MR JUSTICE BLAKE: So somewhere between the next five to 10 minutes, a break for the stenographers would be appropriate.

MR HEPPINSTALL: Well, maybe if we just deal with this one point then.

MR JUSTICE BLAKE: Right.

MR HEPPINSTALL: So SB11, tab 2, this is Professor Regan's first report.

A. Right.

MR HEPPINSTALL: Page 15, paragraph 46, please. He says:

"For higher altitude bursts much of the nuclear weapon's debris is carried into the upper atmosphere following the initial explosion due to the large heat of the nuclear fireball. This causes a strong convection effect in the air surrounding the nuclear explosion which causes some of the reaction products to be lifted to high altitudes where they are dispersed around the globe."

Do you agree or disagree with that statement?

A. I believe that to be correct. But I have no specific expertise in that area. But nevertheless from what I've understood I believe that to be correct.

Q. Well, I think questions were put to you several times in cross-examination about that statement.

A. Yes.

Q. Is this one of the sources that you rely upon?

A. Yes.

MR JUSTICE BLAKE: So you rely upon it as reliable even though you don't have the expertise to contradict it?

A. That's correct, my Lord. But there was similar information from Mr Johnston.

MR JUSTICE BLAKE: Right.

A. And other -- well, in fact quite a lot of information in UNSCEAR reports and also in a book, "The Effects of Nuclear Weapons" by Glasstone.

MR JUSTICE BLAKE: All pointing the same way?

A. Yes, my Lord.

MR HEPPINSTALL: That's a convenient moment, my Lord.

MR JUSTICE BLAKE: Yes, 25 past. Thank you.

(3.08 pm)

(A short break)

(3.25 pm)

MR HEPPINSTALL: Back to SB14, please, again to the cross-examination of Professor Regan at 5.1, this time page 189.

MR JUSTICE BLAKE: Sorry, which tab?

MR HEPPINSTALL: Sorry, tab 5.1, the first tab.

MR JUSTICE BLAKE: Right.

A. Then which page?

Q. Page 189.

Now I don't think you gave it a name when you were being cross-examined but I am just turning to look at line 19 on page 189 and the start of my question on that

day was "Let's move on to co-deposition".
I think when you were being cross-examined you were describing the idea that the alpha, the beta and the gamma are always together when they fall out of a nuclear weapon detonation; is that correct?
A. Yes, that's correct.
Q. You said that you thought the debate had moved on at the last Tribunal so that Professor Regan actually agreed with Ken Johnston that there was co-deposition?
A. That was my recollection from what I read.
Q. Let's see. At page 189 I say:
"Let's move on to co-deposition because as I understand it you are now -- I think you were sceptical about co-deposition but now in your third report at paragraph 10 you say:
'I tend to agree that the likelihood of plutonium...'"
Then I read out the words at paragraph 10 of his report.
"I think I would agree with that. Okay, there are different levels. We've discussed fractionation effects which are known, but I think if you make a big explosion and then you have a variation of droplet sizes and vapour levels in hundreds of kilograms of radioactive materials I think the likelihood of having no

co-deposition is quite small. Yes, I would think that."
Then I think I have another go at page 191 at the top, line 6:
"Co-deposition is the Secretary of State's answer to your criticism that there was no separate measurement of alpha radionuclides because if there is co-deposition then if you are finding amounts of gamma you know there's alpha 2."
He says:
"That is a reasonable scientific statement I would say."
Although he goes on to give some qualifications.
So was that the evidence that you were referring to?
A. Largely, yes.
MR HEPPINSTALL: My Lord, I don't wish to appear to be selective, I am sure the Tribunal will read on, Professor Regan said what he said and then said more things, but I don't propose to detain you further. If anybody wants to draw attention to those other things I am sure they will in due course.
That is also -- the idea of co-deposition is also picked up in the Clare report, so if you pop back to SB17/8. Perhaps the best thing to use in this multi-numbered report, page-numbered report, is the paragraph numbers. It's paragraphs 12 and 13. Mine has

a "75" at the top and a "4" at the bottom by way of page numbers.
If we look at paragraphs 12 and 13 it says:
"It was well known at the time that radioactivity materials such as plutonium emitting alpha radiation were present in fallout from a nuclear detonation as well as beta and gamma emitters. In view of the relative ease of detection of beta and gamma radiation compared with alpha radiation it was therefore decided that the form would be measured to monitor the environment. Additionally, it was known that the hazard from beta and gamma emitting radionuclides overwhelmingly dominated in the short-term that posed by alpha emitters.
"The only scenario when alpha emitting nuclides might have been present in the absence of beta and gamma emitters would have been in the event of an accident to a nuclear device, dispersing plutonium without a nuclear detonation ...(Reading to the words)... this contingency."
Which happily never was required.
But is that an accurate description of co-deposition being used as a reason for monitoring only beta and gamma?
A. It is, it is. I think it's reasonable to add that of

course the activity is decaying, and therefore the gamma measurement will drop off relatively quickly. The beta level will drop off rather more slowly. So the measurement has to be made at a time when you are still going to -- when you still have enough of the fission products to be measured.
MR JUSTICE BLAKE: If you are doing this after the half life of beta and gamma have gone then that's a bit of a pointless exercise?
A. Exactly.
MR JUSTICE BLAKE: You are not going to pick up any -- you can't then work out whether there was alpha because your alert mechanism has gone?
A. Exactly, my Lord. So while there is enough fission products there, the gamma level will drop off fairly quickly, in perhaps one to two days, if I remember correctly. The beta level will, because it's 5 times greater, so the surface level of beta contamination will be present for rather longer.
MR JUSTICE BLAKE: Yes. This is just to test my own state of understanding. When the author of this report says at paragraph 12 "additionally it was known that the hazard from beta and gamma emitting radionuclides [et cetera] overwhelmingly dominated in the short-term", they are talking about external radiation, are they not?

A. And also some inhalation and ingestion as well. I mean, a number of the pathways that I've looked at in my report, initially the fission product levels would actually dominate both externally internally.

But, with time, particularly with extended periods of time, the fission products will have decayed to such a point that it's only actually either the long-lived fission products such as caesium or strontium, but particularly the plutonium nuclides, and we're talking inhalation.

MR JUSTICE BLAKE: Or, it could be argued, uranium?

A. Sorry, or uranium, although the beta concentrations tend to be rather lower.

MR JUSTICE BLAKE: So in the longer term, which may, depending on upon our view of the arguments and the evidence be this case, that then the alpha emitters or -- become more relevant?

A. Yes, they do.

MR JUSTICE BLAKE: Right.

MR HEPPINSTALL: You were cross-examined about hot particles and you referred to a paper by Charles and Harrison. Can you turn to SB3, tab 5, please.

MR JUSTICE BLAKE: We might still dip back into 17 at some point, might we?

MR HEPPINSTALL: There is always a risk, my Lord.

MR JUSTICE BLAKE: I will put it up there in case it becomes unstable.

MR HEPPINSTALL: Right. Is this the Charles and Harrison paper that you were referring to?

A. Yes, it is.

Q. Is there anything that you want to draw to the Tribunal's attention from this paper?

A. There's some useful information on the paper. Particularly table 1, which is on page 5, which gives dose rates. You need to -- sorry.

MR JUSTICE BLAKE: Yes. I'm there now.

A. -- you do need to interpret the dose rates a little because the activity they are quoting is a caesium activity, and for many of these particles there is a similar level of strontium and yttrium 90. So the actual activity is twice the activity that's mentioned there. But that's only a factor of 2.

MR JUSTICE BLAKE: Sorry, I am trying to get my bearings --

MR HEPPINSTALL: Let's perhaps just orientate ourselves first. This paper is about hot particle dosimetry.

A. It is.

Q. So a single, highly active particle, I think you explained when you were being cross-examined.

A. It is. A single, highly active particle. Yes, sorry --

MR JUSTICE BLAKE: So the context is hot particles or

single, highly active particles.

A. Yes.

MR JUSTICE BLAKE: The table that we are looking at at the moment occurs under the subheading "7.1 skin Exposure".

A. Yes.

MR JUSTICE BLAKE: They are estimates of time taken for stationary MTR?

A. MTR is a type of particle, I am just trying to remember which it is. Sorry, it's a source of the particle.

MR JUSTICE BLAKE: Is it, second line, CSMTR?

A. MTR stands for "material test reactor", which was a reactor at Dounreay. All of this is written around particles which were found at Dounreay. So the previous page, page 3, the start of the last but one paragraph refers to the materials test reactor, MTR, and the Dounreay fast reactor, DFR fuel. That's what the acronyms mean.

MR JUSTICE BLAKE: So we borrow the acronyms from the earlier discussion.

A. Yes, so that is the acronym.

MR JUSTICE BLAKE: The table, which is where you've been asked to comment.

A. Yes, the activity, when it says "activity becquerel 137CS", that means caesium 137.

MR JUSTICE BLAKE: Yes.

A. It quotes a certain level of activity, and below that it mentions the fact that there is an activity ratio of 0.9 for strontium and yttrium and caesium 137, which I've interpreted as meaning that there's roughly the same level again of strontium yttrium as the level of caesium, which is a factor of 2.

Perhaps in this context I'm going -- that isn't really important.

MR JUSTICE BLAKE: What do we get, in fairly simple language, from this table that is relevant to our inquiry?

A. What it gives you is an activity and then a dose rate, in the next column, in gray per hour. The column after that, the threshold means the time it would take to get a skin dose, for example, of 2 gray from any one of these particles. You can see that as the particle goes up in activity, the time to get to 2 gray goes down.

Then, finally --

MR JUSTICE BLAKE: Yes.

A. -- in the last column there is the time it would take to get to ED -- to a value of 10 gray where you would expect to see significant reactions to the skin blistering, that kind of thing. Probably skin burns.

MR HEPPINSTALL: So, just to check, it would take two weeks to get to skin burns if you encountered one of these hot

particles of caesium 137 with an activity of 10 to the power of 4 becquerels?
A. Yes. The total activity would probably be 2 times 10 to the 4, because of the other materials present.
MR JUSTICE BLAKE: If you had the similar thing with an activity of 10 to the power of 8 it would be 10 minutes?
A. Yes. But the order of magnitude of the particles that we are talking about, some calculations were done for the First Tier Tribunal, there was an exchange of letters between Professor Regan and Mr Johnston, and the size of -- and the activity -- I am going from memory -- but the activity of a 1 micron particle was estimated to be of the order of about 5 times 10 to the 4, from memory. So it's about halfway between the 10 to the 4 and 10 to the 5 particles, roughly.
MR JUSTICE BLAKE: The activity of a -- just let me get that down.
A. That was a 1 micron particle.
MR JUSTICE BLAKE: A 1 micron particle.
A. Yes. So that's a particle of 1 micrometres.
MR JUSTICE BLAKE: Right.
A. They were asked to do that calculation by one of the members of the First Tier Tribunal.
MR JUSTICE BLAKE: Right.

MR HEPPINSTALL: It's the medical member then, Dr Anscombe.
A. Yes.
Q. Somewhat opened Pandora's box with his question: what's the activity of a 1 micron particle? The results are in the bundle.
A. Yes.
MR JUSTICE BLAKE: Okay. But your recollection, it was 10 to the power of --
A. I think it was about 5 times 10 to the 4 becquerels. I believe so. We'd better check it in the bundle.
MR JUSTICE BLAKE: So, in this list, that goes between two weeks and 33 hours?
A. Yes.
MR JUSTICE BLAKE: Right.
MR HEPPINSTALL: Right. I think Mr Harrison then re-features when you were looking at these uncertainty levels in terms of the dose co-efficients. If you turn to SB3/10, I think you kept mentioning a paper by Puncher and Harrison.
A. Yes.
Q. I think this is the paper. Or, you tell us, is this the paper that you were referring to?
If it helps, if you turn to page 43, I think, from looking at a comparison, that might be your table 4.1?
A. Ah, yes. It is, thank you very much. I was just

looking for that. I have read the whole paper, but I just wanted to confirm that it was the same paper. And this is the same paper.
Q. So when it said in your report "this study", and, as it says in table 4.1 "this study", we're talking about the paper we're now in, are we?
A. We are.
Q. I see.
A. Sorry, I should have picked that up when I did the copy and paste that there was some ambiguity there, but I just didn't notice.
Q. Well, I think, actually, Mr Hallard, if you turn back over the page in your report to page 129, you --
A. I did explain it there, yes.
Q. Anyway, let's look at the summary and conclusions of this paper, please.
"ICRP is clear on the intended use of equivalent and effective dose as reference quantities, without uncertainty, for use in internal radiation protection."
Is that your understanding?
A. Sorry, which?
Q. Under 5, "Summary and Conclusions", the words, the first sentence; do you agree with that?
MR JUSTICE BLAKE: Which page are you reading from?
MR HEPPINSTALL: Sorry, page 43, my Lord.

MR JUSTICE BLAKE: Right.
MR HEPPINSTALL: In tab 10?
MR JUSTICE BLAKE: Yes, I have the tab. I was starting at the beginning.
MR HEPPINSTALL: I beg your pardon, I fear we probably don't have time.
MR JUSTICE BLAKE: No, no.
MR HEPPINSTALL: So at page 43 we find table 4.1, which is now perhaps familiar to us.
MR JUSTICE BLAKE: Yes, I have the table, I've caught up with you now.
MR HEPPINSTALL: I am grateful. The first sentence of section 5:
"ICRP is clear on the intended use of equivalent and effective dose as reference quantities, without uncertainty, for use in internal radiation protection."
Do you agree with that?
A. Yes. That's the section I was thinking of in this section and there was equivalent comments in ICRP 103.
Q. "However, ICRP and others also recognised there are uncertainties in the process of estimating dose and risk that affect the derivation and application of these quantities."
Do you agree with that?
A. Yes.

Q. "This report addresses this issue as follows."
Then the first point they make is:
"The issue of relevance for regulators and other stakeholders is not the magnitude of the uncertainty on dose estimates but how reliable dose co-efficients are for protection purposes as a protection device."
Do you agree with that?
A. Yes.
Q. "It is argued that a dose co-efficient as applied to a defined exposure pathway is considered reliable if it ensures exposures comply with dose limits and constraints."
Do you agree with that?
A. Yes.
Q. Over the page.
"The best estimate of risk and its uncertainty for a given internal exposure pathway is a prerequisite for making an informed judgment on the reliability of a particular dose co-efficient in the context of a specified exposure pathway."
Again, do you agree with that?
A. Sorry, I just want to read that again.
Q. Yes, please read it to yourself. (Pause)
In fact, do you want to read the whole of that paragraph to save me reading it to you. (Pause)

A. I agree with the paragraph. I probably don't have sufficient expertise in internal dosimetry to be able to make a definitive statement, but the paragraph makes sense to me.
Q. Then at paragraph 3:
"A general assessment of the reliability of dose co-efficients can be made by assessing the reliability of dose co-efficients that applied to the more significant exposure pathways."
So is it correct or incorrect that what is happening here is a review of the uncertainties in order to establish the reliability of the ICRP dose co-efficients?
A. That's my reading of it.
Q. We can see at 5:
"The analyses indicate UF values of around 2 to 3 for ingestion and 2 to 6 for inhalation. The UF values are the same for the three age groups considered, 1-year-olds, 10-year-olds and adults. The UF values are consistent with those inferred from other studies, although a general assessment of reliability of the protection quantities is beyond the scope of this report.
"The derived UF values for the radionuclides considered here seem acceptable when considered

alongside the likely levels of exposure that is expected from them and the dose limit for planned exposures to members of the public, 1,000 microsieverts."
So is it correct or incorrect that the conclusion here is that, because of -- the unreliability factors are 2 to 3, 2 to 6 and so forth, that the ICRP dose co-efficients are reliable?
A. Sorry, could you just repeat the question?
Q. Well, let's -- do you agree with that --
MR JUSTICE BLAKE: That seems --
MR HEPPINSTALL: -- do you agree with what the authors are saying at paragraph 6, that "the derived UF values for the radionuclides considered here seem acceptable when considered alongside the likely levels of exposure expected from them"?
A. Yes, I think that's reasonable.
MR JUSTICE BLAKE: What do you think they are saying that you agree with?
A. I think they are saying that the factors, that the uncertainty factors which they have derived -- well, seem acceptable when considered alongside the likely levels of exposure that we're talking about.
So when we're talking about exposures of the order of a 1,000 microsieverts, which is about a millisievert, that these uncertainty factors are acceptable for the

purposes of radiation protection.
MR JUSTICE BLAKE: Obviously I want to try and marry up the answers you are giving me with the answers we had a little earlier this afternoon.
A. Right.
MR JUSTICE BLAKE: I may be getting this wrong, and I'm sorry, if I do, I apologise.
The uncertainty factors, are they the uncertainty factors that the authors have previously set out in the table at 4.1 which found its way into your answers to questions?
A. Yes.
MR JUSTICE BLAKE: Right. I was trying to find out where the table goes in terms of relationship.
They are saying, given those uncertainty factors, nevertheless the planned exposures to members of the public are acceptable.
A. Yes.
MR JUSTICE BLAKE: Despite the uncertainty factors mentioned in 4.1 earlier.
A. That's my reading of it.
MR JUSTICE BLAKE: What is the relevance of 1,000 microsieverts and such like and annual dose of 2,700?
A. 1,000 microsieverts is the normal limit for a member of the public.

MR JUSTICE BLAKE: Set by who?
A. By the ionising radiation regulations.
MR JUSTICE BLAKE: Based on what?
A. Based on ICRP recommendations.
MR JUSTICE BLAKE: Right.
So we've therefore got through that rather lengthy route to an ICRP recommended level?
A. Yes, that's the ICRP recommended limit for a member of a the public.
MR JUSTICE BLAKE: Right. And at 6 the authors, therefore, you understand to be saying, despite the uncertainty factors earlier, that doesn't affect the overall safety limits ultimately coming from ICRP?
A. Yes.
MR JUSTICE BLAKE: Right.
MR HEPPINSTALL: When you were giving your evidence on this subject earlier, you said there was some doubt about the United States Environmental Protection Authority figures.
A. There was doubt expressed in this paper.
Q. Is that at the top of page 42?
A. Yes, it is. I haven't read the whole paragraph but that is the paragraph which I was recollecting.
Q. It says:
"The UCPA analysis calculated age and gender average

risk co-efficient but used an obsolete representation of the lung and did not use a probabilistic approach when including bio-kinetic uncertainties."
Is that the sort of doubt or criticism that you were referring to?
A. Yes. Again I'm not an internal dosimetry expert and so I couldn't amplify that but yes, it is.
Q. I'm not entirely sure how a representation of the lung becomes obsolete but there we are.
A. The dose models and the models that they use have been developed over the years and a more sophisticated model has been adopted now, has been developed now.
Q. Now there's another paper in the next tab that I confess to be a little confused by. It's by Puncher. But the text and Harrison disappears, although he is credited -- thanks are given to him for reviewing and providing comments on the manuscript. But it seems to me that this is the same text or very text. For example, table 4.1 seems to now be table 6. Those conclusions at the end of the paper appear to be the same conclusions.
Is it as far as you are concerned the same paper?
A. I believe it is a summary paper of the more detailed paper which we just looked at.
Q. Right, fine.
A. It's designed for publication in a journal and I think

it just didn't go into the same depth.
Q. Thank you very much.
Details of the Washington survey from 1975 were put to you. I don't want to go back to that but I do want to show you another document, another one we will be handing up from B8B62.
A. Which bundle is this?
Q. It's going to arrive just in a moment. (Handed) Operation Dominic.
MR JUSTICE BLAKE: So this is extra to our core bundles so another candidate for 22?
MR HEPPINSTALL: Yes, SB22/14. It comes from the library.
MR JUSTICE BLAKE: Yes.
MR HEPPINSTALL: It's an extract. The full report is in the library, but I've just extracted it. This is a report on Operation Dominic, which I think I can lead, which is the series of operations that followed on Christmas Island --
MR JUSTICE BLAKE: We've come across Operation Dominic.
MR HEPPINSTALL: Yes. We were looking at an environmental survey of Christmas Island on 1975. If you turn to the last page of this extract --
A. Page 2?
Q. Yes. You will see that between 25 April 1962 and 11 July 1962 there was a range of other nuclear tests

conducted on, over or off Christmas Island.
A. Yes.
Q. Is it incorrect or correct that when you are considering the results of environmental surveys at Christmas Island after 1962 you'd have to take into account the fact that there had been both British tests and these US tests?
A. You would have to, and the scale of the US tests was larger than the British test.
Q. I should say that in that list, just to be clear, there are two tests on 11 May and 8 July which were not in fact related to Christmas Island. One was south west of San Diego and the other one was --
MR JUSTICE BLAKE: We'd better --
MR HEPPINSTALL: -- Johnson Island. So Swordfish --
MR JUSTICE BLAKE: Swordfish is non-Christmas Island.
MR HEPPINSTALL: That's an underwater, yes. And Starfish is --
MR JUSTICE BLAKE: Starfish?
MR HEPPINSTALL: -- Johnson Island.
MR JUSTICE BLAKE: 8 July.
MR HEPPINSTALL: 8 July.
MR JUSTICE BLAKE: But all the rest are Christmas Island, are they?
MR HEPPINSTALL: Yes. In fact, if you look at the text it says:

"Christmas Island ... Accept as noted."
MR JUSTICE BLAKE: And the curious reader will be informed as to the nature of the explosive activity going on?
MR HEPPINSTALL: At the time when this report was published, or made unclassified by the United States Government, the description of the yield is only given as intermediate, low megaton, low. I think there is public domain information that gives you more information, but I don't think it is verified by the United States Government. So I think they stick to intermediate, low, high.
MR JUSTICE BLAKE: Without being specific as to --
MR HEPPINSTALL: What I can tell you is that Yeso, 10 June -- I can get you the reference -- Mr Johnston worked on that test and that is equivalent to the R3 megaton explosion in Grapple Y so they described that as low megaton.
Hopefully that doesn't get me into any trouble.
Right. SB11/2, please.
MR JUSTICE BLAKE: Since I am just about to put this in my tab 14, just give me a second.
MR HEPPINSTALL: Certainly. (Pause)
MR JUSTICE BLAKE: Which tab are we looking at?
MR HEPPINSTALL: 2.
MR JUSTICE BLAKE: 2.

MR HEPPINSTALL: Tab 2, Professor Regan's first report.
MR JUSTICE BLAKE: Yes, Regan 1.
MR HEPPINSTALL: Turn to page 44 and paragraph 189, please.
MR JUSTICE BLAKE: Yes.
MR HEPPINSTALL: You were asked questions about radionuclides being in the sea, Mr Hallard, and here we have Professor Regan considering that question. He says:
"There are no reports in the defence papers [referring to the Secretary of State's papers] of contamination of fish following the Grapple test. Direct neutron activation of sodium 23 and chlorine nuclei in the seawater would give rise to some relatively short-lived activity which should have been evident in any flyover of the region close to the explosion using gamma ray dosimetry equipment. For fallout which fell on to open seawater this would most likely be dispersed quite quickly and diluted down by the natural wave motion of the seawater."
Do you agree?
A. Yes, I do.
Q. Then at 193 he is answering the question:
"What steps should have been taken to remove all fallout that fell out on to land and on to freshwater in the sea to make these areas safe to occupy and use by

humans?"
He answers:
"The first step would be simply [I think he means to use] the decay half life effect to reduce the activity associated with ... fission fragments and neutron activation products with time."
I think you've already referred to that yourself.
A. I have, yes.
Q. Then he says:
"Fallout on the sea would be dispersed quite quickly through the natural motion of the sea."
Do you agree with that?
A. Again, I've made a similar point.
Q. "This effect would be less apparent in the case of freshwater where the radioactivity from the fallout would collect in the sediment and where it could be transferred to the food chain by feeding off fish and shellfish."
Do you agree with that?
A. Yes.
Q. Have you taken into account that last sentence in your report?
A. Yes, I've considered the potential ingestion dose from activity falling into a lagoon, and then assumed that somebody would drink 4 litres of water, drinking water,

a day from that lagoon and that's one of the pathways that I've considered in my report.
MR JUSTICE BLAKE: A lagoon?
A. The lagoon water. There are lagoons on the Island, my Lord.
MR JUSTICE BLAKE: Freshwater lagoons, are they?
A. I think most of them are saltwater lagoons but --
MR JUSTICE BLAKE: Quite. But people drink 4 litres of seawater?
A. There are one or two lagoons which are referred to as freshwater near the southern part of the Island. The reason I've included it is again the video that I referred to earlier from the Imperial War Museum actually showed water being sucked from a lagoon into a bowser which was then going to be treated and used as freshwater. So the assumption that I made -- and perhaps I didn't make this very explicit in my report -- the assumption that I made is that it would either have gone through some sort of desalination plant, although that would have removed the activity, or that they were sampling from the small number of freshwater lagoons on the Island. I believe that most of the lagoons are actually saltwater but it was a conservative assessment that I made based on that assumption.
MR JUSTICE BLAKE: Yes.

MR HEPPINSTALL: On that topic of seawater monitoring that Professor Regan mentions, SB17, tab 8, back to the Clare report, please.

At page 7 at the bottom of that page we pick up the heading "Seawater monitoring". Paragraph 34:

"Seawater immediately below a nuclear detonation is exposed to neutrons. These neutrons are absorbed by sodium in the water to give rise to sodium-24 which is radioactive and has a half life of 15 hours."

Is that correct?

A. Yes.

Q. "Seawater was monitored by three methods. Firstly, sensitive monitoring instruments were carried by low flying aircraft in flight patterns designed to locate any radioactivity that might be present in the sea immediately after the detonation."

Is that your understanding?

A. Yes, it is and I think that was one of the principal purposes of the Shackleton survey.

Q. "Secondly, samples of seawater were collected by helicopter in the vicinity of Surface Zero shortly after the detonations and [something] at Christmas Island.

"Thirdly, Her Majesty's ships made measurements of radioactivity in waters through which they sailed."

Is that your understanding?

A. Yes. I'm less certain about the last sentence but certainly the helicopter. I believe the last sentence is also true but I am just less certain about that. I suspect that the missing word at the start is probably "counted". I think it's probably "counted at Christmas Island" because the seawater samples certainly were taken back to the Joint Operations Centre and counted.

MR JUSTICE BLAKE: I am reading this whilst holding in my head the answers that you just have given me about lagoons. Am I right in thinking that this report doesn't refer to freshwater lakes, as I shall call them? They refer to rainwater monitoring and something about recommended drinking water, but I don't think we've got anything about lakes?

A. No. There's nothing in this report at all from memory about the lakes. What they are particularly talking about here, particularly at the bottom of page 7, that final sentence, "The samples of seawater were collected by helicopter", again that's described in some detail in the residual radiation measurements paper which we looked at earlier. So a helicopter flew over Surface Zero, it effectively flew on a grid pattern until it found the highest level of radiation from the sea and then took a sample of that.

The reason that the sea was radioactive, if I can put it like that, was that the neutrons which were emitted from the detonation would have been absorbed in the sodium in sea, the seawater obviously contained sodium chloride, but that sodium is obviously not radioactive but that would have absorbed 1 neutron from the detonation which would have then turned it into a radioactive nuclide.

MR JUSTICE BLAKE: That's why they are particularly interested in seawater.

A. Yes, so it's effectively converted from 1 nuclide, called sodium-23, which is stable sodium into another nuclide called sodium-24 which is radioactive sodium. That is the nuclide which has got a half life of about 15 hours.

MR JUSTICE BLAKE: Okay. I am just trying to get back to drinking water.

A. Right.

MR JUSTICE BLAKE: Drinking water would not be seawater unless it's been desalinated.

A. That's correct, my Lord.

MR JUSTICE BLAKE: If it's been desalinated then the very hypothesis that you are exploring would have been contraindicated because it would have filtered out --

A. It would have taken out the radioactive salt. But they

wouldn't have been drinking this material. If I remember correctly -- ah yes, they do and I think this is probably what's causing the confusion. Although they're talking about sodium-24, radioactive sodium in seawater, they are then comparing the level that they measured with the maximum level for drinking water. I think simply because they probably had nothing else to compare it with.

MR JUSTICE BLAKE: Yes.

A. So there is an element of apples and pears there.

MR HEPPINSTALL: I think what my Lord is doing is pursuing the question of whether drinking water itself was tested.

A. Ah, I see.

Q. In your reports, correct me if I'm wrong, but you consider possible contamination to a water lens below the surface.

A. That's one of the two.

Q. And the allegation made in respect of that water lens that I think you take into account is that it was potentially contaminated from effluent from where the planes were being decontaminated. Is that right?

A. That's correct.

Q. Have you taken into account that potential contamination of that water lens which was used for drinking water?

Have you taken that into account in your dose assessment?
A. I have. But there is also a second element, which is the one I was just referring to, where I looked at direct deposition of activity. If the activity is deposited on the ground then it would also be deposited on a lagoon, a lake if you prefer. Although a lot of the lakes were saltwater --
MR JUSTICE BLAKE: I always thought a lagoon was the area between the coral reef and the island which is where the fish go. But never mind about that.
A. I am just looking at the map actually.
MR HEPPINSTALL: Please use it. It has been sat there.
A. This is the same map I've been using although it's not a particularly clear copy.
MR HEPPINSTALL: Mr Verma will hold it for you.
A. So it was particularly the fact that I saw on the video that they were extracting small quantities of water from the lagoons and that's the reason that I've included it.
Now, I think quite a lot of these lagoons are referred to in two places. One is the Lorna Arnold report. She makes a very passing reference to lagoons being saltwater, and I think the other place that refers to lagoons being salt, again a passing reference, is in the New Zealand survey it just refers to lagoons as

very rapid calculation that would be the equivalent to 28,000 grams of carbon-14.
Q. 28,000 grams of carbon-14 in all UK shots?
A. That's based on the upper end, the 2,000 moles.
Q. So 1,500 plus 500?
A. Yes.
MR JUSTICE BLAKE: So 1,500 plus 500 moles is 20?
A. That's 28,000 grams --
MR JUSTICE BLAKE: 28,000 grams?
A. -- of carbon-14.
MR JUSTICE BLAKE: 2.8 kilograms?
A. 28 kilograms.
MR JUSTICE BLAKE: 28.
MR HEPPINSTALL: 28,000.
MR JUSTICE BLAKE: Yes.
MR HEPPINSTALL: Mr Hallard, the only note of caution which you may wish to express is that that paragraph is entitled "Mosaic, Buffalo, et cetera", so "from all UK shots" I think is at best, perhaps you would agree, ambiguous as to what shots are being considered?
A. Yes, it is. I hadn't remembered that detail from this report, but you are quite right, that does raise a question mark as to what they are referring to. In fact they go on to the Grapple series later so I'd forgotten that detail.

being salt.
But again I looked at this and in some places it does refer to shallow freshwater lagoons.
So I've just made a conservative assumption that that is where the drinking water was being extracted from that I saw on the video and that then formed the basis for that second assessment of drinking water.
MR JUSTICE BLAKE: Right, okay. But the shallow freshwater lagoons did not appear to have been mentioned in the Clare report?
A. No.
MR JUSTICE BLAKE: Right, okay. Thank you.
MR HEPPINSTALL: Just as the cross-examination was completing you mentioned that you thought in the documents somewhere there was a measurement of carbon-14. If you turn to SB13, tab 43 --
A. Tab 43?
Q. SB13, tab 43. I think, or rather I know, this is the record of the exercise undertaken to gist information in classified documents into open, and I think you mentioned the gist in answer to questions.
A. I did.
Q. And at paragraph 3 there is a last sentence there. Is that what you had in mind?
A. It is. That's the sentence that I remembered and from a

Q. Yes, that was my fear.
A. Thank you for identifying that.
Q. There we are. That's the figure that you recall.
A. Yes, but it may not be relevant to the Grapple series from what you are saying.
Q. You have not used ECRR dose co-efficients in your assessment. Why not?
A. I think for the reasons that I said before, that the ICRP is taken as the international standard, the international benchmark, and the data from that is used directly in the International Atomic Energy Agency, that's the IAEA basic safety standards, in the EU Directive basic safety standards. It's used internationally.
MR JUSTICE BLAKE: I mean certainly if you are doing something in the UK about emissions of radiating ions you'd have to use the EU regulations --
A. You would.
MR JUSTICE BLAKE: -- and their enabling provisions. Well, the regulations are directly effective, aren't they?
A. Yes.
MR JUSTICE BLAKE: Because that's the legal requirement, and the tracing of the parentage of that legal requirement is the ICRP?
A. Yes.

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

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