Environmental Protection Authority
Te Mana Rauhī Taiao

TRANSCRIPT OF PROCEEDINGS

ENVIRONMENTAL PROTECTION AUTHORITY HEARING

Chatham Rock Phosphate Limited Marine Consent Application

HEARING at
NORWOOD ROOM, RA VANCE STAND,
BASIN RESERVE, WELLINGTON
on 14 OCTOBER 2014

DECISION-MAKING COMMITTEE:
Neil Walter (Chairperson)
Dr Nicki Crauford (EPA Board Representative)
Dr Gregory Ryder (Committee Member)
Lennie Johns (Committee Member)
David Hill (Committee Member)

[9.01 am]

CHAIRPERSON: Right, good morning and welcome to day 8 of the hearing. I have got a couple of announcements to make before we get underway.

The first thing, as many of you and maybe most of you know, we were obliged to postpone the hearing on the Chatham Islands last week because of a death on the island. It is now proposed that we spend the week beginning 10 November in the Chatham Islands. This involves quite a bit of rearranging, flight schedules and other factors make holding a hearing in the Chathams quite a complicated exercise. There will be no resultant changes to the October hearing schedule but there will be – there will have to be a number of changes to the November schedule.

We will issue a draft new schedule for November later today and my suggestion is that all parties take a look at it and use tomorrow to register any problems or concerns with the secretariat. We will then take a further look at it and come out on Thursday or Friday with a final schedule. We will show as much flexibility as we can where parties have been adversely affected by the changes and have a problem with it. Our aim still will be to have the hearing conclude by 18 November.

And the second matter, you may have seen on the EPA website two memoranda from Mr Currie on behalf of the three submitter groups about the late evidence submitted by Dr Ketten. Our response to the first of those memoranda was posted on the website yesterday and we expect to be able to respond to the second later today. And also posted on the website is a memorandum from CRP about the supplementary staff report. We aim to deliver our response to that memorandum also later today.

All right, our schedule for today does focus on toxicology, water quality and radioactivity and the first witness is Dr Phillips on behalf I think of the Deepwater Group, Ngāti Kahungunu and Te Ohu Kaimoana.

[9.05 am]

MR CHRISTENSEN: Thank you, sir.

CHAIRPERSON: Over to you, Mr Christensen.

MR CHRISTENSEN: We are just going to have to wait for a wee moment while these copies are made.

CHAIRPERSON: Okay.

When you are ready, Dr Phillips.

DR PHILLIPS: Okay, are you happy for me to sit or would you prefer I stand?

CHAIRPERSON: Yes, that is fine, and if you could talk into the microphone please just to make sure people hear.

DR PHILLIPS: I'm short, okay, so, good morning, my name is Ngaire Robyn Phillips. I hold a doctor of philosophy in environmental science gained from Griffith University in Brisbane, Australia which I received in 1994. I also hold a master of science with first class honours in zoology and a bachelor of science in zoology both gained from the University of Auckland.

I am currently a director of Streamlined Environmental, a company specialising in aquatic science consulting. My specialist roles within the company are as an aquatic ecologist and ecotoxicologist. I have worked in the field of environmental science for more than 20 years and I have experience in government, academia and the private sector. Prior to my current role I was employed at NIWA in Hamilton as group manager freshwater biology and in its subsidiary NIWA Australia's principal scientist aquatic ecology for a period of 10 years.

I have also held senior roles in Australian government agencies and environmental consultancies providing specialist expertise in aquatic ecology and ecotoxicology. I have worked on a wide range of environmental science issues including effects of land use on aquatic ecology both freshwater and marine, water quality, customary fisheries relating to iwi and responses to contaminants by aquatic organisms which is ecotoxicology.

I am author of 27 peer reviewed publications, 51 conference proceedings, 53 public or media presentations and more than 80 consulting reports on the above issues. I have undertaken research and consulting in ecotoxicology in both marine and freshwater environments particularly in relation to heavy metal pollution. My PhD examined the effects of pollution from a zinc sulphide smelter on marine mussels in the Newcastle in Australia. Subsequent research has examined the resilience of estuarine and freshwater bivalve communities to metals and other stresses in both New Zealand and Australia. I have experience in both lab and field based toxicological investigations.

I also have experience in linking human and environmental health as a toxicologist with the New Zealand Department of Health and most recently as programme leader in a research project determining the risks of contaminants in traditional food sources.

I confirm that the contents of this report are correct to the best of my knowledge. I confirm that I have read the expert witness code of conduct as contained in the Environment Court consolidated practice note 2011 and agree to comply with it.

Other than what I state when I am relying on the advice of another person this evidence is entirely within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from my opinions that I express.

So just in terms of my scope of evidence I have been asked by Te Rūnanga o Ngāi Tahu to prepare evidence in relation to the potential toxicity to the aquatic environment of contaminants associated with the mining of phosphate. In doing so I have considered bioavailability of other metals associated with mining and processing of phospherite, toxicity of metals to marine biota and the methods used by the experts engaged by CRP to determine bioavailability and toxicity and whether these methods are appropriate. I have specifically commented on Mr Paul Kennedy's evidence relating to sediment and water chemistry.

So I will now present a summary of my evidence.

[9.10 am]

DR CRAUFORD: Would you mind speaking up a little.

DR PHILLIPS: Oh, I am sorry, I'm probably a little bit too far away. Is that better?

DR CRAUFORD: Keep going.

DR PHILLIPS: Okay, cool. In assessing potential toxicity associated with the proposed mining activities the bioavailability of metals and other contaminants associated with the materials produced during mining needs to be considered. And by "mining" I refer to the whole process, the dredging, processing and return of dredged material to the seabed and the overlying seawater.

A contaminant is considered to be bioavailable if it is in a form which can be taken up by the organism either directly or indirectly and assimilated, so taken into or onto the body. Bioavailability of uranium

and other trace elements was assessed by Golder (2014) in their report by performing 30 minute elutriate tests. An elutriate test involves mixing dredged material with dredging site water and allowing the mixture to settle. The resulting liquid or elutriate that remains after the sediment has settled is considered to contain the metals and other contaminants that are most bioavailable. The water used in the elutriate test was not sourced from the Chatham Rise but rather from the Raglan coast and at a site en route to the Chatham Islands.

The elutriate test is designed to simulate release of contaminants from a sediment during dredged material disposal. The elutriate tests were undertaken on seabed material that most closely resembles the dredged sediment rather than the processed or returned sediment. The processed material would be comprised of sediment particles less than two millimetres in size. In contrast the sediment used in the elutriate tests can be comprised of as much as 30 percent of material greater than two millimetres.

The physical and chemical properties of the processed and returned material have not been determined therefore I do not believe that the seabed material represents the bioavailability associated with the processed or returned material. In addition I do not believe that 30 minute elutriate tests adequately represent the effects on sediment chemical and physical properties that may arise from mining activity or return of the material to above the seabed.

Bioavailability does not necessarily provide evidence for toxicity therefore toxicity testing is necessary for definitive understanding. Toxicity is dependent on the exposure pathway of the toxicant and its mode of action. That is how the toxicant enters an organism and what happens to it when it is inside. Toxicity varies with species and with life stage and can be affected by chemical and physical properties of the test solution.

Tests were undertaken by NIWA in the report Hickey et al (2014) which is found in Paul Kennedy's evidence. They were undertaken to determine the toxicity of elutriate solutions produced from three sediment samples collected from the Chatham Rise that had been actually frozen for three years. The state of the sediments at the time of sampling versus when they were used in the elutriate and toxicity tests has relevance to how representative they are of the Chatham Rise sediment that will be mined as storing of sediments may alter chemical and physical properties.

Toxicity was determined only for elutriates derived from surface sediments however the sediment to be mined may consist of any

combination of a mix of three layers, namely surface, subsurface and chalk. Given that all three layers will be disturbed during mining I consider that toxicity tests should have been performed with elutriate derived from all three layers. CRP data showed differences in the metal concentrations of a number of metals in the different sediment layers. This suggests potential differences in the chemical composition of elutriates derived from each sediment layer which could be manifest as differences in toxicity.

Toxicity was assessed using three species of organisms, namely a crustacean - an amphipod, a mollusc - in this case a mussel, and a bacterium. The toxicity tests involved exposing the test organisms to a series of dilutions of the elutriate solution ranging from 0 percent to 100 percent. The crustacean used is known to be sensitive to high salinities. Because of this the amphipod tests could not be undertaken at full salinity so therefore 100 percent elutriate concentration and differences in the pH of the test solution were also noted. These differences may have affected the toxicity of metals. I consider therefore that the species is not a suitable representative of species found at depth in full salinity on the Chatham Rise.

[9.15 am]

Elutriates used in the toxicity tests were derived from 30 minutes and 24 hours elutriation although the amphipod test was only conducted with 30 minute elutriates. Hickey et al (2014) stated that the short term of the short elutriation period is appropriate for assessing near field mixing effects while the longer elutriation period would be considered to be better to indicate equilibration conditions which might occur after resettling of the sediments.

For all three sediment samples tested a response for amphipods was detected in 5 percent of test animals and for one sample in 10 percent of test animals exposed to as little as 3.71 percent of the elutriate derived from 30 minute shaking.

Effects on 5 percent of a population are I believe equivalent to the ANZECC guideline for protection of 95 percent of species. These guidelines are a trigger for further investigation into the possibility of effects rather than a definitive indication of an adverse effect. Further investigation was not undertaken.

Effects of 100 percent concentration of elutriates from two of the three sediment samples derived from the Chatham Rise elicited toxic responses in bacteria. These effects were evident for elutriates derived from 30 minutes and 24 hour elutriation. Copper, molybdenum,

strontium, uranium and vanadium increased in concentration in 24 hour elutriates compared to 30 minute elutriates indicating continued release of these metals.

The results of the elutriate tests suggests that disturbance of the sediment, as would happen during mining, over longer periods than the standard 30 minute elutriate test is likely to result in the continued release of metals and nutrients. In turn this represents a significantly greater potential toxic effect than if the contaminants were generated for short periods during mining operations.

As toxicity effects and increases in some contaminants were observed with the 24 hour elutriates I consider that further examination of the potential long term accumulation of metals in fish in particular is warranted given the importance of the Chatham Rise as a commercial and customary fishery. The data I have reviewed suggests that toxic effects may occur as a consequence of mining, processing and/or return of material but I can't be sure of the extent of that effect. There is no proposal by CRP to mitigate these effects. I believe that CRP needs to undertake further studies/investigations in accordance with best practice. Without assessing the results of these studies/investigations the effects of the proposed mining on the aquatic environment in terms of bioavailability or toxicity remain uncertain and aren't quantified.

Globally there is limited information on the toxicological effects of uranium in marine environments and what has been undertaken indicates significant variability in different groups of organisms. I believe that a precautionary approach is required until further investigations are undertaken to provide greater certainty of the likely effects. Thank you.

CHAIRPERSON: Thank you very much, Dr Phillips. The Committee first, David or Greg?

DR RYDER: Thank you. Good morning, Dr Phillips. I have got a few questions in relation to your evidence but also in relation to the joint conferencing statement.

DR PHILLIPS: Sure.

DR RYDER: Just in relation to the elutriate tests and the toxicity testing of elutriate, you would accept, wouldn't you, that there is always going to be difficulties in undertaking those sorts of tests using these samples from the Chatham Rise given the difficulties in time constraints in terms of collecting samples and shipping them back to a laboratory?

Those constraints are going to compromise to some extent the standard protocols for those sorts of tests, is that reasonable?

DR PHILLIPS: Yes, that is reasonable. I guess it could be argued that you could have done toxicity tests on board the ship.

DR RYDER: Right. Are you aware of that sort of practice taking place?

DR PHILLIPS: I know that NIWA does some testing, like as part of their research voyages they will do on board testing.

[9.20 am]

DR RYDER: Okay.

DR PHILLIPS: Not necessarily with those species, but - - -

DR RYDER: No, well, just while we're on those species, now, my understanding is that they are fairly standard species that NIWA – I mean, you'll be familiar with that - - -

DR PHILLIPS: Yes, they are all widely used in toxicological investigations, that's correct.

DR RYDER: Yes, and one of the reasons why they are standard species is because they – the toxicity that they exhibit for whatever samples they're exposed to, can be assessed on a relative basis because you're using the same species on a range of different samples.

DR PHILLIPS: Yes.

DR RYDER: So that has got some appeal in terms of assessing the relative toxicity of a sample, if you like?

DR PHILLIPS: Yes.

DR RYDER: Okay, and there are other logistical details with, for example, testing Chatham Rise species and using that sort of technique, so you just can't grab a whole lot of, I don't know, some benthic invertebrate from the Chatham Rise, take them to a laboratory and then set up a toxicity type testing arrangement?

DR PHILLIPS: Yes, well, certainly not and perhaps not in a commercial venture, but potentially in a research way, which is what we've suggested in our joint statement, was that potentially some research

could be done around this. I agree that in a commercial sense this could not be done.

DR RYDER: I mean you've identified some concerns with the methods and approach used, which I accept, but I'm just trying to look at the practicalities of the approach and the criticisms in relation to the real world type environment we're dealing with.

Just looking at effects, trying to relate the observations in terms of toxicity back to the environment and the situation of the mining, is it not the case that – I'm struggling a wee bit with what the real effect would be of potential toxicity given that the mined bed is going to be devoid of any animals once the drag head is moved through, so I guess my question is what is there to be affected by it in the short to medium term anyway?

DR PHILLIPS: Yes, sure, it would be more likely in the pelagic species in the pelagic zone, and the level of toxicity will depend on how long that sediment plume is in the area and how long – I mean, I agree that, you know, the effect of the actual dredging and taking all of the habitat away is far, far greater than any potential toxicity, no two ways about that.

DR RYDER: Do you have any view as to whether the effects of sedimentation and increased levels of suspended sediment, particularly in the near field area, would they not outweigh any potential effect of toxicity on marine species?

DR PHILLIPS: Yes, and that's another thing that we identified in our joint statement, was that we accepted that there were multiple stressors happening here and the sedimentation, the physical effects of the sedimentation are quite likely to be much, much higher than the toxicity. But of course the sedimentation will actually affect the amount of suspended sediment, it may affect the bio availability of the toxicants because they will be attracted to the sediment, and if you've got things moving through the water column and feeding, there's a potential toxicity associated with food borne, it's not just water borne, it will be food borne potential toxicity as well.

DR RYDER: All right. Now, just in relation to the joint statement, issue one, you are agreeing that there should be more sampling of the water and analysis of water composition and quality undertaken in the mining area before any mining operation is commenced, and this must also continue after mining commences, so is that – my question is, is that just to develop a broader information base on water quality in the area, is there any sort of feedback mechanism into the operation itself in

terms of, if you find something that you didn't expect to find in terms of water quality, does that have any repercussions for the commencement of mining, or is this just purely to build up the database prior to mining commencing?

[9.25 am]

DR PHILLIPS: Well, I mean I guess it's ongoing, yes, building up, having a baseline and then continuing to monitor to – I mean because, we have – like in the draft consent conditions that we're proposing, we don't actually propose a consequence I guess, is what you're asking - - -

DR RYDER: Yes.

DR PHILLIPS: - - - what is the consequence of – but I guess the assumption is that considering that the initial assessment of effects was comparing to ANZECC guidelines, for example, to look at potential toxicity associated if these guidelines are exceeded, my expectation would be that that assessment process would continue, that part of the mitigation strategy would be that CRP would be monitoring their water quality to see that they're not exceeding guideline values and then taking appropriate action, however they might do that.

DR RYDER: Through a consent condition?

DR PHILLIPS: Yes, through a consent condition, which I'm not sure – I'd have to have a look through to see whether we actually applied that further, I'm not sure we have.

DR RYDER: I'm not sure if it is.

DR PHILLIPS: No, I don't think it is either. But it was initially this feeling that there was very little existing information on the water quality of the Chatham Rise that related to the mining and the potential for changes in water quality, which Gauldur **(ph 1.41)** actually identify themselves, for example, increased in carbon reductions and dissolved oxygen, however long they occur for, so it was just getting that picture of what was in the environment and how that might change with the mining.

DR RYDER: Okay, so turning to issue two, again, under the expert opinion/ conclusion column, that first bullet point where CRP be required to validate the toxicity tests with fresh sediment samples during its baseline pre-mining sampling programme. So again, in practical terms, you have suggested a condition of consent to require that, but there is

no consequence type condition, for example, if the testing did find significant adverse effects, if you like, from toxicity on benthic species.

DR PHILLIPS: Yes, no, we haven't, you're quite correct, we haven't specified a threshold above which we would consider the effect to be unacceptable. Yes, I'm not sure what else I can say to that, I mean I guess the feeling was that particular comment related to the fact that the sediment samples that were used to produce the elutriate from the toxicity tests were three years old and had been frozen, so there was this question of how representative are they of the mined sediment. But again, that could be something that – I guess in my evidence, like my summary of my evidence at the end I talk about taking a precautionary approach, and I guess one of the – I mean, that's not really my decision obviously, that's up to the DMC, but one approach could be to define an acceptable level of impact, which is more of a value judgement than a scientific one that could be used on a scientific basis. But we haven't suggested that obviously, sorry.

DR RYDER: Just finally, the application of the ANZECC guidelines, are you comfortable with the way they've been used and their appropriateness for this particular environment and activity given we know little, I think the experts are fairly in agreement on this, knowing little about the sensitivity of individual species that might be on the Chatham Rise bed or in the water column even.

DR PHILLIPS: Yes, I mean, I guess in the absence of anything else they're useful and I guess what we were trying to, the point that we were trying to make here was that – to be very conscious that the ANZECC guidelines are not a trigger, they're not a – sorry, a value which we say, okay, above this there is definitely a toxic effect, they're a trigger for further investigation, and I guess our feeling was that in some cases they're not being applied in that way, they're just – the attitude is that, okay, it exceeds the guidelines, therefore there is a toxic effect happening but we are saying that we need to have more of a – take into account what the guidelines were actually designed for which was actually to decide on whether further investigation is needed and what kind of investigation that was.

[9.30 am]

DR RYDER: Okay, and so just to take that a bit further, you have agreed in the joint statement that that would be achieved by this additional testing prior to mining commencing?

DR PHILLIPS: That would certainly – I mean I guess in terms of the joint statement there are a few things there that we have suggested that collectively, I believe, would provide a more robust dataset on which to make some decisions about what is acceptable and what is not acceptable.

DR RYDER: But I mean that is assuming though the consent is granted, and as I say, there is nothing in there that would put a halt or a pause, if you like, to mining commencing, there would have to be some sort of followup if results did indicate there is a greater issue than perhaps what is being suggested at the moment, in the evidence?

DR PHILLIPS: Yes, that's right, and that is why I point out in my summary that, I mean, there is no proposal by CRP to mitigate any potential peaks and I guess that is how, a good example of adaptive management. I mean, if an adaptive management – if the adaptive management included a consideration of the possibility of toxicity which it currently doesn't, then some of this derivation – like one of the things we have suggested is deriving an ANZECC guideline value for uranium because - there is no guideline value in the world for the uranium toxicity in marine environments.

So we can't make a decision about whether it is acceptable or not because there is no guidelines.

DR RYDER: Just finally on that because that is quite apparent in all the evidence and I am wondering is it because it is not deemed to be an issue in terms of the toxicity aspect of uranium, because you would think somewhere around the world this would have been looked at?

DR PHILLIPS: Well, I guess it is because – like if you look, for example, in estuaries, in ports where they load phosphate fertiliser, you get quite high uranium concentration, very high concentrations in uranium in the biota and in the sediment but it tends to be the radiological – because, you know, uranium can be chemically toxic and it can also be radiologically toxic – so the radiological toxicity tends to be higher, but I guess in deep sea mining, I mean, the fact is this hasn't been done anywhere in the world, I mean, we are not looking which there is any sort of benchmarks against for people to assess against. I mean this is new stuff.

Probably – I mean, if you look at, the EPA has a database, I think, it is called ECOTOX where they store all of the toxicological studies and the results of those, and there is nine records for marine species for the whole world and most of those – and in all of those studies, none of

them were actually looking at toxicity, they were looking at bioaccumulation, whether it has been taken up or not.

So the question about toxicity and uranium in marine environments just simply hasn't come up because it hasn't actually needed to be – it is not an issue that anyone has had to address before.

DR RYDER: So the radio activity aspect of uranium has been the focus rather than the toxicity?

DR PHILLIPS: Yes, certainly in places like Japan and in places in Europe where, you know, like you've nuclear actives and all this sort of thing – well obviously the earthquake in Japan and all that sort of thing, and the potential for human consumption of the food rather than toxicity to the animals themselves.

MR HILL: And Dr Phillips, I have just got a couple of questions which come out of the joint witness statement rather than your evidence as such, just pick up on one of the matters that Dr Ryder was asking you on.

With respect to Issue 7, and the ANZECC guidelines, the group concluded as to its importance to give it a high ranking in terms of that issue, but there is nothing in the far right columns in terms of translation of what that might actually mean.

Was that because you didn't get to that point or – I mean, the advice from the experts presumably is that the guideline needs to be used appropriately. How do we actually write that up if you like, in the event that we go there, and what does it actually mean?

[9.35 am]

DR PHILLIPS: I can't remember why, I'm not sure why we didn't write a draft condition in here, I think the feeling was that when we were talking about this, we were talking fairly generically about the whole idea as a group of people involved in toxicology and water quality.

MR HILL: Let me ask you then, how would you do it rather than how the group might do it?

DR PHILLIPS: I will just read through the notes if that is okay.

Well I guess it links back to the initial, I think it is Issue 1, about doing water quality testing and we also talk somewhere about testing at the end of pipe which is basically at the discharge point measuring water

quality coupled with – so that's a first start for assessing against the guidelines and using them as a trigger for further investigation.

And then the second thing would be for, as we talked about, there is no guideline for uranium and this is something that is potentially an issue, not necessarily from scientific, but from a public perception perspective as well, is that it is an opportunity and we suggest it in Issue 5, the idea of undertaking some research to establish an internationally recognised toxicity threshold for uranium in the marine environment.

MR HILL: Sorry, you are fading out a little bit.

DR PHILLIPS: I'm sorry, I am quite short, so what I am saying was – so how I would address it would be to ensure that water quality monitoring was being done, baseline monitoring was established before mining proceeded and then monitoring was done on a regular basis and assessed against ANZECC guidelines and then the ANZECC guidelines were used as a trigger if the guidelines were exceeded, then there was a requirement to do further investigation and that may be in the form of further monitoring, water quality monitoring, sediment monitoring or toxicity testing as the case may be.

MR HILL: All right, thank you.

If we just turn to Issue 3, and I just want to understand – again, in the far right column there, it is indicated that Dr Peake disagreed on this particular issue and we will hear from him later obviously, I just want to be clear – did you agree with that condition or the reservation that Dr Peake has in there is with respect to what happens and what do you do and the same questions that Dr Ryder was asking you.

DR PHILLIPS: No, I felt that – this related to whether the species used for toxicity testing were appropriate or not and I felt that there was definitely scope for developing some further toxicity test relevance to deep sea species. So I was totally in agreement with this.

MR HILL: Thank you. Issue 2 in the central column there on the uncertainty. That second bullet point – I just want to be clear.

In the brackets it indicates that you and Dr Tremblay were neutral on the issue, Dr Peake was absent and Mr Kennedy disagreed.

Who was in the room who actually agreed to that particular - - -

DR PHILLIPS: No, that is actually a little bit misleading, I agree.

MR HILL: I thought that might be, yes.

DR PHILLIPS: I agreed with this issue.

MR HILL: Right.

DR PHILLIPS: And then Dr Tremblay was neutral and - - -

MR HILL: You agree with yourself?

DR PHILLIPS: Yes, I agree with myself, yes, and that is why over in the first column, I've ranked this differently from the rest of the experts.

MR HILL: Right.

DR PHILLIPS: I didn't write this.

MR HILL: Just to understand on Issue 1 on the assumptions column there where it is indicated that you weren't in a position to offer an opinion on the assumption.

Just clarify that for me if you would?

DR PHILLIPS: Sorry, I just need to read through it.

MR HILL: It is column 3 in Issue 1.

[9.40 am]

DR PHILLIPS: So this related to basically Mr Kennedy telling us that he didn't think – that's why it is couching terms of CRP has assumed spatial variability and in the sediment analysis is minimal and the existing – and temporal – so this related to knowledge around the temporal and spatial variability in the metals and the sediments, and we felt that we hadn't actually been presented with any evidence about the spatial and temporal variability of the sediments, so we couldn't make a comment – we didn't feel that we could make a comment about that.

MR HILL: But you didn't feel strongly enough to disagree with those assumptions as a basis?

DR PHILLIPS: Yes, and I guess for me obviously I can't speak on behalf of Louie – but for myself, it was the fact that there's, there just wasn't any evidence one way of the other to show and it was just that complete lack of evidence - - -

MR HILL: Okay.

DR PHILLIPS: - - - around seasonal and temporal variability.

MR HILL: All right, thank you, Dr Phillips.

DR CRAUFORD: Dr Phillips, in regards to issue 2 of the joint statement, you mention in terms of facts, the second column that the tests were done on samples that had been frozen for three years - - -

DR PHILLIPS: Mm'hm.

DR CRAUFORD: - - - and you mention that also in your evidence as being an issue, but then in the third bullet point you say that you agreed on balance that this is not a major issue, can you explain that?

DR PHILLIPS: Yes. So basically – I mean potentially we agreed that it was an issue but Dr Hickey who undertook the toxicity test on behalf of NIWA on behalf of CRP, I mean he identified this is an issue, a potential issue as well, but his conclusion was that, it was unlikely that there'd been any major degradation of the sediments and I would tend to agree with Dr Hickey.

DR CRAUFORD: Okay. And really just returning to the questioning of my colleagues, you're saying that CRP are not proposing any mitigation effects, but I guess – but you're also saying that, whilst you think there may be toxic effects you haven't actually any identified what those toxic affects might be therefore it's very difficult to set any conditions to mitigate them, is that kind of what you're saying?

DR PHILLIPS: Well I'm saying that CRP haven't really identified whether there's definitely no toxic effects. I haven't identified these.

DR CRAUFORD: So no one has?

DR PHILLIPS: No, there's very, very, very little toxicity data - - -

DR CRAUFORD: So - - -

DR PHILLIPS: - - - existing toxicity data.

DR CRAUFORD: So from that perspective are you suggesting that sampling occurs during the mining process or are you suggesting that sampling occurs and then testing in order to establish what those effects might be prior to any mining commencing?

DR PHILLIPS: Both, so sampling would need to be done prior to mining and then during the course of the mining as well.

DR CRAUFORD: Are you suggesting that that's merely just as a baseline or are you suggesting that further testing on what the toxic effects might be needs to occur and have been completed prior to mining so that then limits can be put?

DR PHILLIPS: No, I guess this relates to the question that I answered before about the ANZECC guidelines and how I might apply them in the terms of mitigation. And also it also relates to Dr Hill's – Ryder's comment about, you know the reality of being able to do these tests prior to - - -

DR CRAUFORD: That's right.

DR PHILLIPS: - - - and especially the – so that's why we suggested a research approach to deriving – to working on relevant, more relevant species and also working to develop an internationally recognised guideline on uranium, so that all relates to things that could happen during the course of the longer term course of the mining.

DR CRAUFORD: But you're suggesting that that should occur whilst the mining is occurring, so in effect your saying to me that we don't need conditions upfront because you're happy that that research occurs as mining takes place, that's what I'm trying to get at.

DR PHILLIPS: Yeah, yeah. So there's two – so you – sorry, when you said "monitoring" or "sampling", I thought you were referring to, so there's monitoring which is the establishing the baseline and doing the, you know, the ongoing checking if you like - - -

DR CRAUFORD: Yes.

DR PHILLIPS: - - - and then the response to that checking could be, it could be – the initial response could be about applying the existing ANZECC Guidelines, and then using the ANZECC guidelines appropriately as a trigger for further investigation if they are exceeded or something around that.

[9.45 am]

DR CRAUFORD: Okay.

DR PHILLIPS: But then there's a longer term vision, if you like, of the experts around the fact that, yes it would be great to have toxicological data

relevant, that is actually relevant to this environment, and that has been derived "out of" the re-, you know, through – which would need to be done through research, yet it's not something you can just go out and do very easily, it would definitely be a PhD project or a Masters project.

DR CRAUFORD: Okay, I'm just trying to distinguish between the altruistic scientists always want more information - - -

DR PHILLIPS: Yeah, oh no, no, no, no, no, no.

DR CRAUFORD: - - - about an area and - - -

DR PHILLIPS: Yep.

DR CRAUFORD: - - - and what we might need prior to mining being able to - - -

DR PHILLIPS: Yep, okay.

DR CRAUFORD: - - - to commence, and my apologies for not being - - -

DR PHILLIPS: No, no that's okay, no.

DR CRAUFORD: - - - specifically clear in my questioning.

DR PHILLIPS: No, and I guess that also relates back to the relative impact of the toxicity – the potential toxicity versus all the other things that are happening and as I said earlier, we acknowledge that the effects of sedimentation the actual, you know, the sediment plume and also the destruction of the habitat itself, we predict it'll be much far greater than any toxicological effects.

DR CRAUFORD: So you're still not suggesting to me then that there needs to be limits set prior to any mining taking place?

DR PHILLIPS: I think there needs to be – the consents need to be around the monitoring and using the existing limits if you – well, I wouldn't call - - -

DR CRAUFORD: Right.

DR PHILLIPS: - - - "existing guidelines".

DR CRAUFORD: So if the existing limits are then exceeded through that monitoring process what would you suggest then needs to occur?

DR PHILLIPS: Yep, so that's when that's – and that's getting back to the whole thing of applying the ANZECC guidelines appropriately and the ANZECC guidelines will say, "If they are exceeded you need to do further investigation". Now what that could be, that could be anything from additional monitoring to see if you're getting continued release, continued exceedance or if it's just a one-off, and then it – and then if you're getting continued exceedance what's the next step after that? And that could be, that's when – well, it could mean lots of things.

DR CRAUFORD: Okay, thank you.

DR PHILLIPS: But – yes.

MR JOHNS: Hello, Dr Phillips.

DR PHILLIPS: Hi.

MR JOHNS: My question relates to your paragraph 31.

DR PHILLIPS: In?

MR JOHNS: In your - - -

DR PHILLIPS: My evidence?

MR JOHNS: - - - evidence this morning.

DR PHILLIPS: In the summary of evidence summary?

MR JOHNS: Evidence of summary, yes.

DR PHILLIPS: 31, yes.

MR JOHNS: Yes. And it's really to help me understand really how uranium, well I guess "accumulates" in the food chain because I think it's well known that mercury does.

DR PHILLIPS: Yeah.

MR JOHNS: And I know this from years of fishing.

DR PHILLIPS: Yep.

MR JOHNS: So I'm just wondering just, I'm just wondering whether that's the same with uranium.

DR PHILLIPS: No, mercury acts in a very different way from uranium. Uranium and mercury are what they call "biomagnifies" so it increases as it goes up the food chain.

MR JOHNS: Right.

DR PHILLIPS: Whereas uranium doesn't do that. It does – it does get taken up, the uptake rate in the body, depending on the species - obviously we're talking very, very broadly here – can be – is generally reasonably slow, it does get taken up, and it also has been shown to be transferred in freshwater fish from mothers to eggs.

So it does happen but it is completely different to mercury, and I've done quite a lot of work on mercury in rivers and lakes – Rotorua lakes I know a lot about it as well, yeah.

MR JOHNS: Right. Okay, so in order for it to become an issue, at what sort of level would it have to accumulate or be taken up if you will?

DR PHILLIPS: Well, that's the thing, there's no information - - -

MR JOHNS: Right.

DR PHILLIPS: - - - around, yes, so – yes, so, so - - -

MR JOHNS: Okay.

DR PHILLIPS: - - - that's a big gap in knowledge basically.

MR JOHNS: Okay, thanks very much.

CHAIRPERSON: Thanks. I'd just make the comment that these uncertainties and where there are differences of view, those differences of view and the information gaps are going to pose an interesting challenge for the conditions and adaptive management experts when they come into their own later in the hearing.

DR PHILLIPS: Sure.

CHAIRPERSON: The only notification of questions is from the applicant, Mr Winchester.

MR WINCHESTER: Thank you, sir. Good morning, Dr Phillips.

DR PHILLIPS: Good morning.

MR WINCHESTER: Just initial question, the summary of evidence you've presented this morning does that take into account the outcomes of caucusing or is it more a distillation of your written evidence?

DR PHILLIPS: Yes it does take into account - - -

MR WINCHESTER: It does?

DR PHILLIPS: - - - the caucusing, sorry.

MR WINCHESTER: Now, as I understand it - - -

DR PHILLIPS: Sorry, can I just clarify that? What I mean is that, subsequent to caucusing there was a slight change amendment to my evidence, and so the summary reflects that change.

MR WINCHESTER: Yes, yes, no I understand that - - -

DR PHILLIPS: Okay.

MR WINCHESTER: - - - but it doesn't go further and necessarily reflect what you agreed or disagreed in caucusing.

DR PHILLIPS: No.

[9.50 am]

MR WINCHESTER: Thank you. Now, your concern, to put it bluntly, is about what comes out of the pipe in terms of the return sediment and the processed material?

DR PHILLIPS: Compared to what goes in?

MR WINCHESTER: Yes.

DR PHILLIPS: Yes.

MR WINCHESTER: Yes, so it's the toxicity and the impacts of what comes out?

DR PHILLIPS: It's the toxicity associated with the change in the composition of the material that goes in versus what goes out.

MR WINCHESTER: Thank you. I've just got a question then about an answer you gave, I think to Dr Ryder, and you said that the effects in terms of what comes out are going to be most likely in the pelagic zone?

DR PHILLIPS: Well, yes, it was in the context of Dr Ryder talking about the fact that the seabed will be completely destroyed, so, yes.

MR WINCHESTER: So in that context, what we're concerned about is whether the plume enters that pelagic zone, aren't we?

DR PHILLIPS: Sorry? I mean of course it will enter the pelagic zone because it's just going to be distributed out into the water column.

MR HILL: Sorry, I'm having difficulty in hearing either of you.

DR PHILLIPS: I'm sorry.

MR HILL: Can we do something about the speaker?

MR WINCHESTER: Have you looked at any reports about the extent of the plume?

DR PHILLIPS: I've looked at Deltares' reports, yes, that were submitted, yes.

MR WINCHESTER: Right, thank you.

Can I just take you to your summary of evidence and paragraph 30, and you register a concern there about a significantly greater potential toxic effect of mining in comparison to 30 minute elutriate tests, but that's essentially what you're saying?

DR PHILLIPS: Yes, keeping in mind that mining is not just a disturbance of the seabed, but the processing and return of the material which are defined in point 13 of my submissions.

MR WINCHESTER: Yes, thank you. Isn't it the case though that what you're going to get pretty quickly when material is discharged out of the pipe is quite significant dilution, and that that dilution is going to increase significantly as the plume spreads?

DR PHILLIPS: Well, yes, based on the modelling there will be some dilution, obviously you're putting it into the environment, but it's not just what's happening when it gets dispersed out into the environment.

MR WINCHESTER: Yes, thank you. If we're thinking about not necessarily the level of toxic material coming out of the pipe, but rather the effect, isn't the difference in effect going to be really rather small compared to the elutriate testing?

DR PHILLIPS: Well, I think my point was that we don't know what the characteristics of the elutriate that's coming or the sediment, the material that's coming out the end of the pipe is compared to – we don't know anything about it compared to what was used in the elutriate tests.

MR WINCHESTER: Thank you. Can I just take you to your primary statement of evidence, and I'd just like to clarify a couple of matters. Paragraph 14, the second part of that paragraph, you suggest that water used to discharge the processed sediment will be derived from the surface rather than near the seabed. Do you still understand that to be the case?

DR PHILLIPS: No, that was an oversight actually, no, that's correct. Mr Kennedy explained that in caucusing actually that that won't be happening, that the water will be pumped through in a continuous process.

MR WINCHESTER: Yes, okay, and just for the record I think that's repeated at your paragraph 31.

DR PHILLIPS: Yes, sure.

MR WINCHESTER: Thank you for that. Now, in terms of the concern about ecotoxicology being a consequence of sediments being disturbed, mixed with the water column and then returned into the environment, are you aware that trawling activity is widespread on Chatham Rise and generates a significant sediment plume?

DR PHILLIPS: Yes.

[9.55 am]

MR WINCHESTER: Have you read Dr Tuck's evidence at all?

DR PHILLIPS: I might've briefly looked at it. It wasn't so relevant to me because I wasn't considering the suspended sediment issue.

MR WINCHESTER: Right. That activity though would release trace elements of concern into the water column, wouldn't it?

DR PHILLIPS: It's not an area that I've looked at.

MR WINCHESTER: Okay. Can I just take you to your paragraph 30 in your statement and this issue about the elutriate tests and their reliability or their ability to mimic the mining process, that's your concern, isn't it?

DR PHILLIPS: I don't have a problem with the elutriate test at all, no, I've never said that I didn't think the elutriate testing process was inappropriate, it's the material used in the elutriate tests and what they represent, that's my issue.

MR WINCHESTER: I see. So when Mr Kennedy ensured that there was 24 hour shaking to try and best represent the mining process, you would accept that that's, based on what we've got available to us, a reasonable approach?

DR PHILLIPS: Yes.

MR WINCHESTER: Can I take you to your paragraph 36 and on page 10 you make the statement there, with regard, I think, to your figure 3, for arsenal, nickel, lead and molybdenum, the concentrations are highest in the fine sediments. Are you actually referring to the nodules rather than the sediments?

DR PHILLIPS: No, I am referring to fine under the definition under the graph, it says fine, less than 8 mm CR phosphorites.

MR WINCHESTER: I see, but it is the phosphorite nodules rather than the sediments?

DR PHILLIPS: That was the data that was presented in the report, yes.

MR WINCHESTER: Thank you. So when you say then the composition and metal concentrations of the processed material could be substantially different from the host sediment, what do you mean by that?

DR PHILLIPS: The host sediment is the term that was used in Golder's report, so the host sediment is, as you can see under the graph in the legend, it says host sediment is surface and subsurface.

MR WINCHESTER: Yes. And you're not suggesting that the concentration of any of the elements that you've described will increase, are you?

DR PHILLIPS: No, I'm not suggesting that increase, I'm suggesting they could be different.

MR WINCHESTER: Right. And different in the concentration is only likely to go down, isn't it?

DR PHILLIPS: No, I won't say that, no.

MR WINCHESTER: No. Can you turn to your paragraph 38 please, and you make a statement at that paragraph that it's unclear what the chemical composition of the return material will be in comparison to the mined material. That's not really going to be the case is it, because the sediment that's being returned is that which is less than two millimetres in size, so it's going to be the same particle size range as used in the analysis, isn't it?

DR PHILLIPS: No, the analysis went up to whatever I show here, greater than eight millimetres, so no, the elutriate tests were conducted on sediments that were quite variable in composition, sediment size particle size composition, so no, that's not the case at all, no.

MR WINCHESTER: And you understand what's going to be retained on that - - -

DR PHILLIPS: What is going to be returned is anything less than two millimetres.

MR WINCHESTER: Thank you, yes.

DR PHILLIPS: Which is quite different from what was used in the elutriate tests.

[10.00 am]

MR WINCHESTER: Yes. In terms of your concern about not using water from the Chatham Rise to conduct the elutriate test, I think Dr Ryder asked you about a couple of questions about that.

Do you understand the reasons why water from the Chatham Rise couldn't be used to conduct the tests?

DR PHILLIPS: Well, no, I mean, I don't recall it being actually presented in a report as to why those water samples weren't used, but just that they were used. And in fact, the water sample – sorry, did you say water sample or sediment water sample?

MR WINCHESTER: Water samples.

DR PHILLIPS: The water sample used in the elutriate test was actually a Raglan because the Chatham Rise – the sample collected from the Chatham Rise was contaminated I think with zinc, so they couldn't actually use that one anyway.

MR WINCHESTER: Yes, that was the purpose of my question, that the Chatham Rise water was contaminated, wasn't it?

DR PHILLIPS: But they are not sure why it was contaminated.

MR WINCHESTER: Yes. And in terms of determining the effects or the difference in terms of the outcome of the testing, what is the difference that you can point to in terms of using different water?

DR PHILLIPS: I think the Raglan – I think it is a minor issue and that is why I didn't highlight it any further, but in terms of following the US EPA protocol, the US EPA protocol specifically talks about using, it requires water from the area that is going to be mined and sediment from the area that is going to be mined.

MR WINCHESTER: Yes, and that can all be addressed through a condition and it can and will be undertaken if mining commences, so you will actually be able to use the sediment and the water and do the testing when the mining occurs. Do you understand that?

DR PHILLIPS: I haven't seen yet – there is nothing in the mitigation which talks about monitoring or doing testing for water quality as yet which is why we put it into our joint statement.

MR WINCHESTER: Yes.

DR PHILLIPS: I was just saying that there is nothing in the current mitigation part of the report of the AEE which talks about doing water quality monitoring, beg your pardon.

MR WINCHESTER: But that is what you have recommended and from your perspective it is easily doable, isn't it?

DR PHILLIPS: I haven't been out on the ship to the Chatham Rise, so I don't know how easily doable it is, but my understanding from talking to other NIWA scientists when I've been there is that it is a fairly routine sort of thing to do.

MR WINCHESTER: Thank you. Paragraph 69, please Dr Phillips. That is referring to your figure 3 early in your evidence which I think is back at page 10 - - -

DR PHILLIPS: Can I just point out that the sediments used for the toxicity tests are not the same as the ones that were used for the initial elutriate test that Golder did?

MR WINCHESTER: It is really just for the sake of clarification. You say that that figure, figure 3, shows differences in the metal concentrations of a number of metals in the different sediment layers - - -

DR PHILLIPS: Mhm.

MR WINCHESTER: Doesn't it actually just show the concentrations in sediment and nodules?

DR PHILLIPS: The nodules are part of the sediment that was used in the elutriate tests.

MR WINCHESTER: I think you have repeated it in your summary statement at paragraph 28 where you talk about effects of a hundred percent concentration of elutriates from two of the tree sediment samples elicited toxic responses in bacteria.

Is that correct, based on your understanding of the reports, in fact, two of the three samples did not elicit toxic responses in bacteria.

[10.05 am]

DR PHILLIPS: Sorry, are you referring to something in my evidence and something in my summary, or?

MR WINCHESTER: Well, it is in both. It is in your summary at paragraph 28.

DR PHILLIPS: Yes.

MR WINCHESTER: And I believe, let's see, paper war, your paragraph 83 in your main statement.

DR PHILLIPS: So it is the same thing, it is saying that yes, they are exactly the same sentences.

MR WINCHESTER: Yes, and my question is, is it your understanding that two of the three samples, the bacteria samples, did not elicit toxic responses?

DR PHILLIPS: No, it specifically says that they elicited a toxic response.

MR WINCHESTER: Yes, and had you read the relevant NIWA –this is based on the relevant NIWA report, is it?

DR PHILLIPS: Yes, I certainly went through it with a fine tooth comb and if you read through the actual data reports that are presented, how they calculate the toxicity test results, if you look into those in fine detail, you will see that there are actually responses there that were not in the main part of the report, toxicity report.

MR WINCHESTER: And you don't recall off the top of your head, where those results are recorded in the NIWA reports, is it table 2, 31 and 32?

DR PHILLIPS: I will have to see whether I referred to it in my – my reference 22, C4, - I am just reading through my evidence, it looks like in table C4 of the Hickey Report.

MR WINCHESTER: Thank you. Can I just turn to the caucusing report, I just want to ask you a few questions about that? Just so I'm clear on some of the answers you have given this morning.

DR PHILLIPS: Sure.

MR WINCHESTER: In terms of the toxicology tests that have been conducted on the three year old frozen material, I think you agree, that it is sourced material, the fact that it has been frozen is not a major issue?

DR PHILLIPS: Yes, I agree with that.

MR WINCHESTER: And if you were able to do similar tests or repeat the same tests on fresh sediment using the seawater, you could do that post this decision, that is something that could be done after a decision came out and before mining commenced?

DR PHILLIPS: I think that is what we suggested, I should point out that taking into account the criticisms that were made about the toxicity tests per se in the choice of species, so questions would need to be made about whether those species were the most appropriate ones to use.

MR WINCHESTER: Yes. Can I just ask you to turn to Issue 3 and it is just about this disagreement expressed by Mr Peake about the amount of time that might be taken to do research on relevant species?

What sort of research programme do you think is going to be needed to implement your recommendations and how long would it take?

DR PHILLIPS: I think – that would be a little difficult for me to say just off the top of my head, it would be – I would imagine it would be a PhD topic, but there is a whole lot of other sort of questions that would need to be asked before you got into it, like how you actually even culture samples in animals that may be from the Chatham Rise, so there are a whole lot of questions that need to be answered.

[10.10 am]

So at least a PhD I would have thought which would be three or four years, but I certainly wouldn't want to say that that is all that needed to be done. I don't – we didn't go into that sort of detail.

MR WINCHESTER: Right.

DR PHILLIPS: I think the research came out of a recognition that for the reasons that Dr Ryder brought forward about the realities and the practicalities.

MR WINCHESTER: And had you thought about things like how relevant species can be recovered and preserved and laboratory tests?

DR PHILLIPS: Yes, like I say, there are a whole of questions that need to be asked before you could even do a toxicity, even think about doing a toxicity test on those kind of species.

MR WINCHESTER: Thank you. Just a final question and it's about – I think it is issue five – no sorry, it is issue six, and it is around trying to derive a guideline value or toxicity threshold for uranium in the marine environment.

Given that it is, as you say, I suppose it hasn't been done before, or it doesn't appear to have been done before, who do you think should lead this exercise. Should it be Government led?

DR PHILLIPS: No, and that is why we are suggesting it – that is why we made a suggestion, sorry, that is why we have made a suggestion about it here.

MR WINCHESTER: Right.

DR PHILLIPS: That this is something – I guess our feeling was that this is potentially something that could be funded by CRP as a leader in this field of this kind of mining where this is potentially an issue.

MR WINCHESTER: I guess my question is, even assuming CRP does that, it can't make a decision about what the appropriate value is or how it is translated into regulation, can it?

DR PHILLIPS: No, there is a process that you can – so the idea is not necessarily just to provide a – one number, there is a process that is applied to the – there is a way of deriving a threshold, a toxicity threshold, an internationally accepted way of deriving a toxicity threshold which requires undertaking toxicity tests on a minimum number of species.

I would see this as being a great opportunity for international collaboration. Yes.

MR WINCHESTER: Okay, and in terms of a product that comes out of it, can you advise what that is, is it something that is set by a New Zealand regulation or is it an international guideline through a representative agency?

DR PHILLIPS: I would see it as being something that would be integrated into the ANZECC guidelines which are the New Zealand Australian Guidelines and probably if we were using the same kind of approach, you would have three different levels of protection of species, 95, 99, that sort of thing. So – yes.

MR WINCHESTER: And is it your experience that private organisations usually lead such exercises and initiate changes to these guidelines?

DR PHILLIPS: I guess it depends on what you mean by 'lead', I think if it is a leader in the funding cycle I mean, obviously, they can't actually do the research so will actually have to fund that research to be done.

MR WINCHESTER: I see - - -

DR PHILLIPS: Yes.

MR WINCHESTER: - - - and, I suppose, do you have any idea about timeframes, how long it would take to get through the process?

DR PHILLIPS: No, I think you should talk to Paul Kennedy about that. They are currently revising the ANZECC Guidelines, the ANZEECC Guidelines are currently is 2000 and they are currently revising them. I think they started revising them about five years – five years ago - - -

MR WINCHESTER: Yes.

DR PHILLIPS: - - - and they are still going, so it is not a fast process.

MR WINCHESTER: But in terms of the research necessary to underpin any changes, how long would that take, do you think?

DR PHILLIPS: Well, this could also be part of a PhD perhaps or some sort of research project like that, so - - -

MR WINCHESTER: Thank you, yes thank you, Dr Phillips, that's all, sir.

CHAIRPERSON: Thanks Mr Winchester, does any other party wish to address a question to Dr Phillips. If not, I would say thank you very much, Dr Phillips - - -

DR PHILLIPS: Thank you.

CHAIRPERSON: - - - much appreciated.

DR PHILLIPS: Sorry about the - - -

[10.15 am]

CHAIRPERSON: And the next witness on my list is Professor Barrie Peake who is called by Mr Currie on behalf of Greenpeace/Kiwis Against Seabed Mining and the Deep Sea Conservation Coalition, Mr Currie.

PROFESSOR PEAKE: Thank you, Mr Chairman.

MR CURRIE: I'll just introduce you, Dr Peake, so you're an Associate Professor, Dr Peake, at the University of Otago, is that correct?

PROFESSOR PEAKE: It is.

MR CURRIE: Thank you, and will you please just read your, I think you're going to give a summary are you of your evidence and then you are going to remain to answer questions.

PROFESSOR PEAKE: Yes, thank you - - -

MR CURRIE: Thank you.

PROFESSOR PEAKE: - - - thank you, Mr Currie.

My name is Barrie Peake, I'm an Associate Professor in the Department of Chemistry at the University of Otago where I've worked since 1972. I've undertaken extensive research on a broad range of

topics related to marine and freshwater chemistry both in New Zealand and overseas. I hold a Bachelor of Science with first class honours in Chemistry and a PhD from the University of Canterbury New Zealand.

Now my research includes investigations of the levels of trace metals and a range of New Zealand aquatic organisms, including dredge, bluff oysters, scallops, cockles, greenlipped-mussels and marine collected from a variety of sites within New Zealand.

What I haven't included here, is I've also undertaken research and published a lot on the trace element and nutrient distribution in various freshwater and natural waters and I've looked at the effects of pollutants such as aromatic hydrocarbons and trace metals in stormwater and estuarine environments.

I have published 45 research papers on a wide range of aspects of natural aquatic chemistry and supervised 42 Masters and six PhD theses on this topic.

I'm a Fellow of the Institute of Chemistry, I'm also a certified independent RMA Decision Maker Resource Consent Commissioner, I've been consultant for a number of situations, I've also been the Minister of Conservations appointee on Hearing Committees concerning restricted coastal activities.

I confirm that I've read the Code of Conduct for Expert Witnesses as contained in schedule 4 and the Judicature Acts 1908 and the Environment Court Consolidated Practice 2011.

I agree to comply to these Codes of Conduct except where I state otherwise, this evidence isn't within my sphere of expertise and I've not committed to consider material facts that are known to me that might alter or detract from the opinions I express.

I have also read the transcript of the proceedings of this hearing last week and the specific comments about expert witnesses that had been careful not to take sides with the parties that they're representing or present evidence in that and I will do my best to abide by those comments.

I think my evidence – I haven't prepared a written summary as such, but as it stands in the basic document presented on my behalf, also Minister Currie in his presentation also summarised I think very clearly my views on a number of these aspects.

If I can summarise and say that I am a Water Chemist, and so my primary interest is in the nature of the elements and the concentration of them and the speciation and the chemical forms of those elements that occur in the water column, in sediments and also in marine organisms.

What I'm not an expert in, is the mechanism of uptake of these trace metals into those organisms that give rise to the levels that I and my research group have measured. I'm also not an Eco-toxicologist either and so – but of course that overlaps a little bit with when you do have concentrations in biological species, you then naturally say, "Well are these above the toxicological limits", so to that extent I do overlap with that area.

[10.20 am]

I guess and summarised in my evidence, my basic concern is the lack of baseline data on the quality of the elemental composition of the water column through the proposed mining area. If one is going to measure, assess the effect of a mining activity you must know what the quality of the water is before you start mining, and I do not believe that the applicant has provided adequate evidence for what that quality is, only then can you judge subsequently when mining starts at some particular degree with the effect you are going to have, so I guess that's one of my primary concerns.

I was also asked to look specifically at the situation regarding uranium and as Dr Phillips has pointed out and in the summary of our evidence there, it's very clear that there is no accepted or published values for the toxicity of uranium in the marine environment, there is evidence for the freshwater environment and the panel, hearing committee may well wonder why that is, and the reasons are very practical, that the toxicity measurements have been driven by need and the measurements have been made in relation to the release of waste water from nuclear power plants, which is typically into a freshwater environment. There has not been perceived anyway the need to make measurements in a marine environment, so that's the reason why there are no known or accepted values for toxicity in the marine environment.

Obviously from the measurements that have been made of the elemental composition of uranium in the sediments that are going to be mined, they will be discharging at an elevated level. This doesn't mean there's literally tonnes of uranium that are going to be discharged, but relatively they are increased over the background levels of uranium, so in my mind the question is are these pose a toxic risk to the major pelagic species that are in the Chatham Rise area.

Now, tests have been done, NIWA tests, on three species but these are not the major species that are present on the Chatham Rise, and I have another question then as to how appropriate are the species that have been tested compared to what is on the Chatham Rise, the major commercial species, hoki, ling, orange roughy and wharehou. So I believe that it is necessary to establish a uranium toxicity level for those species and then compare that with the maximum – well, a starting point would be the maximum possible level of uranium that would be discharged after processing on the ship.

So I see it as two extreme end members. If we assume that all of the uranium that is present in the sediment is available to be taken up by the fish, that's one end member, the other end member of this process is the natural background level of uranium. So if you're starting off to look at the toxic effects of the uranium, you would establish the toxicity for those four fish species and compare that with the maximum possible level of uranium that could come from the sediment.

If that was within some, ecotoxicologist or ethotoxicologist who specifically deals with toxicology of fish, if the levels in the sediment were within perhaps a factor of 10 or 100 of the toxic limit, then at that point you would need to undertake further investigations as to what proportion of that sediment uranium will end up in the water column, also the speciation, and by speciation I mean the oxidation state, whether it's uranium oxide or just what form it's in, because the uptake depends upon the oxidation state, the form of the uranium, both its oxidation state and also it's molecular complexes.

So in terms of my understanding, Mr Chairman, you know, of adaptive management and the notes you made from last week there, I believe that this – well, it's not simple, but I mean this step of measuring the toxicity for the four pelagic species, comparing it with the total possible uranium content in the water at the point of discharge from the discharge pipe, must be done before any mining starts. It may well be, and this is a value judgement on my part, that those levels that are discharged from the pipe are very much less than the toxic levels, in which case then you could then proceed with some limited degree of mining and so forth there. But if they're not, then I don't think any mining or any shape or form should take place.

[10.25 am]

So, Mr Chairman, that's a summary – well, I also have a couple of other concerns here that I raise and that Mr Currie also raised on my behalf. This is the time at which fish pelagic species in the plume

would be exposed to elevated levels, this time, this temporal element, I couldn't find that in my reading of the modelling report there, and of course, I mean if the plume takes half an hour or an hour or a couple of days to dilute, then that would determine or have a big effect on the uptake of any elevated levels by those fish, and so I think that is an element, the time factor, that is missing from the modelling reports there.

I'm also concerned about the sensitivity of the model in terms of the height at which the discharge pipe is above the seafloor. Now, it's specified as 10 metres, but in reality I can't imagine, given the conditions that exist in the Chatham Rise, that it's going to be very difficult practically to maintain 10 metres, and if the model suggests that if it rises to 20 metres, the plume changes its shape, the time at which it takes to disperse changes, then that may be an issue there, and I think that's something from my reading, Mr Chairman, the variability and the height and how that's going to be controlled has not been covered in any of the evidence.

Initially I was concerned about the effect of sunlight on the chemistry of the water that's discharged, but then of course somebody pointed out that that's in the dark, it's deep down, so any phytochemical effects would be negligible but there will be some seasonal variation in the water chemistry even at that depth, and I'm not sure whether the applicant has looked into seasonal variations in the water chemistry.

There will also be, and this overlaps with chemistry in explaining trends and chemical values, there will also be a temporal variation in the physical oceanography of the area, the currents at the height just above the seabed there, and I'm not sure whether the applicant has really addressed the physical hydrography, the variation of physical hydrography with time and that would require measurements just above the seabed.

So, Mr Chairman, I think that's a summary of my views.

CHAIRPERSON: Thanks, Professor Peake.

MR HILL: Thank you, Dr Peake.

I guess it's a question that we'll hear quite a bit of today, which is how long temporally is this piece of string. I mean, in terms of the – I mean can you give an envelope as to the time it would take to institute the, if I can call it that, sort of the pre-mining baseline establishment and then subsequently the sort of steps it might go through?

PROFESSOR PEAKE: This is the time to do this testing there?

MR HILL: I mean, it obviously comes down to how realistic is it to put in place a programme of research effectively to get to a point where you might then have some confidence that you can commence mining and then having commenced the sort of incremental steps that you would need then to tick off as you go through as you referred, your adaptive management steps.

PROFESSOR PEAKE: Well, I think that the time involved in establishing the toxic limits, that's a question that an ethotoxicologist would have to answer. It wouldn't be sure - - -

MR HILL: You will appreciate that every time we ask a question like that it's referred to somebody else. I'm not sure we have a circle which is capable of closure on this one.

PROFESSOR PEAKE: Yes, I appreciate that. I could say, from a chemical perspective, it would not be straightforward, but certainly it could be done. I mean another issue which I haven't raised of course is the toxicity for different stages of the lifecycles of these pelagic species, it could be that the larval stage is more sensitive to uptake than the adult, which would be an added complication there. No, I really could not comment on the time it would take.

[10.30 am]

Mention is made of, you know, a research collaboration involving a PhD student but having supervised PhD students and masters students, including one here on my left, it takes much longer than you plan and I would suspect that it would be better research that's done under contract rather than as a PhD student.

MR HILL: Well, thank you.

CHAIRPERSON: Could I just ask a supplementary, so you are saying that to get the right species that would give you better information and to do it on the Chatham Rise itself, which is what you are suggesting to get the baseline background data, you can't give an estimate of how long that might take?

PROFESSOR PEAKE: No, I mean biological species can be collected there and certainly my experience in my research group collected ling taken from the southeast of Stewart Island there and I mean that was commercial fishery boats collected there. Mind you they were dead because we were just analysing the elemental composition but it would

take some time but it certainly could be done. What will be a lot more difficult is collecting samples for accurate trace metal analysis and that will be particularly important because if you are going to judge any change then your starting point has got to be trace metal clean and my laboratory has gone to inordinate lengths to lower the limit of detection and get accurate values there.

If you contaminated your sample for background and then you made a measurement, say with an elutriate, then it may be that adding the elutriate would only make a small difference to an erroneous background signal whereas if the true background was measured under careful trace metal free conditions, which can be done and certainly is done in my laboratory at the University of Otago, you could be sure that you were looking at a genuine change.

CHAIRPERSON: Thank you. Greg?

DR RYDER: Good morning, Dr Peake. I am wondering if you can give us a feel for the level of risk you see with this issue of uranium bioaccumulation. I see at paragraph 15 of your evidence you talk about the concentration of uranium sediment and, you know, if you assume that is all removed up to the vessel and then brought back down again and then discharged and diluted into the water column and then all of that is available for uptake by marine species and if you accept the plume modelling, as described in the applicant's witnesses evidence, about the level of dispersion and the concentration of uranium that might be in that, are we talking about a great deal of risk here to marine species or are you saying that we just don't really know enough about that?

PROFESSOR PEAKE: I think I am saying that we don't know because there is no uranium toxicity threshold that has been established anywhere in the world for any marine species, we really don't know. If I was asked to give an opinion we are the only people that have measured uranium content of ling anywhere in the world and the uranium levels were very low - this is in the flesh of ling collected off the southeast of Stewart Island – which would suggest then that there is no bioaccumulation, no biomagnification of uranium at least in that species in that area there. So if one was to extrapolate those results to the Chatham Rise then I think there probably would be no cause for concern but in the absence of a value we just don't know both in terms of toxicity and also the background content of uranium in those four pelagic species at present, you know, before mining starts. It's not just known and that should be established.

DR RYDER: Thank you for that. The importance of initial dilution of the discharge, I think you mention at paragraph 10 of your evidence about the 2000-fold dilution in the wider field. Am I right in thinking that dilution is important but it wouldn't necessarily satisfy you one way or the other if dilution was greater? The fact is that this chemical has potentially become available in the wider marine environment for uptake by species would still be an issue of concern to you regardless of that level of dilution?

[10.35 am]

PROFESSOR PEAKE: Yes, it is still of concern, I mean ultimately it will return, it will mix. You won't be able to distinguish it from the background and the distance of the plume is really irrelevant, I think it's really the time it takes to disperse that will determine the extent of exposure of fish that are swimming in that area to those elevated levels.

DR RYDER: So you have given your view on why there are no guidelines for uranium in the marine environment, are you saying it is purely driven by need and that there has been no need for such guidelines given the focus has been mainly discharges to freshwater environments?

PROFESSOR PEAKE: Yes, I mean the Canadians, for example, all of their nuclear power plants are on rivers and so they have been primarily concerned with the immediate discharge from the plant into the freshwater river. So that would be my understanding of why there haven't been anything like the extensive studies for marine species as there has been on freshwater species.

DR RYDER: So, just finally, your paragraph 22 where you have asked some questions about monitoring, and was that addressed further in the expert conferencing a bit more specifically those questions?

PROFESSOR PEAKE: I guess, I mean as a final issue there I just got thinking, "Well, in any resource consent conditions what would they specify specifically about monitoring the ongoing trace metal content of those four predominant pelagic species?" I added that into my evidence, it really wasn't addressed in the caucusing there, we really didn't get onto possible conditions that might cover our areas of concern.

DR RYDER: So if there were to a programme of monitoring uranium in those species you mentioned, particularly those commercial fish species, given the fact that they are quite mobile would you be able, do you think, to be able to distinguish if there were increases or if the levels of uranium were elevated to determine whether there that was due to the

operation of the mining work or some natural elevation? I mean do you think it would be possible to distinguish the CRP operation from other potential effects?

PROFESSOR PEAKE: Well, I guess if you did get an increase you would have to compare that with the background and this is where I don't think there has been adequate spatial sampling, a variation in the sampling of either the sediment or the water column. The question of how much do fish migrate, I guess that's a fish biologist and there are people far more expert than I am that could comment on that. It could be an issue but if the fish migrated significantly away from the mined area there then that would only lower, wouldn't it, you would get a lower value than if they had been concentrated in the plume where there is elevated.

DR RYDER: Well, we wouldn't know though, would we?

PROFESSOR PEAKE: No, you wouldn't, but you would expect it would be a bit lower there.

DR RYDER: I can just see a few issues there with apportioning blame, if you like.

PROFESSOR PEAKE: Indeed.

DR RYDER: Thank you.

DR CRAUFORD: Yes, thank you for the explanation as to why there is no information on uranium for marine species, your explanation of radioactive plants and so forth makes it obvious when you know but when you don't it's not obvious. I was wondering though whether any analogies or learnings from experiments that have occurred in freshwater species, whether we could draw any analogies to the marine environment?

[10.40 am]

PROFESSOR PEAKE: Well, I guess from a biological perspective you would need to talk to a fish biologist there about extrapolating freshwater results to marine, that's a fish biologist. It is a different environment the marine environment, the chemical composition, you have got these major irons, you have got a high salinity, you have got the presence of sodium, calcium, magnesium and all these other irons. So that may well make the uptake different in a marine environment from what it would be in a freshwater environment where you don't have those major iron composition. So from a chemical perspective I would

suspect there would be a difference and the uptake mechanism would be different in the marine environment but in terms of different species from a biological perspective I couldn't comment.

DR CRAUFORD: So not even to the extent of going back to Dr Ryder's question of how much of a risk is this really? I mean you have said that we really don't know the impact on fish and we can't draw any analogies, you don't think, from the freshwater environment as to what those impacts might be?

PROFESSOR PEAKE: No.

DR CRAUFORD: Okay, fair enough. In terms of the height of the plume I think we were told, if I am right, that the discharge was likely to be plus or minus two metres, is that right, two metres I think that was correct, with a mean of about 10 metres above the seabed, would that still give you concerns as to the changes in the plume?

PROFESSOR PEAKE: Yes, if it has been stated in the modelling report I was sort of unable to work out just what the sensitivity is to the discharge height but having been out on the Chatham Rise and seen the swell the practicalities of, you know, keeping them in more than 10 metres I think are almost impossible. And so it comes down to the sensitivity of the modelling and that's an issue which the radiochemistry group were concerned about, the uncertainties associated with many of the estimates that came out of the modelling there.

DR CRAUFORD: Thank you very much.

CHAIRPERSON: Okay, CRP I think has some questions.

MR HARWOOD: Good morning, Dr Peake, the first question relates to paragraph 16 of your evidence, if you have got that handy, and it relates to determining toxicological levels for pelagic fish. Did you raise that issue in conferencing?

PROFESSOR PEAKE: Yes, I did and I think it's sort of covered in issue – well, probably issue 5, "There is an absence of baseline data on bioaccumulation". Yes, and issue 3, "Were the three species used in the toxicity testing appropriate for the proposed mining?" So I guess the issue was raised and I did have an opportunity to comment on that.

MR HARWOOD: And did the agreed outcomes in terms of draft conditions and the suggested research satisfy your concerns?

PROFESSOR PEAKE: Well, I agreed. Well, it depends on what you call "research" but I mean I agreed that an investigation was required to establish toxicity levels for those fish but I wasn't happy with the wording of the expert opinion conclusion there. Well, in fact it's the draft conditions there and that's why I asked to specifically disagree because my concern is that if this research extended over a long period of time and mining had started what would happen if there were some alarms raised from the results of that research.

[10.45 am]

MR HARWOOD: Thank you. You talked about risk earlier, in terms of elevated levels of uranium would you agree that once uranium levels reach background levels but through dilution the risk is gone?

PROFESSOR PEAKE: So once they reach background levels?

MR HARWOOD: So once the uranium that comes out of the pipe is diluted such that it's at natural background levels, does the risk posed to pelagic fish no longer exist?

PROFESSOR PEAKE: No, it wouldn't because that's the uranium content of the environment which the fish live in. The question is though it is elevated from the moment that it's from the discharge pipe for a given distance, spatial distance, and also for a given period of time and so the question then is how long is that elevated and is that sufficient time for a significant uptake by any of the four pelagic species.

MR HARWOOD: An important part of that is also how far or the scope of that distance where uranium levels are elevated to, isn't it?

PROFESSOR PEAKE: Yes.

MR HARWOOD: And are you aware that dilution of uranium to background levels occurs within the near field within 250 metres of discharge?

PROFESSOR PEAKE: Yes, well, the modelling would suggest it. I mean ideally it would be nice to do some pilot studies and actually to - I guess you could use dye studies to actually establish the accuracy of the distance but that would be almost impossible, you know, in the environment there so I guess modelling probably is the only practical solution there.

MR HARWOOD: Thank you, and so we are talking about any pelagic fish that encounter the plume within that sort of 250 metre circumference –

well, actually it would be closer, wouldn't it, because at 250 metres I think dilution is something like 750 times?

PROFESSOR PEAKE: (No audible response)

MR HARWOOD: Thank you. And within that tight area there would also be elevated levels of TSS, there would be a sediment plume, there would be other reasons why fish might avoid that area, would you agree with that?

PROFESSOR PEAKE: I couldn't comment on the behaviour of fish in elevated sediment plumes.

MR HARWOOD: And in terms of a population level effect on fish species, given the Chatham Rise is rather large and there is millions of individual hake and hoki present on the Chatham Rise, the chance of a population level toxicological effect from uranium must be low given the small size of the area where elevated uranium would occur?

PROFESSOR PEAKE: Well, Mr Chairman, through you, I mean I don't want to duck for cover here but that is a question for a fish biologist in terms of population and density there. I mean there is sufficient density to warrant commercial fishing so I guess there must be enough there for a given square metre or square kilometre there to possibly be a potential risk but I think that's really a fish biologist who would have to comment on density of fish.

MR HARWOOD: I am just interested really in the scale of the potential toxicological effects because if what you are saying is right that the uranium levels are high enough to cause an effect only within a small distance from the discharge pipe and if fish species occur over a very vast area we are only talking about this small number of fish that would encounter that area of elevated uranium, just from first principles would you not agree that the chance of a population level effect would be low from this activity?

PROFESSOR PEAKE: I couldn't comment on that without knowing what the fish density is for these four species and that's a fish biologist.

MR HARWOOD: I was going to ask you a series of questions about bioaccumulation and biomagnification but seeing as you have confirmed earlier that that's not within your expertise I will avoid that but just for clarification paragraph 14 of your evidence is all beyond your expertise, is that correct?

[10.50 am]

PROFESSOR PEAKE: Yes.

MR HARWOOD: Thank you.

PROFESSOR PEAKE: I mean I do make the comment that uranium would be expected to increase up the marine food chain, I have really no basis other than other trace elements can be – larger fish have higher concentrations of other trace elements, but - - -

MR HARWOOD: Yes.

PROFESSOR PEAKE: - - - I couldn't be certain about the uranium at all, and from our experience of the uranium measurements on ling collected from the south east of Stewart Island, they were very low, so in fact for those species in that environment they certainly didn't bio-cumulate – biomagnify.

MR HARWOOD: Thank you for that evidence, because it was Dr Phillips in her response to a question from Dr Crauford this morning suggested that uranium doesn't biomagnify at all in fish, do you recall that?

PROFESSOR PEAKE: Yes I do, and it's certainly different I agree with Dr Phillips, it's certainly different from mercury.

MR HARWOOD: Yes, thank you for that.

Final questions, have you read Dr Tuck's evidence?

PROFESSOR PEAKE: No I haven't.

MR HARWOOD: Well it's Dr Tuck's evidence that, sediment plumes are created from bottom trawlers being dragged along the seabed, picks up a – picks out of sediment, you accept that?

PROFESSOR PEAKE: Yes.

MR HARWOOD: And he – his evidence was that or based on assumptions that roughly between 21 and 42 million tonnes of sediment is released into the water column over an area of 18,000 square kilometres from commercial fishing from trawling.

Again on a first principles' basis, would you consider that there would be a toxicological risk from dissolved metals from that activity?

PROFESSOR PEAKE: I guess the physical disturbance of trawling it will be different from what is proposed in this mining activity, and the mining activity will take the top 50 centimetres, it's about 50 centimetres of the sediment to take it up to the surface process and then return it back, the chances of mobilisation of metals I would suggest are much greater with that mining activity than they would be with trawling which doesn't set out to disturb the sediment at all, it sets out to catch the fish that are above the sediment in the process.

Some of the top of the sediment is physically perturbed but wouldn't lead to the same – anything like the same degree of mobilised, potential mobilisation as it would in this proposed mining operation.

MR HARWOOD: But that – am I correct that you're saying it depends on the volume or the size of material that is in fact released into the water column, so the fishing in fact release or cause sediments to be released in a plume that would be relevant wouldn't it?

PROFESSOR PEAKE: Yes it would be, but the extent to which the trawling would release that would certainly be different from your mining operation and I would suggest that your disturbing a much greater depth of sediment and taking it up to the surface and in the process of filtering it and processing it on board there's the potential for release of more elements from a bound state than it would be just leaving a trawler, because the trawler leaves it on the bottom, doesn't it, and I mean there's just an immediate pertubation just above the seabed.

MR HARWOOD: Thank you, no further questions.

CHAIRPERSON: Thanks, Mr Harwood. Does any other party have a question of Professor Peake?

MR CURRIE: Only questions of clarification if I may?

CHAIRPERSON: Please.

MR CURRIE: Mr **(INDISTINCT 4.11)** thank you, Dr Peake just a few questions to follow up some answers that you've given.

Firstly, you answered a question by Dr Ryder about the level of concern and you mention samples of ling taken elsewhere I believe in the Chatham Rise is that right?

PROFESSOR PEAKE: Yes.

MR CURRIE: Were those ling to your knowledge exposed to elevation levels of uranium such as maybe found in the plume?

PROFESSOR PEAKE: We never measured the water column chemistry of the area of which they were – that they were caught. Our interest was really trying to establish a chemical signature based on a combination of the elements in the fish rather than in the water – in any relation to the water column, so I couldn't comment, no, Mr Currie.

MR CURRIE: Thank you. And my next question relates to the joint witness statement on radioactivity, do you have that in front of you?

[10.55 am]

PROFESSOR PEAKE: No, I don't.

MR CURRIE: Shall I hand this?

PROFESSOR PEAKE: I'm sorry, did I leave it behind?

MR CURRIE: Can I hand you my copy, and it's paragraph 5 of that one.

PROFESSOR PEAKE: Under which column?

MR CURRIE: I think it's column 5 on page 1, where you say it is necessary to establish the levels of radionuclides, it's your descent essentially from the joint witness statement.

PROFESSOR PEAKE: Yes.

MR CURRIE: My question is just simply why do you say it's necessary to establish the levels as opposed to being advisable?

PROFESSOR PEAKE: Well, advisable to me seems to be a rather weak term and that I think it is necessary to establish these. I mean advisable would seem to me to give some let out, and if they said well, we don't consider it's advisable, then the work wouldn't be done, but I wanted to be more definite that it is necessary to measure the level of radionuclides.

Dr Phillips quite correctly pointed out that there's two effects here in the case of uranium, there's the ecotoxic effect from the chemical perspective, and then there is the effect that the radiation of the uranium and its breakdown products, and the two are interrelated.

MR CURRIE: Thank you, doctor. My last question relates to the issue of bioaccumulation, have you read the statement of evidence of Dr Ross Antony Geoffrey for the EPA?

PROFESSOR PEAKE: I have, it was a while ago.

MR CURRIE: Do you have that in front of you, or would you like me to pass - if the staff have a copy that's great, thank you.

PROFESSOR PEAKE: I might add that measuring the levels of radionuclides is a whole lot more difficult than measuring just the total elemental concentration and that would not be easy to do that, but certainly in the caucusing there we agreed that there were nuclide breakdown products short lived, things like polonium 210, that potentially could pose a risk if there was an enhanced uptake of uranium by any of these species, and so not only have you got to measure the total uranium but also the concentration of these in it.

MR CURRIE: Thank you. The staff are now showing you the evidence of Dr Geoffrey. Can you please turn to page 2 of his executive summary, paragraph 4, and he does talk indeed about polonium 210 there.

PROFESSOR PEAKE: Yes.

MR CURRIE: His final sentence is that, "however given the absence of any data from Chatham Rise on levels of polonium 210 and any other these organisms" – I think there's a typo there but – "or water, any further assessment of the enhanced exposure of human consumers of fish, such as ling and hake, would be scientifically premature". Do you agree with that statement?

PROFESSOR PEAKE: Yes, I do.

MR CURRIE: Thank you, doctor. No further questions.

CHAIRPERSON: Thank you very much.

MR WINCHESTER: Sir, just, it's too late to object now, but I'm not sure that that was necessarily a question of clarification, it was rather leading new evidence and I know we have a degree of flexibility about how this – the questioning operates, but by my recollection that did not relate specifically to a question raised in the primary questions of this witness, so I simply want to register that particular fact, sir.

CHAIRPERSON: Thanks, Mr Winchester, I will think about that over the morning tea break.

MR CURRIE: If I am able to respond, sir? I mean there was extensive discussion, including in answer to my other friend's questions about bioaccumulation, so I thought this was directly relevant.

CHAIRPERSON: Yes, okay. So that concludes the questions, whether of clarification or not, Professor Peake, many thanks on behalf of the hearing and the committee. I suggest we break now for morning tea and then the next witness will be called by the committee, and that's Dr Tremblay. Thanks.

ADJOURNED **[11.00 am]**

RESUMED **[11.22 am]**

CHAIRPERSON: Okay, the next witness is Dr Tremblay, called by the committee, and I invite our legal counsel to introduce him.

MR SLYFIELD: Thank you. Good morning, Dr Tremblay. Would you confirm please that you're the author of a statement of evidence dated 15 September, which annexes a critical appraisal of the same date?

DR TREMBLAY: Yes, I am.

MR SLYFIELD: You have also contributed to the joint witness statement in the topic of toxicology and water quality?

DR TREMBLAY: Yes, I did.

MR SLYFIELD: Thank you, and you've sat through the hearing this morning and therefore heard the evidence given by Dr Phillips and Associate Professor Peake, are there any matters arising out of their evidence this morning or the questions that were put to them and their answers that you would like to comment on before I hand you over for questions from the committee or the parties?

DR TREMBLAY: Yes, thank you for the opportunity. I just want to raise a few points from the questionings from the two previous witnesses, just making a few points here.

[11.25 am]

The first one is around the questions, around the inadequacy of the toxicity testing and the choice of species, and I think that one of the key points is probably about identifying the receptive species that need to be protected and decide at the site, and this is quite a challenging one in

terms of ecotoxicology because, particularly in relation to the destruction of the benthic ecosystem, so what are then the species that you want to protect.

The second one, again, that is related to that is the recovery time scale because this is really what the risk is about, it's about the taxa **(ph 0.57)** that are relying on nodules, they are basically gone, but will be then the medium to long term effects on the recolonisation and all that.

So the issue that the long term potential impacts is really a challenging and difficult one to assess and it relates to multigenerational impacts or potential impacts and in also around basic concepts such as ecosystem functions and nowadays called services, and the knowledge gaps particularly in that environment, in the deep sea environment is quite big, particularly around relationships within and between populations and how those interactions maintain the functions of that ecosystem.

I have heard things around a high level of dilutions as some of the solutions and I think, you know, in that case it is quite relevant because it is a big sea out there but another line of questionings was probably around trying to rank the risk for instance, between fishing activities and the mining.

And I think it is quite important here to realise that in terms of the metals which are the main toxicants in this case, the oxic and suboxic layers composition is extremely important.

Fishing activities for trawling would probably be much more at the oxic level where it is more unlikely that you are going to have remobilisation of metals, whereas in this case with the mining, you go deeper, you go to 50 centimetres, so the suboxic layers will be risk suspended, and this is where you have most of the metals.

And then another point that kept coming was around baseline information and I think this is, from my perspective as an ecotoxicologist, we have a very great opportunity to go into an environment where there hasn't been any impacts or stressor so it is a great opportunity to create that baseline information.

How much – how long it is going to take, how much investment it is going to take, is probably to be discussed. But I think – I would like to point out that in their EIA CRP has raised particularly in section 8 and I think this is something that is very good to have, so thank you for that.

MR SLYFIELD: Would you remain there and answer any questions from the Committee and then the parties.

DR TREMBLAY: Certainly.

CHAIRPERSON: Thank you, Dr Tremblay, David.

MR HILL: Thank you, Dr Tremblay. Can I just take you to that matter you were just talking about in terms of oxic and suboxic layers which you have covered off, and which has been covered off in the expert conferencing issue one, I think in the facts column, which is the fourth bullet on that facts. I note that that doesn't appear to have been carried over as I read it, into any of the proposed draft conditions. Am I missing something here?

DR TREMBLAY: I think that there was something around, better characterisation of those two layers would be quite important, I don't remember - - -

MR HILL: All right, I don't see it specifically, but if that is something that you have been looking at?

DR TREMBLAY: It is something that we have agreed.

MR HILL: Yes.

DR TREMBLAY: Yes, definitely.

[11.30 am]

MR HILL: All right, thank you. And I notice just in your conclusions, and you just mentioned it a moment ago, where you talk about potential long term multigenerational effects during recolonisation and a small pilot scale study is recommended, is that what's intended under the – again, issue one, the draft conditions column, the last bullet point there or is that something different?

DR TREMBLAY: We didn't discuss that per se at the conferencing, during the conferencing discussions, but I think, from my perspective, you know, the scale of the proposed activities, you know, is quite large and I felt that, you know, such a recommendation would be comforting to see that there's a better understanding of potential impacts at a smaller scale before going all out. You know, I think it would be ideal, it may not be the way we'll go, but at least I think that Dr Peake has raised that sort of point in one of our – where we're saying by the time we collect some information, what if it's too late and we've already – in this case, you know, I don't think that would be, you know, operations could stop if there's really something significantly adverse, but maybe

it's a question of having it fairly well implanted in the adaptive management plan that - - -

MR HILL: So what would this look like?

DR TREMBLAY: Well, because, you know, in the evidence there's a lot of, you know, the word uncertainty has been fairly – models often need to be validated and I think, you know, a little bit of information or real data goes a long way, so I think that would be in that space, that we – as those operations move along that some information gets collated that can then be fed into those models to validate their outputs and input a little bit more assurance in terms of risk characterisation of those activities.

MR HILL: But presumably, and again I don't want to put words in your mouth, but presumably this is more than simply toxicological and water quality monitoring.

DR TREMBLAY: Well, yes, I mean, yes, definitely.

MR HILL: So it really is a – what you're suggesting is a pilot of a full scale operation in effect.

DR TREMBLAY: Identifying the main areas of impacts or potential impacts and then providing some information to better characterise, you know, because I think the scale of it, even though it may feel like it's a small area in a vast ocean, but because we have little information about some of those interrelationships between species and local populations with regards to the wider ecosystems, I think all information is important.

MR HILL: Do you have any advice for us in terms of how long that pilot might run for and what the interval would subsequently be before you might consider a full scale?

DR TREMBLAY: Well, I think – you know, like I mentioned the fact that it's starting at ground zero provides a great opportunity to develop a good monitoring plan to try to make sure – and then, you know, obviously it's going to be adaptive as well, you know, one of the ones that we were interested in particularly with the toxicity was around metals, you know, what is the level of metals being released by the activity? So once you have – and those can occur very quickly in the early stages, so once there's a better understanding, so then, you know, other sort of more longer term parameters can be as well monitored and better characterised. So it would be a question of ranking, go after the low hanging fruit and then, you know, and then identify whether there is or there is not a risk.

MR HILL: Yes, all right, thank you, Dr Tremblay.

DR TREMBLAY: Thank you.

[11.35 am]

DR RYDER: Can you turn to paragraph 13 of your evidence, and I just want to ask you a question that sort of relates on from your findings about posing a risk to marine species, and in particular, there has been comments about the use of the elutriate data based on samples taken from the seabed, they haven't been processed in the way that the mining would.

And I'm thinking, and I would like to hear your comments as to whether there is any argument to have that that elutriate testing may, in fact, represent a more of a worst case type situation than if you were to take samples from the seabed, rinse them and process them as would happen during the mining operation, and then be discharged back into the water column and be essentially rinsed or washed by the native seawater above the bed, then set on the bed.

So taking that and samples that have then settled down in an elutriate test, to my mind the potential risk I suppose, associated with ecotoxicology, associated with that would be less than if you were to take the unwashed seabed samples.

Do you see what I am getting at with that?

DR TREMBLAY: Yes, I think you are quite right, you know, I mean literally an approach should take the worst case scenario, I mean, once the process sediment would be returned, there would already be quite a bit of manipulations but at the same time, you know, the main point of the elutriate is to try to assess what will be the risk to the recepta species, if it is returned to the bed if the benthic bed has been disturbed then, you know, there is basically no more living things for a certain time.

You know, what is the relevance of doing it?

So then it is a question of, you know, whether the plume of that resuspended metals will move into the nearby outside the mining area, but I think you are right, you know, the **(INDISTINCT 2.49)** represents the worst case scenario, how the information is used then, it is about, you know, how you can protect the potentially exposed biota.

DR RYDER: So is the potential risk in your view, more to do with the species that might come into contact with the plume rather than species on the bed, either within the mining area, which will be none, **(INDISTINCT 3.20)** essentially none, or on either side of the mined area.

DR TREMBLAY: It would be the pelagic ones that are, you know, not just **(INDISTINCT 3.29)** as well, you know, the movement of the plume to the nearby plots of unmined benthic sediment.

DR RYDER: Your paragraph 20, the last two sentences, if you can have a look at those. About the scavenging by mainly these oxides and then say, "Therefore the impact of the release of metals into the water column is likely to be of short duration."

So can we take it from that that short duration also implies minimised risk in terms of effects, adverse effects?

DR TREMBLAY: Yes.

DR RYDER: And in terms of short duration, that would also imply a minimised or limited area of potential effect as well?

DR TREMBLAY: Yes. So if I can add, it really relates to the accrued potential of those metal release so then it moves more into what are potentially some chronic effects that are so lethal.

DR RYDER: Chronic effects.

DR TREMBLAY: So that is the little, yes.

[11.40 am]

DR RYDER: Okay. Under your discussion in paragraph 27, your last sentence there, "As the physico chemical conditions of the processed sediment would likely be altered, it could modify metal leaching rates."

And my question is, if you could just elaborate on what you mean in that last sentence, and in particular, what do you think is the risk of an adverse effect given the known chemistry of the seabed.?

Is this just a question of uncertainty or do you see a real risk there?

DR TREMBLAY: well, I think it is just a question – it is still a gap, you know, what will be released under real conditions, once the sediment is pumped up to the processing ship and then released.

I mean the elutriate gives you an idea or an indication, but again, it is a surrogate so – it would be just a question of getting more certainty around the levels but I think in terms of assessing the risk, it still would be, you know, probably negligible because of the conditions once they are returned to the seabed.

DR RYDER: And finally, I think, at paragraph 30, you make a comment about ANZECC Guidelines based on single chemicals and they don't account for multiple stresses, I understand. CRP did go on to do some whole effluent toxicity testing which does look at the multiple stress type conditions, so is that in your mind the correct way to go in terms of addressing that issue you have raised, notwithstanding some of the concerns we have heard about that testing procedure we have heard today?

DR TREMBLAY: Well, the thing is the approach that was taken is very valid because, you know, I have heard this morning that those tests are well validated and their predictivity, you know, how predictive they are of adverse effects on various organisms, but they are all based on acute endpoints so short term toxicity endpoints so they don't take into account those longer term chronic potential multigenerational impacts, so that is the only limitations. Well, not the only limitations but - - -

DR RYDER: Some of those tests say 96 hour tests and you are saying that beyond that sort of time scale - - -

DR TREMBLAY: Well, when you talk about chronic you need to take into account endpoints such as reproductive endpoints and ability to produce viable offspring and so forth so that is the next step. And then you have the next step which is multigenerational. Obviously there is an increase in terms of resources requirement for assessing those but, you know, that is the area that hasn't been explored by those tests, particularly when you start thinking about levels that are fairly low.

DR RYDER: Notwithstanding, you are saying the effects are likely to be of a short duration?

DR TREMBLAY: Well, those tests they tell you whether there is an acute effect which is short term, basically your organisms going belly-up, but they won't tell you, for instance, whether those organisms are still alive but what is their ability then to reproduce.

Saying that, you know, I should mention that the muscle test is a good one because it looks into the early life stage which are, you know, generally the more sensitive stages, but its ability to predict long term effect are not very strong.

DR RYDER: Okay, thank you.

[11.45 am]

DR CRAUFORD: I just wanted to continue on that line of questioning, because it appears from my understanding, and I hope this is right, from paragraph 25, you are suggesting that metal concentrations might decrease below guideline trigger values, but there will be potential risk for long term effects, I understand that. But I guess my concern would be how a small scale pilot study would actually ascertain those long term effects. It is as you have just said, it is going to establish whether something dies or not, but it is not going to - - -

DR TREMBLAY: Mm'hm.

DR CRAUFORD: - - - so how are you suggesting that that might be established and how important do you feel that the intergenerational effects are likely to be versus the short term ones?

DR TREMBLAY: You know, in ecotoxicology at the moment, it is a very topical area of research those – particularly around threshold values because there are many studies that demonstrate that you will have impacts at levels that are below the threshold values, so basically if you were a manager and would go outside and measure copper levels, they're below the toxic levels or the threshold levels, you would think that your environment is healthy, but there is evidence that now, you know, some impacts can happen at those levels.

But obviously those impacts are very, very challenging to monitor, particularly, you know, we're working in areas like estuaries where we understand quite well the ecosystems there. Here, you know, in the case of the Chatham Rise you are in a – there is a lot of uncertainty so indeed, it would be quite challenging to assess what is a change in the populations and that to characterise it that change is leading to adverse impact so, yes, it would be very, very challenging.

DR CRAUFORD: And how long might that take. Do you think the pilot test scale study would identify intergenerational impacts, I mean, are we talking years, are we talking months?

DR TREMBLAY: Well, it depends on again, the species that you are looking at, if you are looking at the longer living organisms – but at the macroinvertebrates levels that have life cycles that are shorter so you can, you know, we're talking years but then again, it relates to our poor

understanding of those ecosystems down there, so it would be very challenging.

DR CRAUFORD: Are your concerns with the intergenerational impacts sufficient for you to say that you think these studies should occur prior to mining commencing, or is this something that you are saying, well, you know, you're saying, as I understand it, that probably the short term impacts will mean that any metal concentrations will be within guidelines. Your greater concern is the longer term impact – is that sufficient to say that we shouldn't be doing the mining until we have ascertained that?

DR TREMBLAY: Well, in order to see it, in fact, you have to have the activity ongoing so it is a bit of a chicken and egg kind of thing but I think this is something that in the monitoring program, that it should, you know, certainly take into consideration those - - -

DR CRAUFORD: So it is more of a monitoring thing rather than occurring prior to mining?

DR TREMBLAY: Yes.

DR CRAUFORD: Thank you.

MR JOHNS: Hi Dr Tremblay.

DR TREMBLAY: Hi.

MR JOHNS: This, this – I think we are still in the morning? This morning, you mentioned the – well the word 'interrelationship', so I wasn't to – I think I missed part of it but to a knowledge gap in regard to interrelationships.

First of all, what are the interrelationships you are talking about here?

DR TREMBLAY: I was referring to interrelationships between trophic levels between the different species, you know, the easiest one is a species as a food to another one and so forth and those sorts of, yeah, interrelationships.

[11.50 am]

MR JOHNS: Have you read the evidence of, I don't know whether you have or not, of Dr Pinkerton?

DR TREMBLAY: No, I haven't.

MR JOHNS: Okay, thank you.

DR TREMBLAY: Thank you.

CHAIRPERSON: Thanks, Lennie, I have just CRP on my list of notified questions.

MR HARWOOD: Thank you, sir. I only have a couple of questions for you this morning, Dr Tremblay.

First, if we could turn to paragraph 14 of your evidence, in particular table one, that's all it is, have you got that in front of you?

DR TREMBLAY: Yes, I have.

MR HARWOOD: Now is that – I understand that table is predilution, is that right, the elutriate samples are predilution?

DR TREMBLAY: This is from the table 3 from the Kennedy, so it would be - - -

MR HARWOOD: Is the elutriate samples before any dilution occurs?

DR TREMBLAY: Yes, yes it is, that's a fault, yeah.

MR HARWOOD: And in response to a question from Dr Ryder you suggested that these concentrations would be conservative, that's right?

DR TREMBLAY: Conservative?

MR HARWOOD: In terms of the quantity of all the concentrations of these elements?

DR TREMBLAY: That they would be, yes, fairly representative - - -

MR HARWOOD: Okay.

DR TREMBLAY: - - - that would be the word. Yes.

MR HARWOOD: Okay. Just looking at the figures, on their face the concentrations compared to the ANZECC Guidelines, and it appears to me that it wouldn't take much dilution for those elements to decrease below the ANZECC levels. Would you agree with that?

DR TREMBLAY: Yes.

MR HARWOOD: Thank you. Skipping along to paragraph 25 of your evidence. In the first sentence you talk about a dilution of at least 200 would reduce concentrations to non-toxic levels. Now, I understand that the modelling suggests that within the new field, within 250 metres, that dilution would actually be 750 times, is that your understanding as well?

DR TREMBLAY: Yes, 750 times – yeah.

MR HARWOOD: Thank you. That's all, no further questions, thank you.

CHAIRPERSON: Does any other party have a question of Dr Tremblay. If not, many thanks, Dr Tremblay - - -

DR TREMBLAY: Thank you.

CHAIRPERSON: - - - and thanks for your contribution.

Now – next on my list is Dr Alec McKay called by CRP. I understand he might be prepared to go ahead of time and take the stand before lunch. If so, I thank him for that and ask Mr Winchester to introduce him.

MR WINCHESTER: Yes, thank you, sir. Dr McKay's qualifications and experience are set out in his statement of evidence, he has participated in witness caucusing as well and in particular, has participated in the joint statement of experts in the field of radioactivity. He has prepared a PowerPoint presentation of the key points of his evidence and unless there are any preliminary matters I will – that he wishes to raise, I will simply hand over to Dr McKay.

DR McKAY: Good morning and thank you. Look, I have just put a few slides together in terms of a summary of my evidence and really just a – I feel a little bit on the fringe here, but I suppose focused on trying to put the role of sort of phosphorous in New Zealand Agriculture in place for you this morning to give a bit of a sense of the wider perspective and the potential use of Chatham Rise in Agriculture in New Zealand in the future.

So I will have just covered off in my summary of evidence, just the importance of phosphorous to pasture agriculture, sources of phosphate rocks, talk a little bit about the Chatham Rise, Chatham Rock Phosphate briefly, a little bit about the unwanted elements we find in our phosphate rocks and then talk a little bit about the drivers around the decisions on phosphorous fertiliser use in New Zealand right now,

and then a little bit about potential future markets for Chatham Rock Phosphate given some of the changes drivers in our agricultural industry, so I am driving this am I, sorry, my apology.

[11.55 am]

So look, just to put it in perspective, essentially half of New Zealand's involved in essentially pastoral agriculture, the total area of New Zealand's 26 million hectares, half of that's in pasture, agriculture and forestry, we've got – and half of that, about 6.5 million, is sort of flat and rolling landscapes for pastoral agricultural, from very intensive pastoral agricultural activities, and then the balance of the country tends to be hill and steep land, so probably another 6 million hectares, and we tend to have more extensive systems and they're primarily sheep and beef operations.

I just want to put that into perspective for you in terms of the size of the importance of this to the economy and of phosphorite, and the next slide, simply the areas in yellow are the areas that are in sheep in beef and the areas in red around Waikato, Taranaki, Canterbury and increasingly Southland in dairying and clearly those areas are expanding in the South Island, but just putting that in perspective for us for a later slide, and I can't emphasise enough the importance of our pastoral agricultural systems to the economy and the importance of mixed pastures in our pastoral agricultural systems in the fact they are mixed pastures **(INDISTINCT 1.40)**, and at the heart of the productivity of those pastures is the legume component of the pasture.

It fixes gaseous nitrogen and that nitrogen then is transferred over to the grass component, which makes up the bulk of the animals diet, so the legume component of the pasture might be less than 10%, but it really drives the bulk of dry matter which is provided by grass. Good legume production requires phosphorous potassium sulphate and trace elements in line.

Legumes are less competitive than grasses or phosphorous, so a whole programme around phosphorous fertilising our pasture is about trying to encourage good legume growth and vigor, which drives nitrogen fixation, which drives production, and to give you some idea of the quantities we're talking about, a dairy operation producing 1,000 kilos of milk solids per hectare per year would require in the order of sort of 350-500 kilograms of superphosphate per hectare per year to maintain the system, just to balance losses.

For a sheep and beef operation running, say, 10 stock units per hectare, that's going to need 150-200 kilograms of superphosphate per hectare

per year, that's sort of 15-20 kilograms of phosphorous just to maintain it, it's not increasing it at all.

Just again, and I thought this might be useful for the conversation, one of the long term trials that we run within AgResearch and which I'm responsible for, is a site on the foothills of the Ruahine's, where we've had a long term fertiliser grazing study that was initiated in 1975, and we have areas of up to 10 hectares which have had no fertiliser now for over 35 years and areas which have had high inputs over that same period alongside each other.

Just to, there's some information here to demonstrate, there's about a threefold difference in the productivity of those pastoral systems between where fertiliser is put on and there is no fertiliser. Just a bit of a scale, struggling to run probably six stock units where there's no fertiliser provided now for 30 years plus, and areas where there are good inputs, stocking rates in excess of 16 stock units per hectare per year.

I suppose I can't emphasise the importance of phosphorous to the parks or agriculture, it sort of parallels a world to the New Zealand economy. I don't think that can be over emphasised.

Source of phosphate rocks, all the phosphate rocks used in New Zealand, whether for the manufacture of superphosphate right through to the use of phosphate rocks for direct application are imported. So we're importing all those sources.

I mean, previously we had, through the British Phosphate Commission, we had access to things like ocean ngaru on Christmas Island, now currently we are sourcing - probably more than 50% of the rock is sourced from the Middle East and specifically North Africa.

Just commenting specifically around the Chatham Rise deposit, it is located within New Zealand's exclusive economic zone, so it's close, it's accessible, and we do have some measure of control. The Chatham Rock Phosphate differs from other reactive phosphate rocks in a number of ways, it tends to have a slightly lower total P content around 10 versus other reactive phosphate rocks tend to be around 12, 13, and that's because it has significant amounts of calcite in it or calcium carbonate.

[12.00 pm]

It has a low initial solubility when you are assessing reactivity because of that calcium carbonate. It's a rock that has very low cadmium levels compared to most other rocks. So we are talking about two or three, it tends to be a factor lower than a lot of other phosphate rocks we're using, two versus, you know, 20 to 30 milligrams per kilogram. But on the other side it has above average levels of uranium so probably twice what you might expect in other rocks.

It is probably worth noting that, if you think about world resources of phosphate rocks and looking forward, then those as we exploit and deplete deposits that have got those ideal characteristics and have to move into rocks with less ideal characteristics then having knowledge of a local resource of known characteristics becomes particularly important.

Unwanted elements, a couple of quick comments. All phosphate rocks contain trace elements, some of which are unwanted, and certainly the conversations around cadmium, uranium and to that you have to add fluorine. Again repeated applications of P fertilisers over many years will result in the slow accumulation of these in our soils so regardless of the phosphate fertiliser we are using we will see accumulation of these in our soils. Critically, and I think this is really important, with phosphorus fertiliser an essential input into our ongoing viability these trace elements will continue to accumulate.

Moving through to around the decisions on the choice of phosphorus fertilisers. There is a whole range of factors that are considered when deciding on the type of P fertiliser used in a pastoral system and it could be price, the ability to blend it with other nutrients. It could be just its ballistics characteristics, I mean how it goes out of a plane or out of a truck might determine the product you might use. But increasingly we have got to add to that the issue around the risk of loss to the wider environment so P losses to surface waterbodies and also the issue of unwanted elements or contaminants. If you are making the decision purely on short term agronomic needs then you can't go past a water soluble product like superphosphate, that's ideal.

If you are looking at other issues, and to that we now probably have to include increasing environmental concerns, then I think we can extend that suite to start looking at some of these less water soluble products including reactive phosphate rocks of which Chatham Rise is one.

I just want to leave you with sort of the potential role that a reactive phosphate rock could play in the future economies here in New Zealand and there are probably two distinct markets for the use of reactive phosphate rock. That's what I have termed systems with low annual animal production and demand for P inputs, and here we are probably predominantly talking about hill country **(INDISTINCT 3.35)** steep land, and this covers millions of hectares of both the North and South Island. There is actually a large body of literature, there was a lot of work done in the 80s and 90s looking at the use of reactive phosphate rock in these environments and so we have got good data. These are situations where there doesn't tend to be a really short term demand for phosphorus immediately after application, say compared to an annual crop where you are putting it in and you want rapid growth over a short period.

There is also the potential to increase the P use efficiency through a reduction in the animal P transfer loss factor by using a less soluble product. That means you don't elevate the herbage P concentrations in the period immediately after application and so you reduce that transfer factor which is a key driver for requirements and also the additional ability to reduce the risk of P losses to receiving environments, and certainly we have got phosphorus and nitrogen implicated in the challenge around surface water quality in our streams and rivers.

The other area where it potentially has a market and I think this is the most exciting area, is pastures near the top of the pasture response curve to phosphorus. So our very, very intensive systems, our intensive dairy operations, our intensive sheep and beef systems – and these are now covering millions of hectares of New Zealand - where you are putting phosphorus in just to balance the losses and a pasture response is unlikely. So you are right up the top of the pasture response curve so you are just putting in very small amounts to try and balance those losses.

[12.05 pm]

A product like Chatham Rise phosphorite could be an option for topping up these systems so it doesn't elevate the P levels in the soil, it doesn't elevate the P levels in the herbage in the short term reducing that risk of P loss to receiving environments. This use of this product probably challenges current thinking on the use of sparingly water soluble P fertilisers but I think its interest will just continue to rise as we look at trying to get improvements in phosphorus use efficiency and also the pressure to reduce our P losses from our intensive agricultural systems to receiving waterbodies. So thank you.

CHAIRPERSON: Thank you very much. I might lead off just for a change. We are getting quite strongly divergent views from economists on the merits or otherwise of Chatham Rock phosphate and leaving aside world prices, what is going to happen to them, exchange rates, operating costs and which models you use to demonstrate what the beneficial effects might be on New Zealand, there are some trade-off areas and I would be interested just to get your comments on those. First, there is obviously a security of supply argument although it is hard to put a market valuation on that.

DR McKAY: Sure.

CHAIRPERSON: But the price in New Zealand we are told would be the standard world price, whatever that might be. So the question is how is the market going to assess the advantages and disadvantages, for example you have got low cadmium but high uranium content, do you have any comments on how that trade-off is going to be seen?

DR McKAY: I think the cadmium one is particularly low so, you know, that's a factor lower. Certainly the uranium is higher. We have got now limits in place around cadmium. We're still – the conversation really hasn't been initiated around uranium, as you know, but I'm not sure whether getting into sort of a trade-off situation, that that's actually quite a difficult debate to have. I think we need to as we are looking forward we are going to have to address both those. And so I'm not too sure that the Chatham Rise brings with it the ability of a sparingly soluble product that probably creates some opportunities around environments we have concerns about, say P loss to the wider environment. It has the potential in situations where we have got already elevated uranium levels in some of our landscapes as an option, and that may provide an option there where uranium is not of a concern.

CHAIRPERSON: Okay, that is fine. And on the solubility question, we are told that it does have a lower leaching rate and that is to be beneficial to the environment but there is also a slower uptake into the soil, and again you wonder how the farming community or the market is going to balance one of those against the other?

DR McKAY: Yes, and I think that's probably that last slide is I think where one of the very large opportunities in our intensive systems where we are pretty well near the optimum in terms of the phosphorus levels in our soils for pasture production, where we are really putting fertilisers into that situation to maintain and there is very little demand on the fertiliser per se in any one year. Then putting a slow release product into that particular environment does reduce that risk of P loss to the

wider environment because what happens with a water soluble product you apply it, you get an elevation in herbage in the six to eight weeks after application, elevation in the soil, in the available P level in the soil, and it's during that period when you could have increased losses whereas a slow release product doesn't cause that elevation, it tends to have a very flat surface.

CHAIRPERSON: Okay.

DR McKAY: So that's probably one of the benefits. Certainly going back to the cadmium one is a positive but again I think we have to have this conversation around uranium. It's higher than the rocks being currently used but looking to the future are we going to continue being able to source those?

[12.10 pm]

CHAIRPERSON: Okay, thanks and you mentioned the world supply side of the equation. From what I read, I think there is meant to be certainly some sentries of rock phosphate out there and some countries like Morocco are in fact currently moving to step up their production.

Do you have any detailed information on the supply/demand situation which might give us a bit better steer on just what the price is going to do. Having gone from, I think, around $US40 a ton, up to 400 or so, and back down now to just over 100, very hard to make that kind of assessment.

DR McKAY: Again, I am probably not in a position to make comment on that.

CHAIRPERSON: Okay, that is fine. Thank you very much, Lennie.

MR JOHNS: Yes, I have just got a question around some of these – the accumulation of some of these elements in the soil. There seems to be a lot of literature around in terms of what it may or may not be doing to our soil quality.

What, in your opinion, would be some of the effects of that long term accumulation, not only in our soils but also more in the, I guess, the products of agriculture?

DR McKAY: Look, it is a good point and I think if we're talking in generalities, I think any unwanted material or element we accumulate in our soils, does potentially limit future land use opportunities and future potentially market opportunities.

And certainly around the cadmium one, it is probably around future land use opportunities and also perceptions of the market about, you know, if our vision for the future is a producer of certain foods then that, you know, that does cause us some challenge.

But with the cadmium, while you have got a pastoral system, then the animal to some degree does remove that and accumulate it in its kidneys and livers, it is when you then swap out of livestock agriculture into say a cropping where you are growing something for direct human consumption then, that becomes an issue.

But I think looking forward, we have to be mindful of materials that accumulate in our soils, trying to think that into the future we do not constrain opportunities. But in saying that we – to continue to have a viable primary industry, then phosphates are an integral part of that.

MR JOHNS: Yes.

DR McKAY: And there are some unwanted elements that have come along with it.

MR JOHNS: Okay, and I guess also the effects on water quality, have you any comments about that?

DR McKAY: I am probably confident to talk about the role of phosphorous in water quality but the issues around – is that tenure of your question?

MR JOHNS: Yes.

DR McKAY: Yes, certainly trying to limit the losses of phosphorous discoidal water bodies is a subject of a significant amount of research at the present time up and down the country, and probably at the centre of conversation in quite a few plan change processes going on.

MR JOHNS: Okay, thank you very much.

DR CRAUFORD: Just following on from that, from your evidence you say that Phosphate Rock for direct application makes up less than two percent of usage at the moment.

DR McKAY: Yes.

DR CRAUFORD: Now, why is that so low?

DR McKAY: It has been higher in the past, there has been companies that have imported phosphate rock previously, I think Fletcher Challenge was bringing it in from the Middle East, for a time importing fuscia rock from Peru.

DR CRAUFORD: So is it about price or what is it about?

DR McKAY: I think that is probably the commercial market.

DR CRAUFORD: It is as much about price then as about the fact that it is – or is it also that it is reactive but it takes a long time to produce a result?

DR McKAY: I think less about its agromonic performance, because I think there is a lot of good data to show that reactive phosphate rock was comparable to water soluble products in quite a few environments. In the past debate would have been restricted around, probably agronomic performance. I think as we look forward, there are other factors that are going to play a bigger part in that process, and certainly the issue of implications of intensive agricultural practices and 'P' losses to waterways.

[12.15 pm]

Moving away from a water soluble to a sparingly water soluble product is one mitigation option for reducing phosphorus losses, and it is one of the few that some have, and as a consequence, we probably have to have a deeper conversation about that balance.

DR CRAUFORD: Yes, the nature of that deeper conversation is – I might put it slightly differently, how is that going to happen without regulatory intervention?

DR McKAY: I didn't say that.

DR CRAUFORD: I did.

DR McKAY: No, no realistically – we are – the conversation for the need for actually limits on emissions is now becoming an increasing part of – as you said, conversation, so that into the future where you have to operate within envelopes whether it's 'N' loss and 'P' loss, then all of a sudden you are probably going to start looking at maybe your practices and your input slightly differently. And then all of a sudden maybe those other factors that drive the choice of the 'P' fertiliser you use, may become increasingly important.

DR CRAUFORD: Okay, and I can hear what you are saying in terms of, you know, I can see the advantages and so forth. What I am not getting a feel for though is what the market is, and if anything, from your comments just now, I am getting the impression that actually the market is going to struggle to accept this product for economic reasons, for economic performance reasons.

DR McKAY: You know, I am not really in a position to talk about the pricing and what drives the price of phosphate rock and what drives the price of - - -

DR CRAUFORD: Yes, but I think we are talking about that this product will be priced similarly based on 'P'.

DR McKAY: Okay, so I suppose the comment I can make that the future sort of operating environment, we will be moving to a situation where there will be limits on emissions and limits on 'N' and 'P' and as a minimum, there will be practices that will be required to demonstrate that you are trying to limit losses in sensitive catchments.

And as the pressure comes on from our finite land resources to continue to, you know, lift outputs, then that is going to be an integral part of our future industry.

And so, if you accept that, then I think we will see a change or you will see some changes in the priorities around the attributes of products and as a consequence, the competitiveness.

DR CRAUFORD: I am hearing though, if I can summarise what you have said, that this product may struggle without that pressure, whether that is regulatory intervention or guidelines or whatever, this product is going to struggle economically to compete without that change.

DR McKAY: Yes, that is one, and the other point to just also keep in mind is the fact that there is increasing interest internationally around the whole use of 'P' use efficiency. So as the pressure comes on, particularly on those sources of – as the cost of mining and manufacturing of phosphate rock increases into the future, because as we move to sources which there are more challenges around its recovery and identification et cetera, then the price will go up, so there will be greater and greater interests around the margins of improving phosphorus use efficiency.

And so the other area where these sparingly water soluble products have the potentials around because they do not cause those elevations in the short terms, they do reduce the transfer or the losses that occur

through animal transfer, that they will also start becoming part of the, I think, the conversation as well, and potentially shift and increase the competitiveness of those products compared to current fully processed products.

DR CRAUFORD: But again, that is for the future and we do not know when in the future rather than right now.

I mean, I think you say in your evidence that something between estimates of depletion rates of the world phosphate rock source indicate that by 2100, 40 to 60 percent worst case scenario, could be depleted or potentially only 20-30 percent.

[12.20 pm]

DR McKAY: Yes, and those are taken from the literature – those are the known deposits, but the caveat on that is that the high quality rocks that you would take as the first choice, I think those ones are going to become increasingly difficult to source and access. This country has realised maybe their increasingly strategic value, and so maybe the rate at which we can access desirable products is another - - -

DR CRAUFORD: It could be several decades though before that occurs.

DR McKAY: Yes.

DR CRAUFORD: Okay, thank you.

DR McKAY: Thanks.

DR RYDER: If a farmer was regulated or forced into using slow release phosphorous through regulation, have you got a view as to how many years or what period of time it would take for him to change from his current farming practices, presumably relying on the likes of superphosphate, to a practice dominated by slow release fertiliser without taking a, sort of a major financial hit?

DR McKAY: I'm very much around if we're trying to effect changes it's about driving outcomes, not controlling inputs. So if we're in catchments where there is a surface water quality and phosphorous is implicated and then you're having to put limits on emissions from – at a farm scale, then it would be up to the land owner to demonstrate practices that will reduce it, and one of which might be shifting to a sparingly soluble product. I wouldn't like to see the day where you were prescribed that you have to use a particular product.

DR RYDER: Right. Well, can I ask a question around the quantification, if you can quantify the environmental benefit of using slow release fertiliser, if you've got two farming systems and the only difference is that one uses, say superphosphate and the other one uses a slow release phosphate, so it's Chatham Rock Phosphate, is it possible to quantify the reduction in P loss from the farm, either via surface run off or subsurface leaching or whatever, tile drains, can you do that?

DR McKAY: Yes, and in terms of answering it slightly differently, if you consider – I just have to find the page – I've quoted some work of Richard McDowell, where they look at different mitigation options and I think it's in the order of 10, if I can find the page, so, yes, page 12, bullet point 33, McDowell and Nash report a reduction in total P losses of 0-20% from shifting from a water soluble to a sparingly soluble P fertiliser.

DR RYDER: That's paragraph 33 is it?

DR McKAY: Yes, it's paragraph 33, and they compare that with other mitigation options about shifting to the optimum P range and fencing streams et cetera. So it gives you a bit of a feel for the reductions possible.

DR CRAUFORD: I guess it would be interesting to know the economies of those different, the price of those different options, interventions.

DR McKAY: Yes, and of those, yes, well, you can put that against – if it's probably your last option then it's probably worth an enormous amount, if there's half a dozen options then it may be scaled differently. But in some respects it's probably at the cheaper end because it's not going to require structure investments and probably not a major change in sort of the way in which you operate.

DR RYDER: So that 0-20% is a range?

DR McKAY: Yes, definitely.

DR RYDER: So we don't know what an average is, which could be anywhere between – getting towards one end of that scale or the other, depending on how the data is spread out, so I'm just wondering is it possible to narrow that, I mean, it would be nice to know – I mean you've got zero for a start, so there's no environmental benefit there, and possibly up to 20%.

DR McKAY: Now, and I can clarify that, the 0% would be on your volcanic soils, your undersoil where you've got very high **(INDISTINCT 4.50)**

storage capacity, where in fact losses of phosphorous and surface run off is very, very low because in effect those soils hold phosphorous very tightly, solution concentrations are very low, the 20% would be on those sedimentary soils.

[12.25 pm]

Your pallic soils, yellow graders, those soils that have low anine storage capacity and where phosphorous as it moves across the surfaces would enter into waterways so it would be very much dependent on, in this case, this soil types that you are putting the fertiliser on as to the benefits you would occur.

DR RYDER: So I think you have said in your evidence it is very much horses for courses in terms of local soil types and topography and what not and so in terms of trying to look at a net positive effect from slow release fertiliser it is probably quite difficult to do. It is not widespread across the whole of the country, if it were to be applied, because it wouldn't obviously have a significant effect for some areas in terms of just purely because of the soils and the topography.

DR McKAY: Sure but there would be very large areas. We are still talking millions of hectares where it would be, you know, that would be a potential option, if I think about our sedimentary soils and if I think about some of the catchments where those challenges are currently.

DR RYDER: Okay. Thank you Doctor.

MR HILL: Thank you, Dr McKay. In answer to a question the other day Mr Castle, and I am reading from page 199 of the transcript, Mr Castle indicated that the direct application rocks sold by Ravensdown, sales of the balance of $432 a tonne New Zealand dollars, 345 US. Now that would seem to imply there is a market for the product at quite a reasonable return, in fact he goes on to sort of say at least in terms of the record anyway that obviously increasing the weight towards direct application would mean we would be significantly more profitable. What is your comment on that?

DR McKAY: It is probably outside my sphere, you are really getting into - - -

MR HILL: But in terms of the – where is it selling? Is that outside your can as well?

DR McKAY: Yeah, no really, and I am not really familiar with where the industry's, what their customer base is, certainly the involvement we have had in research in the past used in hill country, used in lowland

environments, particularly used by the organic industry, used in RPR as opposed to a process fertiliser. But certainly I know of farmers that have been using the RPRs for a long, long time.

MR HILL: But you don't know what percentage of the current market currently uses reactive rock?

DR McKAY: Yes, it was in my evidence, sorry.

MR HILL: Yes, I thought it was somewhere.

DR McKAY: Yeah, sorry, and we could go – if I can direct you to the page?

MR HILL: I thought it would be in your paragraphs 34 following but it is not there.

DR McKAY: My apology. I thought it was sort of around one or two percent, from memory it is about one or two percent, it is of that order. Paragraph 18 sorry.

MR HILL: 18.

DR McKAY: Less than two percent of usage in paragraph 18.

MR HILL: Where does that number come from?

DR McKAY: That was from a conversation through Greg Sneath from the Fertiliser Association. He provided me with that information.

MR HILL: How accurate? Give us in degrees of confidence, what can we take from that? A hundred percent?

DR McKAY: Yeah, no I am very confident that that would be a realistic estimate of current use.

MR HILL: Right, that is the existing market. In terms of the two slides that you have given us on the potential market, and under each bullet you have indicated covers millions of hectares, what is your best guess then in terms of the percentage of the overall market that is potentially the market for DA?

DR McKAY: Sorry I have to sort of put a caveat on it that if you look at the current conversations – there are a couple of players on this – if we look at the current conversation going on up and down the country around the issue of service water quality and the need for actually changes to our practices if we are going to arrest the deterioration in

some catchments but also to protect others from any further deterioration then part of that is probably a change in the way we use and manage phosphorous in our agricultural systems.

[12.30 pm]

And a part of that is going to be probably the greater use of sparingly water soluble products. That is a part of it. I think the other part of it is then what role these products might play in those intensive systems in terms of improving just the efficiency of use of phosphorous. So I am not trying to duck the question, I think the potential is large - - -

MR HILL: Well you have, but that is all right.

DR McKAY: But I was trying to give you, and allowing you probably to, is probably isn't a good situation as to the future environment around those environmental issues.

MR HILL: So when you – well, you characterise as your second potential market systems near the top of the pasture response curve?

DR McKAY: Yes.

MR HILL: I mean you have indicated that covers millions of hectares, I mean again what are we talking about in terms of those areas? Do you have anything more sort of definitive than that? I tell you why I am asking the questions is, I mean there is a – and this is what we used to call an "Aunt Sally" but can't call it that any longer but it is a – if this rock has that potential and has those potential benefits then the question must arise why exploit it now when the market is not yet there?

DR McKAY: That is a good question.

MR HILL: You are not going to answer it?

DR McKAY: Alright, look I probably, and I am sorry I was not intending to be flippant - - -

MR HILL: No I accept that.

DR McKAY: - - - not at all. I think we have got a deposit there, we have got characteristics that it is, you could argue that it is sort of at the back door. If we look at the challenges sitting in front of us in our pastoral agricultural industry around impacts on environment, here is something that potentially has a significant role, that could be a game changer, it is a potentially very large market, but that is going to require both some

change in thinking by I think both the industry, there is also some change in thinking when I say the industry in a wider sense but also probably some regulatory processes if we are going to get some momentum which is probably going to, which will drive some of that necessary behavioural change.

MR HILL: I mean I accept necessarily there is a chicken and egg here but I guess the question is well, how far does the chicken need to lead the egg? Alright.

DR McKAY: Yeah.

MR HILL: That is a lunchtime thought.

CHAIRPERSON: A good question and just to complicate things there are issues such as the different levels of phosphorous in Chatham Rock phosphate versus what is currently being imported and the fact that the two are for some purposes mixed.

DR McKAY: Yes.

CHAIRPERSON: But we have got a team of highly qualified economists coming along to give us a clear picture, or two or three, on those issues, I think tomorrow they begin. So thanks from the Committee and we have no listed questions, but, Mr Winchester?

MR WINCHESTER: I just have one question arising but I detect that possibly Mr Currie.

MR CURRIE: I am happy to go first or second.

MR WINCHESTER: Mr Currie should probably go first.

MR CURRIE: Thank you, sir, just three or four questions. Good morning Dr McKay.

DR McKAY: Good morning.

MR CURRIE: I would just like to ask a few questions for Greenpeace, KASM and Deep Sea Conservation Coalition. Firstly we heard on day two from Mr Castle of CRP, and that was on page 204 of the Transcript, that initially 75 percent of the phosphates would be exported. Is it fair to say that impacts on New Zealand agriculture may be very much less than you have suggested?

DR McKAY: Look again it is probably not, it is not a question I can answer, you know what the Chatham, what the phosphate company intends to do with its product, I am probably just posing that potentially a significant local market for a product of those characteristics.

MR CURRIE: Well to flesh that out his next comment was that and I quote "You can't actually sell much more than we were proposing to sell to the fertiliser companies because they can't use more than 25 percent as a blend". Do you accept that as a valid concern?

DR McKAY: A blend in the manufacture of superphosphate?

MR CURRIE: Yes.

DR McKAY: Yeah.

MR CURRIE: Thank you. And secondly I would just like to flesh out the uranium levels in the phosphate. You do accept, don't you, that the phosphate has significantly higher uranium levels than uranium that is currently used in New Zealand?

DR McKAY: Yes.

MR CURRIE: Than phosphates, I am sorry, that are currently used in New Zealand?

DR McKAY: Yes.

[12.35 pm]

MR CURRIE: In paragraph 46 of your evidence, you site a median of 170 milligrams per kilograms and a median of 200 milligrams per kilogram, are you aware of any current sources of phosphate used that contain higher uranium levels than that? That was paragraph 46 of your evidence.

DR McKAY: In terms of – my evidence covers what was in the literature at that time, so I don't know of anything higher than that, no.

MR CURRIE: In paragraph 45, an example, you quote 153 milligrams per kilogram for – I assume that is a mean or a median, do you happen to know?

DR McKAY: It's just a mean, it's from some work we did actually back in the 1980s we had samples from a range of countries which we compared.

MR CURRIE: And that is not currently used, to your knowledge?

DR McKAY: Not that I'm aware of.

MR CURRIE: In paragraph 75 you accept, if I understand correctly, that there will be somewhere between a fourfold and eight fold increase in uranium input, that's paragraph 75, do I understand that correctly?

DR McKAY: Yes, it was in response to, I think, the Crown report which was talking about an eight fold, and I think that was based on a uranium level in a superphosphate sample that seemed very low that they were using as a reference. If you consider 60 then it's about fourfold higher, yes.

MR CURRIE: Thank you. Further up the same page, in paragraph 73, you cite five points and then you say that these called for a comprehensive assessment of the impact of uranium, it's behaviour and it's decay products, not just contained in Chatham Rise Phosphate but in all P fertilisers used in New Zealand environments. Has that comprehensive assessment been carried out yet?

DR McKAY: Not that I'm aware of, no.

MR CURRIE: Thank you. My last question is, would you have any concerns for New Zealand's agricultural reputation about New Zealand either exporting produce or indeed phosphate, which is high in uranium, can you see any possible concerns from that?

DR McKAY: It's certainly something we need to be mindful of, but I'd just probably leave it at that, just something we need to be mindful of.

MR CURRIE: Thank you. No further questions, sir.

CHAIRPERSON: Thanks, Mr Currie. Mr Winchester?

MR WINCHESTER: Thank you, sir.

Dr McKay, we've been talking a lot and a lot of the focus of your presentation was about use of the Chatham Rock for direct application, what understanding do you have in terms of the use of this product as a feed stock for other fertilisers?

DR McKAY: It's probably a little bit outside of my expertise, but certainly it could be used as another source for, for instance, superphosphate manufacturing.

MR WINCHESTER: Yes, thank you for that. Thank you, sir.

CHAIRPERSON: Any further questions from the floor? That's probably a compliment, Dr McKay. So thank you very much and for your flexibility in appearing before lunch. So we will adjourn now for lunch and perhaps return here at 1.45 pm. Thank you.

ADJOURNED [12.39 pm]

RESUMED [1.46 pm]

CHAIRPERSON: Okay, good afternoon. So we've got four witnesses scheduled to appear this afternoon, two in a virtual sense by audio, and that's Dr Geoffrey and Dr or Mr Santillo. So we'll begin and just see how we go on timing for those connections, and first on my list called by CRP is Dr David Bull.

MR WINCHESTER: Thank you, sir. Dr Bull is here, he has prepared a summary of his written evidence, it's an orthodox paper form. Dr Bull also participated in the joint statement of experts in the field of radioactivity and I think you can just commence reading your summary when you're ready, Dr Bull. Thank you.

DR BULL: Uranium is a trace element found in small quantities almost everywhere within the natural environment, including rock, soils, water, air, plants, animals and all human beings. Uranium has no recognised role in the metabolic cycles of plants or animals. Like many other non-essential trace elements uranium is chemically toxic to humans, plants, animals at some elevated level of intake or exposure.

Most threshold concentrations are established by reputable scientific agencies such as the US Agency for Toxic Substances and Disease Registry, European Food Safety Authority, Health Canada, World Health Organisation.

Rock phosphate have been used as fertilisers in New Zealand since around 1900 and currently 100s or 1,000s of tonnes of rock phosphates are handled, processed and applied to land every year, and as such the EPA and the Department of Labour, as it's been known until recently, have already assessed the potential effects on health and the environment.

Rock phosphates are not classified by those organisations as hazardous, they can be handled, stored, transported by any person, not corrosive, low toxicity, and low irritant. Notwithstanding that, worldwide phosphate fertilisers are a major source of uranium in the environment.

Phosphate fertilisers may contain uranium because uranium is often enriched in the parent role.

Based on samples to date the arithmetic mean uranium concentration in Chatham Rise rock phosphate in the proposed mining area is around 155 milligrams per kilogram, and as you have heard that is higher than New Zealand's major current source, Moroccan Rock Phosphate, in which, according to the Fertiliser Association, uranium concentrations are in the range of 76 to 136 milligrams per kilogram. We don't have a mean on that I am afraid.

[1.50 pm]

Chatham Rise rock phosphate could be used directly as a fertiliser as Dr McKay was discussing before lunch. It could also be processed into superphosphate.

So called superphosphate is a manufactured product which is derived from rock phosphate that is mixed with sulphuric acid and then granulated into something spreadable. As the process is carried out in New Zealand, which is not necessarily the same as in other countries, all the uranium in the rock phosphate is retained within the superphosphate. So, for a given application rate as phosphorus, the uranium application rate is the same regardless of what form the fertiliser is applied in.

Based on market research done by Chatham Rock Phosphate Chatham Rise rock phosphate would need to be blended with so called higher grade material, that's to say one with more phosphorus by weight, at a ratio of no more than 25 to 75, one part to three, in order to make a superphosphate product that would be marketable in New Zealand. And in consequence, if you are considering a blend of rock phosphates for superphosphate production, that will always have a lower uranium level than Chatham Rise phosphorised lime.

It is my opinion that uranium is immobile in most New Zealand fertilised soils. The losses of uranium from those soils through leaching, runoff, plants and animals on the land are expected to be small and so all the uranium that's applied in fertilisers will accumulate. And, although there is not a lot of data, regional studies in the Waikato and the Bay of Plenty confirm that some uranium accumulation has already occurred from the phosphate fertilisers that have been used in New Zealand to date.

The uranium accumulation rate depends on the rate of phosphate fertiliser application, the uranium content of the fertiliser and the depth

to which it is mixed into the soils. Based on the fertiliser application rates in Dr McKay's evidence and the concentrations I have just given to you I estimate that if Chatham Rise rock phosphate was incorporated into current New Zealand farming practice then the soil uranium accumulations rates in areas with extensive farming, that's to say typically sheep farming, a low density of animals per hectare, would be around 0.03 milligrams per kilogram of soil per year which is within the range of rates observed in the few historical studies we have of uranium accumulation on specific sites. In intensive farming scenarios, along the lines of those in Dr McKay's evidence, uranium accumulation rates could be higher up to 0.07 milligrams per kilogram per year.

Based on the current available information I have presented in my evidence it is my opinion that uranium in fertilisers derived from Chatham Rise rock phosphate poses little chemical risk to rural residents, people who live on fertilised land. However, I do consider that accumulation of uranium in soils should be limited, firstly in order to protect food quality.

We have no New Zealand standard which addresses this issue and from the initial work that I have done I suggest an indicative threshold of 10 milligrams per kilogram of uranium in soil which includes an uncertainty factor of 50 percent would be an appropriate yardstick for food quality risks. Even on this conservative basis uranium in Chatham Rise rock phosphate appears to pose little risk to food quality.

If it accumulates at 0.07 milligrams per kilogram per year in intensively farmed soils receiving high grade superphosphate partly derived from Chatham Rise rock phosphate, then those soils are going to take more than 100 years to move from the current background of two milligrams per kilogram to exceed a threshold of 10.

And turning to the extensive farming case, if uranium accumulates at just 0.03 milligrams per kilogram per year from direct application of Chatham Rise rock phosphate then those soils will not exceed that threshold for approximately 300 years.

Turning to environmental thresholds rather than human health. I consider an appropriate environmental threshold for uranium would be 30 milligrams per kilogram which is the Canadian environmental soil guideline value for protection of grazing animals rounded to one significant figure.

[1.55 pm]

That value appears likely to protect the most sensitive receptors identified by the Canadian authorities, namely grazing stock. Now, that value is less stringent than the threshold soil guideline value of 10 milligrams per kilogram that I recommended to protect food quality and so it would not be exceeded for a correspondingly longer period of time.

As I have set out in my supplementary evidence while there are numerical differences in our calculations Dr McKay and I agree that potential adverse effects would not be expected for more than 100 years.

Turning to the phosphate component of Chatham Rise rock phosphate, I believe that this poses a low to negligible occupational and health and safety hazard. And I mention that because the EPA staff report presents Chatham Rise phosphorite nodules as hazardous substances because they are reported to contain diphosphorus pentoxide or chemically P2O5. In doing so the staff report completely overstates the risks. The description of phosphorite nodules as containing 19 to 24 percent P205 is just a convention. Conventionally the phosphorus content is calculated and reported as if it was the oxide so that different phosphorus containing fertilisers can be compared on a common basis and that's done for all of them. So, when CRP describes and calculates phosphorus content in that way, there is no intention to imply that phosphorus is present in the chemical form P205.

As the staff report noted P205 as such reacts vigorously with water so it can't possibly exist in the ocean or any other environment where there is any water. Phosphorus in phosphorite nodules is principally present as apatites or, to a chemist, calcium phosphates and those are very familiar minerals because they are the inorganic components of bones and teeth.

To reiterate, under the Hazardous Substances and New Organisms Act 1996 the EPA has already assessed rock phosphates used as fertilisers and hasn't given them hazardous substance classifications.

Turning to conditions of consent. The joint statement of experts in the field of radioactivity, the caucus panel which I was on, considered the prospect of conditions of consent in relation to the accumulation of uranium in soil. We considered that it was impractical to address that matter in this way. The applicant here is not proposing to process or manufacture or apply phosphate fertilisers and has no control over farm level decisions on which fertiliser a farmer uses or how much he puts on.

There is a footnote deep in the EPA staff report, footnote 315 to paragraph 504. It is suggested that the uncontrolled loading of uranium to soils should be regulated by state authorities as is done for cadmium and in that respect I concur with the staff report but all rock phosphates contain uranium, placing conditions on CRP's mining operations can't control what's going on currently.

I note that in the Crown's opening submissions at paragraph 33.2 Mr Prebble recommended that if consent is granted conditions should be imposed by the DMC that provide a level of monitoring from CRP on the uranium content of the phosphate mined. Such a requirement would provide useful information for the development of any future New Zealand standard.

I agree with Mr Prebble that the uranium content if measured in conjunction with the phosphorus content, because you need to know both to get the application rates, would be useful information but it would be far more useful to know the uranium and phosphorous content of all New Zealand's phosphate fertilisers and the EPA, which is the regulator for fertilisers, has got better means of achieving that very desirable outcome than by putting conditions on a particular marine consent. Thank you.

CHAIRPERSON: Thank you very much. David?

[2.00 pm]

MR HILL: Thank you, Dr Bull, I was just trying to fill in a gap on your paragraph 12 of your – is it supplementary, your summary, and I was just wanting to compare that and I couldn't quite get there with what Dr McKay has actually indicated to us. I think in an earlier statement of evidence you indicated there was a – I can't remember your characterisation – but there was a difference in the quantification between you and Dr McKay, I think he was 170-something and you were 100. But more to the point I think in terms of the two market options that Dr McKay outlined this morning, and particularly the one with respect to the options at the top of the response curve, just tell me which or neither of those two bullet points in 12 refer to that sort of market?

DR BULL: I'm afraid neither of them do. He is talking about a relatively small application of phosphorus.

MR HILL: Yes, and that was going to be my question. Well, if that was used in that sort of situation what are we talking about then?

DR BULL: That's going to resemble the extensive farming scenario that I have.

MR HILL: Basically background levels?

DR BULL: The 0.03 is going to be much more representative of that. On the other hand if you look at farms which are already right up on the top of the phosphate curve then those soils have had a lot of phosphate go into them over the years, and so they're the ones that are more likely to be up the top of our existing spectrum of uranium content in soil.

MR HILL: Yes, but you have got no numbers on that?

DR BULL: We have got no numbers on that.

MR HILL: Okay, all right. And just an opportunity just to comment on the expert caucusing generally, a number of these issues, I am not sure whether they are relevant to your evidence or not, but I don't see that you have disagreed with anything in here, I just wanted to check that?

DR BULL: No, not at all.

MR HILL: Okay, so you have agreed with everything or you just not disagreed?

DR BULL: There was only one matter in that particular caucus which was contentious and that was where Professor Peake advised – well, his view was that it was necessary to establish levels of radionuclides in fish and the remainder of the experts considered it would be advisable to.

MR HILL: Right, okay. All right, thank you.

DR RYDER: Can I just pick up on that a wee bit with the issue 1 of the caucusing agreement and the second to last column about adaptive management. There is an agreement there that it is impractical to determine actual uptake of radionuclides before starting mining and then it goes onto say, "Baseline fish sampling could occur at any time, it appears to be practical and cost effective". Now, did I hear before that there wasn't complete agreement about sampling of fish for radionuclides?

DR BULL: The experts were generally of the opinion that it's not the simplest measurement you ever made but it shouldn't be too difficult either. Of course I believe it was yourselves and the panel who raised before that if there are many fish out there on the rise and you have to find the one

that swum through the plume, finding out if there has been any effects after the fact might be harder. But in terms of getting a baseline I mean one could presumably sample from the fish that are currently fished on the rise and simply analyse appropriate body parts for radionuclides and you could start that as soon as one had access to the fish.

DR RYDER: Okay. Well, just moving to the next column about draft conditions and under agreed, there is an agreement there that those radionuclides could be tested for, in discharge waters, suspended fine sediments and water but not in fish? Well, fish aren't mentioned there.

DR BULL: You have got all of those three things right there on your vessel and in your hands. There is discharge water, suspended sediments, water, those are all materials that are well in hand but the Chatham Rock vessel isn't necessarily going to be able to sample the hoki and the ling as it goes past either, so it would be reliant on others, and obviously there'd be effects, if you've got to find the right fish and then if all the fishing boats go elsewhere then that wouldn't work, would it, there's - - -

[2.05 pm]

DR RYDER: From a practical point of view, putting aside the issue of actually having to catch a fish, the ability to collect samples of water and sediment and fish are in-situ and do radionuclide test back onshore that's perfectly straightforward, there's no issues with lag, you know, your times lags presumably, samples can be kept easily preserved or whatever, is required to ensure that when they are or when they do reach the laboratory they're suitable for testing nuclides of radionuclides - - -

DR BULL: I could answer that, but I think if you ask Dr Hermanspahn whose laboratory does these things you'll get a - - -

DR RYDER: Okay, right.

DR BULL: - - - a real good answer.

DR RYDER: Okay, well just finally on issue two, again under expert opinion and conclusion, there's agreement, the apparent need to monitor radionuclides at the sediment water interface and my question is, how practical is that to do?

DR BULL: I'm not sure to be blunt, yeah, there's requirements for benthic monitoring already in the draft conditions, but I'm not familiar with

how they were developed – if you can get the sediment then you can do the test.

DR RYDER: Yes, okay. All right, thank you.

CHAIRPERSON: Yes, thanks very much, Nicki.

DR CRAUFORD: Yes, just the expert conferencing, you were – I think you said to my colleagues you were involved in all of it and the – including issue one which concerns the marine – okay.

In the final column, just following up on Dr Ryder's question, the section that says "disagreed" would require an additional condition et cetera, on fish, was that you who disagreed?

DR BULL: No, that's Professor Peake who's agreed on that one.

DR CRAUFORD: Okay.

DR BULL: That matches up with his comment in the fifth column.

DR CRAUFORD: Right, okay. But you would agree that some analysis on fish would be useful?

DR BULL: In my opinion to analyse for uranium and daughter products in the discharge waters to find sediments in the water, I would certainly recommend that. I'm not sold on the idea of adaptive monitoring of fish.

DR CRAUFORD: Okay. Are there going to be some species that are going to be more at risk than others either due to their sensitivity or location or lack of mobility?

DR BULL: I'm certainly prepared to relay to what was discussed at the expert conference, but you're going to have Professor Jeffrey along later and that's discussed in his evidence, you might prefer to wait for that.

DR CRAUFORD: Okay, all right, thank you.

CHAIRPERSON: Thanks, Lennie?

MR JOHNS: No.

CHAIRPERSON: Thank you, okay, I've just got one point of clarification, Dr Bull, and moving back to the land, you said that EPA would be the

body to assess whether fertilises generally should be categorised as hazardous substances and if so conduct the measurements and so on.

In terms of the uranium content of soil, I think I picked up from the evidence somewhere that would be more the Ministry for the Environment and Primary Industry?

DR BULL: Norm – cadmium for example, in agricultural soils, falls under MPI.

CHAIRPERSON: Yeah.

DR BULL: And it's the MPI who runs the Cadmium Working Group that we currently have. Normally the Ministry for the Environment in its other work on land contamination does not deal with farming soils, but only soils where people live so far.

CHAIRPERSON: Okay. So uranium would fall - - -

DR BULL: If the Ministries were to agree with me that food safety is the number one issue, then it would – it would sit with MPI and presumably a group very much like the Cadmium Working Group.

[2.10 pm]

CHAIRPERSON: Okay. And just to check is there actually a gap in our regulatory regime at the moment, you mention that Canada has set standards for soil, is that a sort of shared international approach which New Zealand is lagging behind or are we one of the many that hasn't bothered to set levels for uranium in soil?

DR BULL: We're one of many, and of course there's a certain amount of piggybacking between jurisdictions, "Oh the Canadians will have a **(INDISTINCT 0.33)** we can borrow that one". It's only since 2011 that New Zealand rejected standards for contaminants in soils. The Ministry for the Environment went through a priority process at that time, uranium wasn't a priority for them and so they've done no work on it.

But there is a big gap generally in what the Ministry has collectively have done with uranium so far. There is no Uranium Working Group as there is for cadmium. We've got no data on uranium in drink water, none on uranium in food, that's why it's in my evidence – it's necessary to look at other jurisdictions and see what's been done there.

To be fair, none of the other jurisdictions have reported any major problems except where they're dealing with mining wastes from actual uranium mines.

CHAIRPERSON: Okay. Thanks very much, I don't have any listed questions, but does any party wish to address any questions to, Dr Bull?

Mr Currie?

MR CURRIE: Only one question, good afternoon Dr Bull, in paragraph 78 of your witness statement, you say that even on this conservative basis uranium in Chatham Rise phosphorite appears to pose little risk to food quality, do you accept that some of New Zealand's food grown on farms maybe exported?

DR BULL: Certainly.

MR CURRIE: And do you accept that overseas purchases or consumers may have a lower threshold for uranium or its derivative components in their food?

DR BULL: Not necessarily.

MR CURRIE: There is for example no minimum residue level for uranium in food set by the European Food Safety Authority who would imagine would have a higher level of uranium than other countries food, then that may prompt overseas jurisdictions such as the European Union to test for uranium and to adopt standards, may it not?

DR BULL: It very well might. They have actual food – they have done studies of uranium levels in food sold in those countries, bearing in mind, however, that some of those countries have been using phosphate fertilisers even longer than we have and may very well have their own issues to deal with.

MR CURRIE: We heard evidence this morning that, at least one witness did not know of any other phosphates with high uranium concentrations in it, so are you aware of any other phosphates with high uranium concentrations then in the Chatham Rock phosphate?

DR BULL: Yes, if you look at the appendix to my evidence, in the Golder report which is entitled "Uranium and Phosphorites" and dated August 2014, table one of that report presents a table of uranium content of phosphorites by different location.

So I said earlier that the average for bulk samples of Chatham Rise rock phosphate was 155 from samples which we have. The global average according to a 2001 study was 75, so while we'd been talking today of Chatham Rise phosphate is high in uranium, it's twice the average which is not grotesque by any manner of means, if you look at single samples then you can find reports of single samples of phosphorite with up to 900 in. and if you look at specific deposits then there's a deposit in Tanzania which reportedly has 330 to 370 milligrams per kilogram with uranium which obviously would be considerably higher than the average bit **(ph 2.11)** of Chatham Rock, Chatham Rise phosphorite.

MR CURRIE: Are all these figures you giving mean or average or what?

DR BULL: Because they're from very different literature sources, they're all over the place to be frank.

[2.15 pm]

MR CURRIE: Yes, so you accept that the Chatham phosphate does have comparatively high levels of uranium?

DR BULL: Well if we are to believe the New Zealand Fertiliser Association – and I see no reason not to – and Moroccan phosphate contains between 76 and 136 there's not a gulf between 136 and 155.

MR CURRIE: The figure we had this morning, Dr Bull, was 200 as a mean, do you accept that figure or do you contest it?

DR BULL: No, I certainly do not and you will find the statistics on uranium and Chatham Rise phosphorite in the report which I am referring to now.

MR CURRIE: Are you saying the 200 milligrams as a mean is wrong?

DR BULL: Yes.

MR CURRIE: And the 185 is also wrong?

DR BULL: I do not believe we heard that this morning.

MR CURRIE: All right, thank you.

CHAIRPERSON: Okay, any other questions, if not, thank you very much Dr Bull, much appreciated and next on our list is Dr Hermanspahn, also called by the applicant, Mr Winchester?

MR WINCHESTER: Dr Hermanspahn, sir, has produced a statement of evidence, he has also participated in the joint statement of experts in the field of radioactivity and he has prepared a PowerPoint presentation which he will take you through.

However, before he commences that presentation, Dr Hermanspahn in relation to your primary statement of evidence are you satisfied that that is a correct statement or are there some adjustments you would like to make to it?

DR HERMANSPAHN: Yes, I would report a typographical error which relates to paragraphs 22, 24 and 25. In the dose assessment and the actual concentration of uranium in seawater that was used was 2.1 millibecquerels per litre not 0.21 milligrams per litre as in the report. I am terribly sorry about that.

MR WINCHESTER: So we should substitute 2.1 for 2.21?

DR HERMANSPAHN: It is a millibecquerel per litre instead of milligrams.

MR WINCHESTER: Thank you, subject to those changes you confirm that otherwise your evidence is true and correct?

DR HERMANSPAHN: Yes.

MR WINCHESTER: Thank you, Dr Hermanspahn, can you please take us through your summary of evidence?

DR HERMANSPAHN: Thank you, I have prepared a presentation where we will try to go a little bit into the background on the work I have done. My statement was relating to the impacts both in the marine environment, as well on agricultural soils.

Just to get a step back we are talking about radioactivity, there are two synonymous terms, radionuclides and radioactive isotopes that are used. These are unstable nuclide that decay and in the process omit ionising radiation.

Within the cell of biota these ionising radiation **(INDISTINCT 3.37)** are ionisation that in turn produces free radicals and then the chemical damage through these free radicles leads to damage within the cell, whether it is the DNA or other part of the cell and radiological protection is then the process of protecting either individuals or populations, be it human or environmental.

Now, in terms of the application the most relevant radioactive isotopes we are dealing with are naturally occurring ones, in particular the DK series of uranium 238. In addition there is two more naturally occurring DK series, those of uranium 245 and thorium 232, but they are of less relevance in terms of impact.

As you can see there is the TK series of uranium 238 contains a large number of different isotopes, they are different elements that have obviously different chemical characteristic, one of them is another gas for example and the different decay times associated with those different isotopes.

[2.20 pm]

I have used two different tools in assessing impact, in terms of the marine environment I've used the ERICA tool, ERICA stands for Environmental Risk from Ionising Contaminants Assessment and Management, now this is the ERICA tool as well as the ERICA approach is the output of a working group that was funded by the European Union and as such you could look at it as being based on international best practice, this assessment approach, as well as the tool, used a tiered approach.

In tier 1 which is the level I worked at for this – for my statement – you use medium concentrations, in this case – so radioactivity concentration in the seawater and it uses reference biota to assess risk to the environment. As such, these reference biota are based on literature values. There is a bias towards biota from the northern hemisphere, but these biota are reasonably generic, that it allows an assessment of the Chatham Rise populations.

What I'd like to point out is that, these – this model assumes that the exposure is continuous, and that's quite important in this scenario because as we can see the exposure will not be continuous, but only of a limited time period.

As I mentioned, I performed a tier 1 assessment. The only input into the assessment is the concentration in the seawater. I used as a concentration the uranium concentration based on the elutriate experiments and diluted to the near-field plume conditions, the value of 2.1 millibecquerel per litre, in addition to uranium 238, also the daughter nuclides were included in the assessment.

The assumption is that the daughter nuclides are an equilibrium that means, the activity concentration values are identical, that's an assumption, but it's a reasonable assumption.

The output of the tool are risk factors, and this is the plot for the assessment of the uranium 238 decay chain. As you can see the risk associated with the uranium itself is very low, it's found on the right hand side of the plot. The most relevant radioisotope, in terms of radiological risk is polonium 210, and in fact you can see it has a risk factor of 1.4, so continuous exposure at concentrations within the near-field plume would be indicative of performing for the assessment.

Going to the tier 2, okay – so my conclusions on the effects for the marine environment, the uranium concentrations they're only marginally increased in the near-field. If you look at the data from the elutriate experiments, in the elutriate the uranium concentration is only a factor 35 above the naturally occurring uranium concentration in the seawater.

[2.25 pm]

So by a dilution factor of 750 as was calculated for the near field, already ensures that uranium concentrations would be close to background levels.

For **(INDISTINCT 0.35)** 10 and in seeing that there is an increased risk factor for the near field, however, my conclusion is that there is still a low risk associated with this. This is due to the fact that, (1), the exposure is only of limited timeframe, the near field as defined as being out to 250 metres corresponds to a mining area of about, daily like a one day mining area so the exposure would be of the order of one day days and also while uranium is quite soluble in seawater, polonium tends to attach to particulates and will be removed from the plume faster than uranium and settle down into the sediment again.

So in conclusion, the radiological risks to marine biota are small.

DISCUSSION

DR HERMANSPAHN: Moving on to the impact of the fertiliser application to soil.

I have calculated accumulation rates in the soil based on fertiliser application rates combined with the uranium content of the fertiliser, assuming a soil layer of 7.5 centimetres of topsoil layer in which the uranium – the fertiliser and the uranium would be distributed.

And the resulting accumulation rates are 0.3 to .01 per milligrams per kg and **(INDISTINCT 3.03)**.

To assess the impact, I have used a modelling software called Razred. This was developed by the Argonne National Laboratory of the United States and again it is following best international practice.

Again, as a model it contains simplifications but as you can see from the diagram, and I don't want to go into the details of it, it is sufficiently, ah, complex to include transfer from the soil to food, for example, and then to humans to assess a dose to the population which is the output of the model.

I have used a very simplified model of what is happening in the soil. We are assuming a top layer, 7.5 centimetres, that contains all the radioactivity in the starting, it is on zero. In terms of the model, I have verified that this is a reasonable assumption, there is no change in dose in varying the size of this layer while keeping radioactivity, the total amount of radioactivity constant. So this starting layer is then exposed to rain and irrigation which drives the elements down into the soil. It is a simple model that does not contain any geological features as such.

[2.30 pm]

So assumptions, all uranium daughters **(INDISTINCT 13.8)** equilibrium. The uranium concentration starting with the top layer, as I mentioned, I looked at the high risk population of a resident farmer and there are some different age groups, one year, 10 years and adults.

So the resident farmer assumes the population spends 100 per cent of their time on the formerly fertilised site. They have a house that's built on top of these agricultural soils and 100 per cent of their food and water is sourced locally, that is the maximum impact.

There is an example of the output of the model, the model is run up to 5,000 years, as you can see there is a logarithmic time scale. And what this spot shows is the different contributions from different radioisotopes and the model clearly shows that the major contribution to this population would be from radium two to six due to direct radiation from the soil and from inhalation of radon gas.

The ingestion of food is of less importance.

These are the calculated dose rates for the different age groups, and for different – at the times of fertiliser applications, so basically just the – which corresponds to a different starting concentration of uranium.

Now these have to be compared to international guideline levels for the protection of the public. The accepted guideline levels, there is one milli seaward (**Ph. 2.34)** and if we do that, if we use this one with a seaward per year guideline level as a limit, we can derive a guideline level for you uranium and soil and based on this it would be 20 milligrams per kg. So that corresponds approximately to the same level as proposed by Dr Bull.

And to repeat, so the dominating pathways of exposure would be radon inhalation, external gamma radiation followed by ingestion of food.

And the latter of course, would be the dose contribution to the general public.

And I believe that is my last slide.

CHAIRPERSON: Thank you, very much Dr Hermanspahn. David, did you understand that?

DR HERMANSPAHN: Of course he could.

MR HILL: Well, I understood the first word. No, Dr Hermanspahn, thank you very much. Just to help me out, your slide 3 on the naturally occurring radioactivity half-life chain, what do I take from that, do I take from that that all uranium 238 will decay through time to lead-206, or, - - -

DR HERMANSPAHN: That is correct, yes.

MR HILL: And is the time period for that constant or is that environmentally independent?

DR HERMANSPAHN: That is a constant - - -

MR HILL: It is your slide number 3, I think it is.

DR HERMANSPAHN: As you can see the half-life of uranium-238 is some billion years, that is the time scale.

MR HILL: I understand the half-life I think, but how long does it take for uranium to decay to thorium 234, does it decay within the half-life or it must be faster than that?

[2.35 pm]

DR HERMANSPAHN: Well, I mean the half-life is a statistical measure. If you have one kilogram of uranium-238 after 4.5 billion years, half of it

will have decayed and you are left with half a kg, so for the individual atom, for the individual nucleus, you can't tell how long it is going to take, it could be the next second.

MR HILL: I guess what I am trying to understand is within – I mean within the proposed life of this mine, for example, will we still simply have uranium 238?

DR HERMANSPAHN: Well within the phosphorite you will have the complete decay chain.

MR HILL: The entire chain will be there because it is X million years old?

DR HERMANSPAHN: Yes, that is correct. So after some million years, you expect the decay chain to be an equilibrium and that means the radioactivity concentrations are all equal.

MR HILL: Is that a model assumption or is that a real world - - -

DR HERMANSPAHN: That is a real world effect, and you have to keep in mind the radioactivity concentrations are not equal to the massic concentrations, so while you have – the mass would be mostly uranium 238, the shorter the isotopes, the mass concentrations of those is incredibly small so there is no chemical risk associated with those decayed products.

MR HILL: Yes, all right, and then so some of these with very short half-lives will be sort of popping in and popping in over the course of the mine presumably?

DR HERMANSPAHN: Um, yes - - -

MR HILL: It is not a technical term, don't - - -

DR HERMANSPAHN: No, the point is that when, for example, during the mining, the elution will affect all these elements.

MR HILL: Yes.

DR HERMANSPAHN: And obviously the elution experiments have only looked at uranium and some stable elements. They haven't looked at, for example, the polonium 210, so there is a little bit of uncertainty around the concentration value of polonium in the water. However, I do not think it will be order of magnitude different. It will be close to the same activity concentration.

MR HILL: Well, I haven't got it up in front of me, I think the conclusion was that they should be assays of this in terms of the water. Is it just in terms of the water that you are recommending that or is it in terms of sediments as well?

DR HERMANSPAHN: The water would be the more critical environment. I am not so concerned about the sediment partly because the – as I understand it and I am not the expert on this, but the recolonisation of the mined areas will take a reasonably long time and I think the radiological impacts on biota recolonising the area would be – there would be a low risk.

It could be included and I think – and you might have to ask Dr Jeffrey, I think, it was his comment on the testing of suspended sediments, I think was a notion that close by populations could be affected by this plume of suspended sediment which will take time to settle, but this timeframe is not years, it is days.

MR HILL: All right, thank you. A slightly more whimsical question if I can, with your next slide. Why is the flower there?

[2.40 pm]

DR HERMANSPAHN: That is an Erica plant, a flowering plant called Erica.

MR HILL: Right, the results for the benthic environment, again it is not numbered, I think it is slide 6, I just to clarify what the blue line represents in your next slide.

DR HERMANSPAHN: Yes, so this is the risk factor for polonium-210. So the risk factor is just the ratio of the dose, the calculated dose, to a guideline level as a risk factor of one, for a tier one assessment would indicate that you should perform additional assessments. In this particular case I would not recommend further assessments based on the fact that one the exposure is only of limited period whereas the model assumes continuous exposure - - -

MR HILL: Yes, yes.

DR HERMANSPAHN: - - - and secondly that the polonium will fall out of the plume faster than the uranium and that therefore the exposure further down the plume will be further reduced.

MR HILL: And you don't have a similar chart for uranium?

DR HERMANSPAHN: Uranium is included, on the far right there is a small purple - - -

MR HILL: Oh is it the purple one on the right hand side, is it?

DR HERMANSPAHN: Yes that is uranium-238 and uranium-234. The green one is radium-226 and on the left there is lead-210. In these models when for example radium-226, that doesn't actually include all the shorter lived isotopes that have radium, millisecond and **(INDISTINCT 2.18)** half-life. Because otherwise it is impossible to model.

MR HILL: All right, thank you.

CHAIRPERSON: Thanks, David. Greg?

DR RYDER: Just following on that line of questioning, the risk level that you have identified in this slide does that relate just to the near field plume area?

DR HERMANSPAHN: Yes.

DR RYDER: Right, and by that you mean is it 250 metres?

DR HERMANSPAHN: Yes it is based on a dilution factor of 750. So basically this stand and falls with the concentration in the seawater. If the initial concentration would be higher would require higher dilution factor, if it is lower than it is even less of an issue.

DR RYDER: That level of dilution is, and the risk associated with that, is that a linear relationship? So if the dilution is half, does the risk double? Does it work like that?

DR HERMANSPAHN: Yes.

DR RYDER: Okay, and doubling the risk for example, what does that mean in terms of potential effects? Is it – I am not quite sure how you translate that? Effect, a real world effect if you like?

DR HERMANSPAHN: For, let me restrict this to effects on humans because it is just easier, it is just the one species. For humans for the low dose scenario dose is proportional to risk so the doubling of dose would increase the risk of developing cancer by twofold. So for the environmental risk it is similar, if you like.

DR RYDER: So it does not necessarily mean for example mortality, it could be just at some sort of sub-lethal effect?

DR HERMANSPAHN: Yes, the risk level that I used for the ring modelling was protection of individuals. So we are not yet looking at population effects. If we are doubling this it will need to be more than tenfold.

[2.45 pm]

Now, I don't want to – it is approximately say a hundredfold I believe. Don't take it too, as a figure set in stone, all right?

DR RYDER: Okay.

DR HERMANSPAHN: It is my best assessment right here.

DR RYDER: In terms of, the point two one milligrams per litre – sorry, **(INDISTINCT 0.43)** per litre, you said you weren't so concerned about effects in the sediment and I am wondering whether, is there any risk of that sort of concentration being any higher in the deposited sediments – the water interstitial spaces of this sediment that have settled back on the bed, should we have a greater concerned there or do you think the greatest risk is indeed in the water column in the plume area, despite the fact there may be no animals left to, you know?

DR HERMANSPAHN: Yes, indeed, my thinking is that the higher risk lies in the contamination of the seawater. The sediment, it is a more complicated scenario, I mean we are just depositing the same material back to the same place it originated from. Obviously there could be some change in the chemical behaviour but by the time recolonisation occurs I would – I am not a chemist - - -

DR RYDER: Well I guess what I was interested in knowing is whether there was a risk of potentially greater effect due to radionuclides in the sediments and that may prolong even further recolonisation, or maybe not so much prolong it but have an effect on organisms recolonising the sediment. I mean I am just probing here as to whether there is initial - -

DR HERMANSPAHN: Yeah, no I understand where you are coming from. No I can't see a huge risk from that.

DR RYDER: Okay, and so moving on to the land, I had one question about, you have done your risk assessment in identifying people working on the land, farmers being the greatest potential group at risk. I was whether those who work in fertiliser factories whether they are at as great or greater risk of exposure than someone working on the farm?

DR HERMANSPAHN: There is the issue of occupational exposure in the fertiliser processing plants. I have not included it in my statement because it is purely an occupational exposure scenario that can be managed in the normal workplace safety.

DR RYDER: Right.

DR HERMANSPAHN: A lot of that exposure would be due to dust inhalation and due to radon gas, which can be managed. If I understand it correctly, in the processing into superphosphate a lot of that radioactivity will be in the scrubbing stacks but that can simply be measured and controlled measures put in place.

DR RYDER: Right, just finally because I asked Dr Bull earlier about the practicalities of collecting samples way out at sea, whether they be sediment or water or even biological samples, and transporting them to a laboratory on the mainland for radionuclide testing, there is no problem in that?

DR HERMANSPAHN: No, there's no – well, I mean it is very easy to get commercial fish species for testing, that is not a problem. Obviously to go out and collect sediment samples or water samples from 400 metre depth is not trivial.

DR RYDER: No.

DR HERMANSPAHN: But the actual transporting into the laboratory and there is no issue with that, the no particular conservation measures necessary.

[2.50 pm]

DR RYDER: Okay, thank you.

DR CRAUFORD: Just going back to the marine area and as I understand it you are saying that the highest risk is in the marine environment rather than on the land and as with polonium 210 and in the near field, would there be I suppose some species that might be, I guess we probably do not know the answer to this, but do all the species react to alpha rays is it not, do they react in the same way or are some species more sensitive to others?

DR HERMANSPAHN: There are differences between the different species but that is taken into account in the model, the model I actually use is a mixture of literature data and modelling of dose effects to biota where

these model species they are actually, the model used is very simple they are just blobs of a certain dimension and without any organs or anything, and then it is just a matter of working out like alpha, how much of this will be absorbed and what would the effect be.

The scientific community is working on improving these dose models to have more complex models for different species, but I mean that is obviously outside the scope.

DR CRAUFORD: We do not really have any evidence in that regard as to whether it would impact say coral more than fish or anything like that?

DR HERMANSPAHN: Well that is included in the ERICA model, it does have a large range of different types of species included and that includes different dose factors.

DR CRAUFORD: It is just the dose factor? In that case what potentially could be the cumulative effects that would simply be a higher dosage and I think you said to Dr Ryder that would be a linear effect, a greater dosage?

DR HERMANSPAHN: Yes, it is a linear relationship to the concentration in the water. The cumulative effects if you are thinking of trophic levels they are taken into account in the model.

DR CRAUFORD: No, I am thinking more kind of multiple, another plume in another year of mining?

DR HERMANSPAHN: Yes, the model is based on continuous exposure so that would be like a scenario where you have an ocean outfall and there is a resident population at the outfall or exposed to the same concentrations continuously so it is a really conservative estimate of effects.

DR CRAUFORD: Your results are based on a temporary exposure of less than a day, is that right?

DR HERMANSPAHN: No, this plot here that is under the assumption of continuous exposure so if you take it then back to if that is only for a day, risk is quite a loss less.

DR CRAUFORD: Do you consider that any conditions are required on this?

DR HERMANSPAHN: I do not think so, apart from in terms of the uranium in soil there is potentially a need to consider the guideline levels.

DR CRAUFORD: But that is going to take decades if not hundreds of years?

DR HERMANSPAHN: Yes, you have got plenty of time.

DR CRAUFORD: In the marine environment you do not think there is a need to monitor the extent of the plume?

[2.55 pm]

DR HERMANSPAHN: It would be useful just to address the uncertainties in the **illusion (ph 0.12)** experiments and uncertainties in the model assumptions, if we have real world data on concentrations in the seawater and in the plume that would certainly help to solidify this data.

DR CRAUFORD: Right, okay, thank you.

CHAIRPERSON: Lennie?

MR JOHNS: Yes, I am just interested in the dose model that you have I think on one of your slides, and just for really clarification for myself.

DR HERMANSPAHN: Yes.

MR JOHNS: On the right hand side you have got a column that is headed "dose or cancer risk" and I think what you are saying is that we are not at a level where that's an issue?

DR HERMANSPAHN: That's correct.

MR JOHNS: All right, okay, thank you.

CHAIRPERSON: Thank you very much. Mr Currie, you had a question notified?

MR CURRIE: Mr Chair, thank you. Good afternoon, Dr Hermanspahn, I would just like to ask you some questions for Greenpeace, KASM and the Deep Sea Conservation Coalition. Can you just go back briefly to your slide results for the benthic environment. Are these current levels prepared for this application, what do these slides show? What does that slide show?

DR HERMANSPAHN: This is the risk factors calculated by the ERICA tool based on a uranium concentration of 2.1 **(INDISTINCT 1.59)** per litre which would correspond to the near field plume conditions.

MR CURRIE: And when did you carry out that test?

DR HERMANSPAHN: That was in preparation for this statement.

MR CURRIE: I am just puzzled why does it say here it starts at 2012 on the bottom?

DR HERMANSPAHN: Oh, I apologise, that's part of the slide layout and I wasn't able to change it, I actually tried.

MR CURRIE: Thank you. The ERICA model is only a model, isn't it, it's not based on measured levels and species?

DR HERMANSPAHN: It is based on literature data - - -

MR CURRIE: Yes, it's not on species in the Chatham Rise I mean?

DR HERMANSPAHN: It is not specific to the species in the Chatham Rise.

MR CURRIE: Thank you. I just want to clear up the issue of uranium levels, you were present during this morning, were you, there was a discussion with Dr McKay?

DR HERMANSPAHN: Yes.

MR CURRIE: Okay, and this afternoon the conversation with Dr Bull?

DR HERMANSPAHN: Yes.

MR CURRIE: And in paragraph 30 of your evidence I see that you are using or quoting the figure of 155 milligrams of uranium per kilogram. Dr McKay in his evidence and in his evidence repeated this morning cited a median of 170 milligrams per kilogram and a mean of 200. I understand that was based on the Cullen samples from 78 and 70 and is it 89? So who is right, is it 150 or is it the 200 or 170?

DR HERMANSPAHN: To my best knowledge Dr Bull used a larger sample, a larger dataset to calculate his values so I would trust the 155 milligrams per kg value more however - - -

MR CURRIE: Is that a median or a mean?

DR HERMANSPAHN: This is I believe a median value.

MR CURRIE: And how accurate is that plus or minus, can you give us a figure?

DR HERMANSPAHN: I can't give you a figure on that but in terms of the risk assessment 155 and 170 is not a huge difference.

MR CURRIE: No, so it could be as high as 170, it could be as high as 200 given by Dr McKay?

DR HERMANSPAHN: I haven't studied the levels in detail.

MR CURRIE: I see. Looking at page 23 of your evidence, you show the RESRAD computer model developed by the US Argonne National Laboratory, this is on page 23, do you have that?

DR HERMANSPAHN: Yes.

MR CURRIE: The last sentence in the first paragraph reads, "The model was developed for contaminated sites but the scenario of naturally occurring radioactivity in fertiliser is well within the bounds of the model". The model wasn't designed for use with the situation of fertiliser being applied to farmland, was it?

[3.00 pm]

DR HERMANSPAHN: It is well within the scope of the model.

MR CURRIE: Was it designed for use with fertiliser applied to farmland?

DR HERMANSPAHN: The model was designed originally for contaminated land from the nuclear industry. It wasn't designed particularly for this purpose but the application is well within the scope of the model.

MR CURRIE: Not land on which, for example, food was grown, was it?

DR HERMANSPAHN: Yes, it does include because the US regulations require the calculation of dose out to 1,000 years into the future. For this timeframe you can't guarantee site safety so you have to assume that people will come and live on the land and grow their food. So it's a part of the model indeed.

MR CURRIE: When was the model developed?

DR HERMANSPAHN: I can't give you the exact year but it is a currently used software.

MR CURRIE: Thank you. Turning to the questions you gave I think to the panel you said, to paraphrase you, you are less concerned about risk from sediment and I think you said, "I can't see a huge risk". There

you are talking about the levels in sediment that may have an adverse consequence to benthic life, are we talking about the same thing?

DR HERMANSPAHN: Yes.

MR CURRIE: On what do you base that risk analysis, on what baseline? Have you measured the existing concentrations of uranium in the benthic life in the Chatham Rise?

DR HERMANSPAHN: No, we haven't conducted any measurements, it's just based on - - -

MR CURRIE: And is – go ahead.

DR HERMANSPAHN: Just based on the model - - -

MR CURRIE: On the model?

DR HERMANSPAHN: Of the model which does not seem to indicate a large risk from the sediment.

MR CURRIE: And I heard you say I think that doubling a dose doubles the chances of cancer. So given that how can you assess that an increased dose may not have adverse consequences on species that live in or on the sediment?

DR HERMANSPAHN: I can't quite understand your question.

MR CURRIE: If I understood you correctly you said that doubling a dose, you were asked about what the difference is made in doubling a dose, doubles the dose of cancer. So if I put the question in a different way, do you accept that doubling a dose for benthic species may have an adverse effect on those species?

DR HERMANSPAHN: I think you have to be careful with the wording because what we are talking here is additional dose on top of the naturally occurring background dose. A doubling of dose means a doubling of risk but if the additional dose is only a fraction of the naturally occurring dose then, no, you don't have a large increase to the risk to the species or to the – and so it depends on the levels.

MR CURRIE: Do you know the background of those, Dr Hermanspahn?

DR HERMANSPAHN: What we have calculated is additional dose based on releases.

MR CURRIE: That's right but you don't know the background, the existing baseline dose, do you, or baseline limits.

DR HERMANSPAHN: We haven't calculated that but that could be easily done.

MR CURRIE: Can I take you to the joint witness statement on toxicology, do you have that in front of you?

DR HERMANSPAHN: No, I don't have the one for toxicology.

MR CURRIE: Can the staff perhaps provide that, thank you very much. Are you familiar with this document?

[3.05 pm]

DR HERMANSPAHN: No, I have not read this one.

MR CURRIE: I see. Well I will take you through it from page one through 11. If you would please read the statement on column four under uncertainty, lack of information?

DR HERMANSPAHN: Yes.

MR CURRIE: You agree with that where it states "the chemical composition and quality of the overlying water column before mining have not been characterised" do you agree with that statement?

DR HERMANSPAHN: It is somewhat outside the scope of my expertise, but I assume this is a correct statement.

MR CURRIE: Thank you, and under expert opinion conclusion it is agreed is it not that sampling of the water and analysis of the water composition and quality must be undertaken in the mining area before any mining operations commence, do you disagree with that conclusion of the experts in toxicology?

DR HERMANSPAHN: I do not see a necessity to conduct sampling for the purpose of a radiological assessment of the waters. It could be helpful to determine a baseline but I do not see it is a necessity in terms of radiological contaminants.

MR CURRIE: Dr Hermanspahn why were you not part of the expert conference on toxicology?

DR HERMANSPAHN: I do not know.

MR CURRIE: I see, we will press on then. If you please turn to page five which is under issue three and the fifth column under expert opinion conclusion states that the experts agreed that CRP should undertake research usually with a research partner that helps to establish toxicity values based on species that are relevant to the site, do you agree with that conclusion?

DR HERMANSPAHN: I think we have to be careful not to mix up toxicology and radiological risk. The expert conference on radiological risks we have come up with our conclusions. I cannot comment on the general toxicology so I am not a chemist I am an expert in radioactivity.

MR CURRIE: Okay, so you do not disagree with that statement?

DR HERMANSPAHN: No, I do not disagree, no.

MR CURRIE: Thank you, and then moving on to page, the following page seven under issue four talking about multiple stressors and it is agreed under uncertainties that there was no information about potential interactions between the different stressors including a toxicity of the mixtures of metals, sediment plume and reduced oxygen associated with increased carbon so do you disagree with that statement about the current uncertainties?

DR HERMANSPAHN: Again, I cannot comment on this, this is outside my field of expertise.

MR CURRIE: I think my last question will relate to the following page, page nine about the potential toxicity of uranium in seawater and it is agreed in paragraph two is it not that there is no guideline value for uranium seawater and then however there will be value in establishing a guideline for uranium in the marine environment and then in paragraph four it is agreed that there is an absence of an internationally recognised toxicity threshold for uranium in the marine environment, so do you disagree with any of those statements?

DR HERMANSPAHN: No, but again just stressing that I was looking at uranium as the radiological contaminant, I wasn't looking at its toxicology.

[3.10 pm]

MR CURRIE: Okay, you're not looking at toxicology, thank you.

Then please to turn the radioactivity report then – do you have that in front of you, the Joint Statement of experts?

DR HERMANSPAHN: No, I don't have it in front of me.

MR CURRIE: Sorry?

DR HERMANSPAHN: I don't have it in front of me.

MR CURRIE: Will the staff – I'm sorry, will the staff manage to please pass a copy of the joint statement on radioactivity – thank you.

Were you part of this working group?

DR HERMANSPAHN: I was.

MR CURRIE: Yes, your name is on it, isn't it. So under issue 1 and column 4, you agreed did you not that "we do not know the uncertainties in the sediment plume modelling, including the constancy of the height of discharge above the benthos"?

DR HERMANSPAHN: Yes.

MR CURRIE: And you also agreed that "there are no available data on the present or potential uptake of radionuclides in the Chatham Rise pelagic species"?

DR HERMANSPAHN: Correct.

MR CURRIE: And that "there are no available data on the levels of radionuclides measured in the four major species in the Chatham Rise"?

DR HERMANSPAHN: Yes.

MR CURRIE: Can you please look at your own evidence in paragraph 59, on page 14, and you state that "marine mining of Chatham Rise phosphorites will pose negligible radiological risk to marine biota". I put it to you that you simply cannot draw that conclusion based on the uncertainties that you have just agreed to, you just simply do not know, do you?

DR HERMANSPAHN: We have sufficient knowledge to make this statement. We don't have any specific values for the species on the Chatham Rise, but we do know based on literature data from other areas and other species and the range of surfta **(ph 2.31)** and that and

the fact that the risk factors are very low that there is very, very little risk in terms of radiological effects on marine biota.

MR CURRIE: Dr Hermanspahn, you have agreed that there were no measurements of toxicity values on the species relevant to the site, no measurements of toxicity thresholds, no baseline data on metal concentrations, no information on potential interaction between the different stressors and there are no international standards relevant to radioactivity, so how can you draw a conclusion that there is – that the marine mining will pose negligible radiological risk to marine biota? And again I say you – I put it to you that you simply don't know at this stage.

DR HERMANSPAHN: We have sufficient knowledge to make the statement.

MR CURRIE: Thank you, no further questions.

CHAIRPERSON: Thanks very much, any further questions of Dr Hermanspahn, if not, thank you very much indeed, Doctor.

And next expert witness on the list is Dr Ross Jeffree who I believe is coming to us over the audio link from Australia and hopefully is waiting extremely patiently in the wings, Dr Jeffree, you are there, okay.

DR JEFFREE: Yes, I am.

CHAIRPERSON: Thanks very much for your patience both past and future, and since you were called by the Committee I would invite our legal counsel, Mr Slyfield to introduce you.

DR JEFFREE: Good afternoon.

MR SLYFIELD: Good afternoon, Dr Jeffree, can you hear me?

DR JEFFREE: Yes I can, very well thank you.

MR SLYFIELD: That is great. Can I get you firstly please to confirm that you are the author of a statement of evidence dated 12th of September which is titled "Assessment of Effects of Radioactive Elements on the Marine Environment"?

DR JEFFREE: Yes, I am.

MR SLYFIELD: And that you have also participated in the expert witness conferencing in the field of radioactivity and are one of the joint authors there of the joint statement dated 18 September 2014?

DR JEFFREE: Yes, I was a member.

MR SLYFIELD: Thank you. Do you have any corrections that you would like to make to the statement of evidence that you prepared?

DR JEFFREE: No, I think that stands.

MR SLYFIELD: Thank you. And you have had the benefit I understand of being on the line for much of today's proceedings during the radioactivity evidence, can you simply confirm whose evidence you were able to hear since you have been on the line please?

[3.15 pm]

DR JEFFREE: Yes, I heard Dr David Bull's evidence, and the evidence of Dr Hermanspahn.

MR SLYFIELD: I am sorry, you are just cutting that out, Dr Jeffree, would you repeat after Dr Bull?

DR JEFFREE: And also Dr Hermanspahn.

MR SLYFIELD: Thank you, is there anything arising from the evidence you heard them give that you would like to comment on before I hand you over to answer any questions?

DR JEFFREE: Yes, there is two issues coming out of Dr Hermanspahn's presentation and some of the questioning following his presentation. Just in terms of the radiation screening level that Dr Hermanspahn used, which was 10 microgray per hour. This is a screening level that is used to determine whether there is any impacts whatsoever on individuals.

There is another screening level, which I actually use, which was 400 microgray per hour which is related to impacts on populations, and that typically is associated with detrimental effects on the growth of the organism or its capacity to reproduce.

The 10 microgray day screening level is a more stringent level and it's really saying that below this level you will have no effects whatsoever on the biological organism, and those effects might be some that we cannot attribute to any morbidity or mortality effect per se.

The second issue that came up in Dr Hermanspahn's presentation and the questioning was the risk to benthos in relation to making an assessment with this ERICA tool. Now, by taking a water concentration of a radionuclide you can assume by knowing the quantified relationship between the level in the water and the sediment what sort of levels you will get in the sediment. And for sediment dwelling organisms an estimation can be made of what the radiation exposure will be.

So the ERICA Programme, which includes benthic organisms, already will take into account impacts on benthic organisms for the levels of radionuclides that are measured in the water. I hope that clarifies that situation.

MR SLYFIELD: I think so, thank you, Dr Jeffree. I will now ask you to answer any questions that the Committee may have.

DR JEFFREE: Yes, I would be happy to.

CHAIRPERSON: Thanks very much, so first we will go through any Committee questions Dr and then open it to other parties. So David?

MR HILL: Thank you, Dr Jeffree, David Hill here, good afternoon.

DR JEFFREE: Good afternoon.

MR HILL: Can I just ask you to just comment in whatever way you feel is appropriate on the expert conferencing outputs?

DR JEFFREE: Well, I think we came to many agreed positions, and I think the most important one was that we agreed that the dilution factor for the nutrients was most important, and that we felt that if the dilution factor was below around about 200 then you really had to go to the so-called tier two assessment using the ERICA methodology.

You really have to go and take some measurements of what were the levels of radionuclides now in the water and in the biota. Above 200 there was this recommended indicated dilution factor of 750 in the near zone, but if you are getting out towards that then there probably would not be a radiological risk to the marine biota.

In other words it is important to feel confident that the modelling is going to give us these dilution factors. If there is a lot of uncertainty in the modelling outputs, and they would indicate that it may well be

below a dilution factor of 200, then we have to go to a two tier assessment.

The second point is with regard to the current requirement to measure the levels of radionuclides in some of the benthopelagic fishes, sure it would be good to do that because we have no data and all scientists want more data, but in terms of following the internationally agreed methodology for assessment of the need to go from a tier one to a tier two radiological assessment.

[3.20 pm]

It already takes into account benthic dwelling fish, and if the situation is okay for benthic dwelling fish then you do not really have to worry too much about pelagic fish.

MR HILL: All right. And in terms of when you would do this analysis, I think the general feeling was it should be done in advance?

DR JEFFREE: Well my feeling is that you really have to hit the ball back into the court of the modellers, and if the general consensus is that dilutions may well be less than 200 then you have to go now before you are mining to determine what are the relationships between the current levels of radionuclides in the water, and in these most exposed biota to determine what are the so-called concentration factors, the relationship of concentration in the organism to the water, and then go back and redo the radiological risk assessment.

So you make it quite site specific. So I think there are two points in that – let us reassess what the modellers have to say and people feel confident about the error bars on their assessments and then we go and decide whether it's necessary to do the site specific assessment.

MR HILL: All right. Thank you very much Dr Jeffree.

CHAIRPERSON: Greg?

DR RYDER: Dr Jeffree, it is Greg Ryder here from the panel. Just wondering if you can turn to paragraph 27 of your evidence.

DR JEFFREE: Yes, okay.

DR RYDER: You make some comments there in the last two sentences about marine taxa that were not part of the ERICA radiological assessment, as they are not available.

DR JEFFREE: Yes.

DR RYDER: And then you have another statement at the end "it is not possible to evaluate whether the radiological assessment undertaken is conservative or not for these taxa or organisms of Chatham Rise." My question is, the organisms that you have listed there, that were part of the assessment, do they not cover a broad enough range of phyla to sort of catch other phyla that have not been assessed or other particular groups of organisms that you are aware of that maybe more sensitive to radiological risk?

DR JEFFREE: I think, it is true that the numbers of phyla or taxonomic groups of organisms that are represented in the tool are good and getting better all the time, but after reading a lot of the documentation on what was known about the taxonomic status of these organisms and the various other groups that seem to be quite unique, I felt I had to say something there about these other organisms and how we know very, very little about them. So I think this is where you have to take in some dimension of conservatism in your assessment.

So I still think it is an unknown, and I mentioned some of these organisms because they seem to be quite predominant in the community formations in the Chatham Rise benthic fauna.

DR RYDER: Okay, thank you for that. And you have already in answering the question from Mr Hill, identified the importance of having confidence in the dilution estimates of the plume - - -

DR JEFFREE: Yes.

DR RYDER: - - - and you have raised that issue in paragraph 40 of your evidence, so I will not dwell on that because I think you have answered that for me. But at paragraph 43 – first of all you talk about Pinkerton's trophic model - - -

DR JEFFREE: Yes.

DR RYDER: - - - in relation to Polonium 210, you talk about a potential pathway for it through the food chain, basically from benthic water and particulates, and up into fish and ultimately humans. Now, I just wonder if you can discuss a bit about that pathway.

DR JEFFREE: Sure.

DR RYDER: Again, and I think I asked the question of an earlier witness, the fact that the mined areas going to be devoid of benthic organisms after

mining, so this potential pathway I assume you are talking about is for areas away from the mined footprint?

[3.25 pm]

DR JEFFREE: Yeah, I guess really the most relevant area are those areas that are completely adjacent – just next door adjacent to the area that has just been mined. And I suppose in terms of a longer time span, those organisms that are starting to recolonize, because there has got to be something for the organisms further up the food chain to feed on, obviously. So it is first of all, adjacent areas to where the organisms have been completely removed.

DR RYDER: And does that level of concern still remain if the degree of dilution available in the plume is verified, in other words, if it is at least 200?

DR JEFFREE: Yeah, I think that is true. I think if you have got this dilution factor and there is going to be no impacts on the organisms themselves, then I – and that means they have not accumulated very much in the tissues, then in terms of a transfer through a food chain or a food web, is not going to be modified very much.

Now, for the most important radionuclide in terms of human exposure for marine organisms, which is polonium, you do not get this biomagnification through the food chain, you may get – you will get transfer from one level in the – one trophic level to the next, but it tends not to get to higher concentrations as you move up the food chain.

So I think what you are saying is correct.

DR RYDER: All right, all right, thank you, that is all I had.

CHAIRPERSON: Thanks, Greg.

DR CRAUFORD: There was just a – hello, Dr Nicki Crauford - - -

DR JEFFREE: Yes, hello.

DR CRAUFORD: - - - here, I'm one of the Committee, I just wanted to refer to clause 30 of your evidence where you talk about the need for a more stringent screening level for sensitive or endangered species, could you just talk a little bit about that for us?

DR JEFFREE: Yes, I think – this refers to what I started talking about. There are two screening levels that have been recommended at the moment,

one is 400 microgrades for populations, where you are not so much concerned about individuals or one or two percent being impacted, but the viability of the whole population. And the 10 microgrades per hour, which is where your concerned about individuals per say.

So you know, I mean if you are thinking about rear species, there are only a few individuals you are concerned about, you know, you might lose one or two individuals and that is a high percentage of repopulation, so in that situation where there's any concern about endangered or geographically restricted populations, then you might want to do your assessment at the 10 microgrades level, and I think that is well within the sort of, the international consensus about, how to use these two existing screening levels.

DR CRAUFORD: So those are your opening remarks in relation to Dr Hermanspahn's evidence?

DR JEFFREE: Yes, it is the same point, yes.

DR CRAUFORD: Okay, and so in relation to his evidence you would still agree with him, though, that the risk to marine species is relatively low and therefore probably this more stringent screening would not be required in this situation?

DR JEFFREE: I mean it is relatively low if you can be confident the dilution factors are greater than 200.

DR CRAUFORD: Okay. So again it comes back to the measuring the dilution factor and measuring the plume?

DR JEFFREE: Yeah, the devil is in the dilution factor really. I mean – I think our radiological assessment models are now good enough to determine whether we need to get more site specific information, I think that is the point.

So we cannot be completely confident that there is no impact, but we can get within some sort of order of magnitude about where we have to make the decision to go and spend more resources and get more information and do a site specific assessment, and I think we both agree, or the Committee agree it is around about dilution factor **(INDISTINCT 4.55)**.

However, **(INDISTINCT 4.58)**, that, you know we need a little bit – this information about the rarity of species plays into the radiological assessment as well.

[3.30 pm]

DR CRAUFORD: Okay, thank you, I have got the message the dilution factor is the key, thank you.

DR JEFFREE: Yes.

CHAIRPERSON: Thank you, Lennie?

MR JOHNS: Hello Dr Jeffree, it is Lennie Johns speaking from the committee.

DR JEFFREE: Hello.

MR JOHNS: I am just looking at table two on page 18 of your evidence in relation to the risk quotations for zooplankton and given its importance in terms of the trophic system can you explain to me what the table is actually saying?

DR JEFFREE: Yes, well it is saying that at the, here I started off saying well let us have a look and see if the nutrients per se have any radiological significance, in other words are there concentrations of uranium and those important **(INDISTINCT 1.22)** lead, and radium 226, are they at levels high enough to exceed the risk question, in other words potentially have a chronic impact at the level of population and doing the analysis based on the water concentration and the effluent zooplankton come up out of all those limiting reference organisms zooplankton come up as being significantly impacted at that concentration of those radionuclides in the elutriate.

Okay, we know that zooplankton can visit these benthic layers as part of their diurnal cycle, they are not necessarily as resident as a benthic flat fish for example, but I have said well okay let us regard them as defog organisms for those organisms that live in the benthic region that we do not have enough radiological and radio ecological information about at this point in time to make a specie specific assessment. In other words based on this you would say the effluent needs to be diluted so that is it is not of a radiological significance. Does that help?

MR JOHNS: Yes, just thinking then in terms of the re-deposited material from the mining process I just want to make sure that, well what's your views are on the risk of that material to biota?

DR JEFFREE: Well again if you just, there is two points to this. I mean in terms of the dilution of the effluent again, you know, above or behind it is not a problem. Sorry, there was a bit of interference then. There is another mechanism for meeting the various submissions, there is this

mechanism of fine suspended material in this layer of water that sits above the benthic zone.

This 10 or 15 metres above the benthic zone of this fine particular material that was not there before and they would have a high affinity for the most important radionuclide for benthic exposure which is polonium 210 and so that's another exposure pathway that was not there before and I think we all agree in the committee that if mining went ahead, then that would have to be monitored because it is something that did not exist there before.

It is another exposure pathway for filter feeding organisms so in other words they could have higher concentrations in their body even relative to the levels in the water because there is another concentrating mechanism and exposure pathway for them.

MR JOHNS: Okay, thanks very much.

CHAIRPERSON: Thanks Dr Jeffree, that clears the committee and I have got notice of impending questions first from Mr Currie on behalf of Greenpeace, Kiwis Against Seabed Mining and the Deep Sea Conservation Coalition.

DR JEFFREE: Okay, thank you.

[3.35 pm]

MR CURRIE: Thank you Mr Chair. Good morning, Dr Jeffree.

DR JEFFREE: Good morning.

MR CURRIE: Just a few questions. Firstly, in paragraph 4 you say that polonium-210 is the most relevant radionuclide for consideration of potentially enhanced exposures of humans - - -

DR JEFFREE: Yes.

MR CURRIE: - - - yes, to radionuclides in seafoods. So polonium strongly bioaccumulates up the food chain into fish, does it not?

DR JEFFREE: Yes it tends to follow, it is transferred from one trophic level to the next predominantly through food. So the other exposure pathways of accumulation from water are not so important as transfer via food.

MR CURRIE: And can eating seafood with high levels of polonium affect human health?

DR JEFFREE: It is all a matter of the radiological dose assessment to make an estimation of the likelihood of impacts. You know, it is about one hundred times more significant than the most significant artificial radionuclide which is caesium-137 which of course is coming out of the Fukushima accident at the moment. So in terms of detriment to people, you know there is not people falling over in the street dying from polonium exposure, it is just part of the background exposure.

MR CURRIE: Can it affect human sperm for example?

DR JEFFREE: Well you know again it is this sort of background exposure that we are all susceptible to and, of course, I mean every radioactive decay can affect every cell in our body. It does so on a frequent basis. So yes we are affected all the time by background radiation including polonium.

MR CURRIE: Is polonium one of the reasons tobacco is considered to be so carcinogenic?

DR JEFFREE: Yes, because it is very highly absorbed it tends to accumulate to higher levels on the surfaces of tobacco leads to my knowledge, and has been implicated in one of the reasons why cancers are induced in lungs from smoking tobacco.

MR CURRIE: Thank you and finally on bioaccumulation and the Committee asked you some questions about this as well. Looking at I think the last paragraph, your overall assessment, it was paragraph 4.

DR JEFFREE: Paragraph 4?

MR CURRIE: Yes, you said polonium-210 is the most relevant – yes paragraph 4 on page 2.

DR JEFFREE: Yes.

MR CURRIE: And then you describe the pathway.

DR JEFFREE: Yes it is a notional pathway but it - - -

MR CURRIE: It is a conceivable pathway?

DR JEFFREE: It seemed plausible, yes.

MR CURRIE: Thank you, and my last question Dr Jeffree relates to the issue of dilution which you discuss with the Committee. If the degree of dilution is clearly as you say critical as a risk factor, how confident are you with the present models dilution factors?

DR JEFFREE: Yes well I mean this was something that I think we have all agreed on in the caucus that because, you know the first assessment of, the first modelling of dilution came up with a factor of 200, 250. The next one came up with a factor of 750 for the new field, so then I started to think about well what are the aero-bars**(ph 4.16)** on these dilution factors? They are only varying by a factor of three, three and a half anyway, and if you went to the other end of the spectrum, if they are erring by a little bit more than that then you are below 200 and you are into this risk region where you have to say to yourself we have to go to a tier two assessment to really make a much more site specific evaluation of the radiation risk prior to mining.

MR CURRIE: Thank you Dr Jeffree yes, no further questions thank you very much.

CHAIRPERSON: Thank you, Mr Currie, and CRP the applicant I think had some questions. Mr Winchester?

MR HARWOOD: I have just got a couple of questions sir. It is Hamish Harwood speaking, I am Junior Counsel for CRP, Dr Jeffrey.

[3.40 pm]

Just on the subject of polonium, were you here when Dr Hermanspahn advised the Committee that polonium would stick very strongly to other suspended sediments and would, therefore, in layman's terms, fall out of the water column quicker than uranium?

DR JEFFREE: Yes, I was, and I agree completely that is true, it would attach to particles, either it would attach to particles on the benthic layer or it would attach to those particles that have been indicated would be part of the resultant effluent plume. So yes it has a very high absorbency heights.

MR HARWOOD: Thank you for that. And you are obviously aware that uranium is naturally present in seawater, isn't it?

DR JEFFREE: Yes of course.

MR HARWOOD: Can we please turn to your table 1 which is between paragraphs 14 and 15 of your report?

DR JEFFREE: Table 1? Yes.

MR HARWOOD: In the second column under uranium-238 the value for fish is set out there. Could you please explain what that means?

DR JEFFREE: You are talking about the whole body concentration factor one to the exponent 10 to zero which is one. So in other words the fish reflect simply what the level of uranium would be in an equivalent volume of seawater. So there is very little accumulatory capacity of fish for uranium-238, or none at all really.

MR HARWOOD: Okay, so that says that uranium does not bioaccumulate in fish at all?

DR JEFFREE: No, it tends not to bioaccumulate, and hence the reason why it does not have a radiological significance compared to these other radionuclides.

MR HARWOOD: Thank you for that clarification. Dr Crauford I think summed it up beautifully when she said that dilution is the key issue perhaps, I may have got the wording wrong, but if we were to turn to page 2 of the joint statement on radioactivity – have you got that in front of you?

DR JEFFREE: I am sorry, I do not have it in front of me but I read it recently.

MR HARWOOD: Oh, no trouble, I will just read it out. It is the second bullet point there and the experts there agreed that the latest sediment modelling calculates a dilution factor of 750 at a distance of 250 metres from a diffuser.

DR JEFFREE: Yes.

MR HARWOOD: That is obviously more than three times more than the dilution level of 200 that you refer to in your evidence?

DR JEFFREE: Yes, that is true.

MR HARWOOD: Thank you for that, no further questions.

DR JEFFREE: Thanks very much.

CHAIRPERSON: If there are no further questions then Dr Jeffree thank you very much, both for the evidence which you contributed a while back and also for your testimony today, much appreciated.

DR JEFFREE: Okay, thank you very much. Good afternoon.

CHAIRPERSON: Good afternoon. The last witness on my list whose alarm should be going off in the UK about now is Dr David Santillo. He is due to come on stream at four o'clock so I suggest we take a break now and return in time for that. Thank you.

ADJOURNED [3.43 pm]

RESUMED [4.00 pm]

CHAIRPERSON: Okay, now the last witness today, called by Greenpeace, Kiwis Against Seabed Mining, the Deep Sea Conservation Coalition, is Dr David Santillo who may or may not be on standby awaiting a call.

Dr San - - -

DR SANTILLO: I'm certainly here if you can hear me?

CHAIRPERSON: Thank you very much and my congratulations on what must have been an ungodly early hour that you got up, so I'll invite Mr Currie to introduce you.

MR CURRIE: Thank you, Mr Chair, very good morning Dr Santillo, the Committee have your statement of evidence, Dr Santillo, so will you please give a, I think a brief summary of your evidence to the Committee, everyone is here I think by and they can hear you, thank you, and then please remain to answer questions by the Committee and by other parties.

DR SANTILLO: Thank you very much, and I very much appreciate you enabling to do this via skype, and I hope the – it's okay and to be clear – I'm getting some considerable feedback, I'm hoping that's what's coming through at your site.

My name is Dr David Santillo. I am a Marine Biologist and Environment Chemist and I work with Greenpeace Research Laboratories and we're based at the University of Exeter, southwest of the United Kingdom and it's the early hour of my engagement to speak to this evidence.

The evidence that I have submitted and that I'll briefly present to the hearing relates specifically to my experience within international regulation relating to marine environmental protection, with particular regard to the disposal of wastes or other matter at sea and the

obligations of states and contracting parties to those international treaties to take all possible measures to protect and preserve the marine environment.

Now I've worked within the London Convention and London Protocol over many years beginning back in the mid-1990s and have sat for Greenpeace International on the technical scientific group and the meeting of parties and also on a number of ad hoc working groups to address various issues relating to the disposal of wastes or other matter at sea over that period and continue to do so.

One of the many concerns for the protection of the marine environment from the introduction of waste or other matter to the marine environment or the redistribution of materials within the marine environment is the occurrence of radioactive substances within those materials, and that's of concern not just if those radionuclides are manmade, it's a concern also where the radionuclides are naturally occurring, and it's also an issue even where those radionuclides are present at naturally enhanced concentrations.

So whether a substance is naturally occurring or manmade, of course there will be specific radiological concern for certain manmade radionuclides, but there are also concerns relating to the natural occurring ones where they're present at naturally higher levels.

And that's clearly something which is of relevance in connection with the Chatham Rise, and particularly the materials – the phosphorite mineral deposits which are proposed to be exploited because of the relatively high uranium series content of those materials.

[4.05 pm]

The concerns therefore relate – not to the introduction of new radionuclide materials to the marine environment from this proposal, but the likelihood that during the exploitation, the onward processing of those mineral deposits but a proportion of the radionuclides from those materials will inevitably become redistributed within the local marine environment and perhaps also on a wider field away from the mining side.

And those concerns relate both to the redistribution of dissolved radionuclides in water in the disposed waste streams, but also the redistribution and re-sedimentation of particulate materials which contain elevated levels of radionuclides.

And that is a particular concern if those materials can be carried over a wider area, not just within the mining site but also to form a surface layer in areas on the boundaries of the site that is being actively mined.

The reason that this is a concern is because the body which is charged with giving guidance and preparing guidelines on the assessments of radioactive materials, that is the International Atomic Energy Agency, the IAEA, has a concern for the modification of radiation fields, so this is once again of concern even if materials are being redistributed within the marine environments and not just relating to new materials that are being introduced.

New Zealand is a party to a number of international treaties and conventions that have the aim to protect the marine environments, and under the London protocol and also under the United Nations' Convention on the Law of the Sea, and on the more regional Noumea Convention, New Zealand has an obligation to take all possible measures to protect and preserve the marine environments from all sources of pollution, and although the situation regarding the regulation of the disposal of waste and other matter relating to seabed mining is complex, that overarching objective is there in all of the relevant Treaties governing human activities in the marine environment.

So there is an obligation to control all sources of pollution.

Putting those two things together, and recognising that the IAEA has said explicitly that in certain circumstances the redistribution of radioactive substances can give rise to legitimate radiological concerns when relocated, there appears to me to be a very strong case for a detailed and site specific assessment of the radiological implications of the proposed seabed mining operations in this area.

Added to that, the availability of recently updated guidelines developed by the IAEA which do enable the conducts of a full de minimis assessment of materials, and by de minimis, what I am referring to here is whether radiological examination can be considered to be exempted or excluded from regulatory control.

The methods exist for that kind of assessment to be carried out on a site specific basis and can, where necessary, lead to a more detailed specific assessment of the potential for radiological impacts where there is a change to the radiological field including in the water column and in sediments.

So recognising that there are some gaps in knowledge there are uncertainties in the detail of the modelling that's being conducted so far.

[4.10 pm]

This is information which is available, of course, from documents available to the Committee, including the joint statements of evidence from the experts, the fact that uranium decay series nuclides are present in these surface deposits that will be mined, and some of those uranium decay series, radionuclides have a high affinity for sediments and maybe expected to re-deposit in particulate material onto the seabed, and also become dissolved to some extent in the plume from the waste. This is clearly an area where there is a need for deep assessment.

At present, on the basis of the information available it does appear that that full assessment, the site specific one, has not yet been done at least not to the extent that could ensure New Zealand's obligations to take all possible measures to protect and preserve the marine environment.

And while we note of course that research during and after mining operations have begun would be possible, there is a clear justification for such research to be done in advance of granting consent, because that's the way, and the only way in which a more complete assessment could lead to an insurance that all possible measures are taken to protect and preserve the marine environments, and that would be consistent with the application of the precautionary principle and with the principle of avoidance of harm as a priority over subsequent mitigation or remediation.

So that concludes my presentation. I hope that the evidence that's brought before you is of value and interest in the spirit in which it's been brought forward, and I'm very happy to take any questions. Thank you.

CHAIRPERSON: Thanks very much, Dr Santillo, both for the testimony and for being prepared to hang in there for a little while yet. I'll turn first to the Committee and then to the parties to the application. David?

MR HILL: Thank you, Dr Santillo, David Hill here. Good morning to you.

DR SANTILLO: Good morning.

MR HILL: I don't really want to ask any questions with respect to the various convention and protocol that you've outlined for us, thank you very much, we'll receive obviously legal representations on that – we have

already and we'll get some more on that I suspect. What I am interested in though is towards the back end of your evidence where you're talking about the IAEA's tech doc 13.75 and the issue of de minimis. You are aware, I take it, Dr Santillo, or have you been provided with the outcome of the expert conferencing on the radioactivity?

DR SANTILLO: I am not certain which - - -

MR HILL: Were you provided with a document that lays out the findings or conclusions and assumptions, et cetera of the expert group on radioactivity?

DR SANTILLO: What I've seen is the joint statement of experts.

MR HILL: Yes, that's the joint statement, yes. So can I assume, or let me ask you the question, and we've had a discussion today with various experts here about the ERICA model that's used and the tier 1 to 3 levels of assessment. Are you familiar with that model and those tiers, and I guess the question is how does that fit in with the IAEA's guidelines, if at all?

DR SANTILLO: Well the modelling in so far as I am aware of the modelling that's been done, it is at the moment a relatively low tier, and it's been using also the approaches that are consistent with the International Commission On Radiological Protection, the ICRP. My understanding is that the modelling that's been done of radiological risk relates to a more generic assessment so far, a tier 1 assessment if you like, rather than a more specific site related assessment and the - - -

[4.15 pm]

MR HILL: Yes, but if I can just pause you there just for a moment. But the joint statement outcome heralds, if you like, or recommends some ongoing assessment monitoring and so on for radionuclides and so on and I guess it was just a question, in your mind, whether there is any sort of parallel, comparable or not, with whatever TECDOC-1375 says?

DR SANTILLO: Well, the new guidance provided by the IAEA will certainly be more detailed and give the opportunity to be more site specific than the tier 1 modelling provided by the ICRB guidance. So it does give the opportunity for far more site specificity and more detailed consideration of the risks to flora and fauna but that would certainly be the case.

MR HILL: And I think did I see in your evidence that is not yet – is it published or is it still in draft, what sort of status does that have at the moment?

DR SANTILLO: It is - - -

MR HILL: Oh, no, it is 2003 so it is obviously live, okay.

DR SANTILLO: Well, there are two – if you forgive me, there are two versions. The original version was published in 2003 and that provided for detailed site specific assessment but only on the basis of criteria relating to human health, either direct exposure or exposure through consumption of seafood. The 2013 updated guidelines allow for direct assessment also of flora and fauna, risks to flora and fauna. Now, that guidance is published, it's published as a draft, but it has already been applied by a number of the contracting parties. The UK is one of those and I am sure there are others also that have begun applying it. The United States I think also has some experience of doing that flora and fauna assessment for particular material.

MR HILL: Thank you very much for that, Dr Santillo.

CHAIRPERSON: Thank you. Greg? No questions. Nicki?

DR CRAUFORD: Dr Santillo, Nicki Crauford here from the Decision-Making Committee. Notwithstanding the legislative environment that we have to deal with and as my colleague has said we will no doubt get some views on that from various parties. Would you say that by considering a marine consent under the legislation that we are considering this under, the Exclusive Economic Zone, that to some extent we are at least complying with the intent of the Noumea Convention?

DR SANTILLO: I think complying with an intent is an interesting phrase. I think certainly in going through the marine consent considerations and this hearing being part of that, I'm sure that you are fulfilling many aspects of New Zealand national law. I think the spirit or intent of the Noumea Convention is certainly a very broad one, I mean to take all possible steps or measures to protect and preserve the marine environment to me implies that there is a detailed knowledge and assessment on which to base those actions and to ensure those actions are precautionary in nature.

And I think from what I have seen so far of the evidence available to yourselves on the Committee there are a number of aspects, uncertainties, gaps in there which would seem to be things that would need to be fulfilled and addressed in order to fully carry out the intent

of the Noumea Convention and also the other marine conventions that I have mentioned.

So I think there is probably a distinction to be made between the actual letter of the legal requirements that you are required to follow within a marine consent hearing and the broader intent of conventions like the Noumea Convention which, you know, place a requirement and obligation on parties to take all possible measures in the protection of the marine environment.

[4.20 pm]

DR CRAUFORD: I am sure you would agree that in our role we have to, however difficult it is, balance the two.

DR SANTILLO: I would certainly accept that and I understand that this hearing and the receipt of evidence including my evidence would be part of that process of considering and balancing those different things so I am just hoping that the additional considerations that I am suggesting is something that can be taken as part of that consideration under the consent application process.

DR CRAUFORD: Thank you very much.

DR SANTILLO: Thank you.

CHAIRPERSON: Lennie, no, so no further questions from the committee, the applicant, CRP, I think notified us that they have some questions.

MR WINCHESTER: Yes, just a few.

CHAIRPERSON: Mr Winchester?

MR WINCHESTER: Yes, thank you sir, good morning, Dr Santillo, it is James Winchester here, I am counsel for Chatham Rock.

DR SANTILLO: Good morning.

MR WINCHESTER: I just have a few questions so I will not keep you long. First of all are you familiar with the legislation that we are working under, the Exclusive Economic Zone Act?

DR SANTILLO: I do not have a detailed knowledge of the Exclusive Economic Zone Act. My knowledge of the case has come from the reading of the various evidence documents and joint statements that have been presented and also of course the application itself so I do not

claim to be an expert in the EEZ Regulations that you are working under.

MR WINCHESTER: Thank you, and before you prepared this statement of evidence did you take legal advice about the application of the various conventions and protocols that you refer to in your evidence under New Zealand law?

DR SANTILLO: I have had legal discussions with people I have not taken formal legal advice. The evidence that I am presenting is based on, as I have said, my experience and understanding that has developed from working within the London Convention and Protocol over many, many years and I was present at the discussions with IAEA when the original cleanliness approach was established and I have been present at all of the meetings in which it has been discussed since then.

The evidence I am presenting is based on an understanding of the legal situation, it is not based on a detailed seeking of advice from legal professionals so my evidence is offered in that spirit of experience.

MR WINCHESTER: Yes, so thank you, it is not specific to the New Zealand context necessarily?

DR SANTILLO: No, it is certainly more of a global overview with reference of course to the conventions that are relevant to New Zealand as New Zealand is party to them.

MR WINCHESTER: Thank you, that is very helpful. Can I just ask you to look at paragraph nine of your evidence and you refer there to the concentrations of naturally occurring uranium etcetera being towards the higher range reported for phosphorus bearing sediments and considerably above levels which would normally be expected to occur in uncontaminated marine sediments. Is it your view based on what you know about the Chatham Rise and this application that the Chatham Rise is natural and uncontaminated?

DR SANTILLO: The Chatham Rise, the radionuclide content of the sediments on the Chatham Rise do not arise as a result primarily of human intervention, human contamination so far, so we are looking at naturally occurring radionuclides in naturally occurring deposits, but the concentrations of uranium and uranium DK series are radionuclides within those sediments are naturally higher than you would expect to find in uncontaminated sediments.

The reason that I refer to uncontaminated there is that there are of course sediments in some regions which contain high radionuclide

contents not because of natural processes, but because of human interventions over the decades, that is the distinction.

MR WINCHESTER: Yes, no thank you for that. When you refer to the high levels of uranium in the sediments it is the case that it is actually in the phosphorite nodules which are contained in the sediments, is it not?

[4.25 pm]

DR SANTILLO: That's right, yes, the high levels of radionuclides are associated with the phosphorite deposits, and that's a natural phenomenon which occurs in phosphorite deposits at various concentrations in different parts of the world.

MR WINCHESTER: And so the flipside of that, to simplify it is that the sediments themselves that contain the phosphorite nodules contain relatively low levels of uranium don't they?

DR SANTILLO: I think that the sediment is a complex mixture of different particles, so I would consider the phosphorite materials to be part of the sedimentary characteristics of the Chatham Rise.

MR WINCHESTER: Thank you. Just a final question, have you read any the statements or caucusing statements about conditions of consents and have you given that issue any thought?

DR SANTILLO: I'm sorry I don't really – I'm not sure I fully understand your question, which consents are you referring to or - - -

MR WINCHESTER: Sure. Well you understand that if a marine consent is granted in this instance the panel has the opportunity to impose conditions on the marine consent?

DR SANTILLO: Yep.

MR WINCHESTER: Just as a general proposition, Dr Santillo, based on the concerns expressed in your evidence would you be happy with radiological testing for key radioisotopes in some of the specific fish species as a monitoring tool, do you think that's appropriate?

DR SANTILLO: I think that monitoring for radionuclides in locally relevant fish species can be a contribution to a monitor – field monitoring programmes for any activities, and I think it would be interesting also to know whether there have been any change in the radiological fields and the results of other human activities that have taken place in the past in this area.

I think my concern though, is that having field monitoring conditions as part of a consent, doesn't really answer the more fundamental question in my mind, which is, "Should the consent be granted given the potential for this change in the radiological field were the mining operations to go ahead", so I see it as being a step before that. There's sort of the information that would come from a detailed site specific assessment, would be able to inform the Decision Making Committee as to whether consent was the right thing to grant at all, and that's irrespective of any conditions that would be applied were that consent granted.

MR WINCHESTER: Yes, thank you for that, no I think you've made that point very clear and you've answered my questions, so I appreciate that and hopefully you may be able to get back to sleep, thanks for your time.

DR SANTILLO: Thank you very much.

CHAIRPERSON: Thank you, Mr Winchester, any further questions from other parties?

If not, Dr Santillo, you've got a whole day ahead of you and we won't hold you any further, thanks again both for your statement of evidence and for your testimony and answers to questions today all of which we do appreciate, thank you.

DR SANTILLO: Thank you very much, thanks for making the arrangements.

CHAIRPERSON: Okay, tomorrow we have three expert witnesses on sedimentation, the trophic model and ecosystem effects and then for something completely different two witnesses on the question of economic benefits, so we'll resume the hearing at 9 o'clock tomorrow morning, thank you.

MATTER ADJOURNED AT 4.29 PM UNTIL WEDNESDAY, 15 OCTOBER 2014