T R A N S C R I P T

ENVIRONMENT, NATURAL RESOURCES AND REGIONAL DEVELOPMENT COMMITTEE

Inquiry into the CFA training college at Fiskville

Melbourne — 9 November 2015

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Witnesses

Professor Jochen Mueller, and
Dr Lesa Aylward, National Research Centre for Environmental Toxicology, University of Queensland.

The CHAIR — I thank Professor Jochen Mueller and Dr Lesa Aylward for attending today. I will just go through some of the formalities before we start, and then hand over to you. If you would not mind, when I hand over to you could you tell us a little bit about yourselves and then go to your presentation. As outlined in the guide provided to you by the secretariat all evidence at this hearing is taken by the committee under the provisions of the Parliamentary Committees Act 2003 and other relevant legislation and attracts parliamentary privilege. Any comments you make outside the hearing will not be afforded parliamentary privilege. It is an act of contempt of Parliament to provide false or misleading evidence to the inquiry. The committee may follow up with a further request for information, if that is okay with you. All evidence is being recorded, and you will be provided with a copy of the transcript to check for accuracy before it is published publicly. With that, I will hand over to the two of you to present, and of course we will then have lots of questions we would like to ask you. Thank you.

Dr AYLWARD — We talked about it, and I am going to start because some of the information I present is sort of background to things that Professor Mueller will present. My name is Lesa Aylward, and I am a scientist consultant in chemical exposure and risk assessment. I have worked in the field for about 30 years in the United States. I am also an honorary associate professor at the National Research Centre for Environmental Toxicology — Entox — at the University of Queensland. My research over the years has focused on the use of biomonitoring in chemical exposure evaluation, chemical exposure response assessment and related fields.

I was asked to come and speak about some background information about how biomonitoring can be used in exposure evaluation for chemicals and some of the strengths and limitations and considerations in that area. So with that, I will start.

Visual presentation.

Dr AYLWARD — As I said, the specific questions I was asked to address were the value of biomonitoring for understanding human exposure to chemicals, the ways that biomonitoring is used to track human exposure to chemicals in the environment, a little bit of an overview of toxicokinetics and other characteristics of chemicals and how that informs approaches to biomonitoring, and limitations of biomonitoring in measuring exposure to chemicals.

I understand that the context of this is with respect to issues surrounding the Fiskville site, so I will try to address some examples and information directly to those sorts of issues — issues relevant to the site — as I go through the more general information.

When I talk about biomonitoring and biomarkers, there are a variety of meanings for those words depending on a specific context. What I am going to be speaking about is the measurement of a chemical or its metabolite or breakdown products which is one of those two things we would call a biomarker in a biological tissue or fluid.

There are actually a lot of different biological media that can be used for biomonitoring. Most often people are talking about measuring chemicals in blood or urine, but hair, saliva, breastmilk, toenails and fingernails — all of these are media that can potentially be analysed. The choice of which are analysed depends on a number of considerations, some of which I will talk about here.

When we think about chemical exposure in the environment, it can be a pretty complicated picture. We have the potential to be exposed to chemicals from a variety of media — from air, from water, from contact with soils or dust, in our trace chemicals, in our food, in consumer products — and then it can be inhaled, it can be ingested, it can come through the skin. So it is a pretty complicated picture if you are trying to do an assessment of exposure in an individual or in a group of people. You have to go out and make measurements and make assumptions.

When we do biomonitoring, though, we are actually getting an aggregated picture. So even if we do not know precisely the ways that a chemical is getting into an individual, we can measure it in the blood or the urine, and that gives us a full picture of what they have been exposed to, even if we do not know exactly how it got there. But at the same time it does not provide information about how it got there, so it is a strength and it is a limitation at the same time.

When we talk about uses of biomonitoring there are a number of categories, a number of types of applications. One of the big ones over the last 15 to 20 years really has been beginning to understand general population

exposures to chemicals. There are national programs in Australia, in the US, in Canada, in Germany, in Belgium; there are quite a number of countries that have national biomonitoring programs, where they look for a variety of chemicals in their population to track levels. Using that information they can understand what things people are frequently being exposed to. They can track changes in exposure levels over time, so if you do repeated studies over a time period, you can track that. We can use biomonitoring to evaluate exposures in specific populations, so with a community or a group of workers in a particular area we can measure their exposures and then we can compare it, for instance, to what we see typically in the general population to decide if it looks like they may be exposed to an elevated amount. We can also in some cases, depending on the chemical, make comparisons to health-based levels. We can say, 'This community maybe has an elevated exposure, but it is still far below the level that might be of health concern' or some other conclusion. There are a couple of different ways to look at information that you get from looking at a specific population.

Finally, we can use biomonitoring in studies where we start to examine possible associations or relationships between exposure and health effects. That is a complicated undertaking, and it requires a lot of considerations because in most cases the health effects that people are looking for have many potential causes. That is a difficult thing to do, but it is a very powerful thing. If you can look at populations and do studies that include biomonitoring information, it is very, very helpful. In some cases it is stronger than just doing external assessments of exposure. It does not provide good information about health effects for individuals though, because in general measuring the chemical in an individual and looking at their health situation will not tell you if that chemical caused whatever health issues that they might have. There are just too many factors that go into health-related issues in most cases.

Biomonitoring works really, really well in issues, in situations where you might have a local community or an occupational population when you pair it with measures in the environment. When you look at chemicals that may be present you can ask, 'Who may have been exposed?'. You could ask, 'Can we measure the chemical in the environment and in the people? Are the biomarkers available? Are there things we can actually measure, and if so, are they elevated? And if they are elevated, how are people exposed?'. We can go back then to the environmental media and say, 'All right, we're finding it here and their people are contacting it, so now we think we have a link'. Then that also provides information that may allow us to take steps to reduce exposures if we understand the linkage between the environment and the people.

Now I am going to talk a little bit about the characteristics of chemicals and how they inform deciding to do biomonitoring and what type of monitoring you might do. In particular I was asked to talk a little about toxicokinetics, and toxicokinetics really is just how quickly the body can get rid of a chemical. PFOS, which I know is an issue here, is a chemical that is very persistent. It hangs around for a long time in the environment, in the body, and so if you have an elevated exposure to PFOS at some point in time, you can go back later and you can see that a person had elevated exposure for quite a number of years after that exposure happened.

In contrast some of the other chemicals that I think may be of interest in the potential exposures of firefighters and the issues associated with the site are things like combustion products: PAHs — polyaromatic hydrocarbons — diesels, solvents, other combustion products. Most of those are very short-lived in the body. If you are involved in a situation where you have an exposure, very shortly thereafter there is no record that can be detected in the body. The choice of whether you look for something as a biomarker of what happened at some point in the past depends on how rapidly the body gets rid of that chemical.

There are other chemical properties that influence how you biomonitor for something. You want to understand the physical chemical properties of the chemical, whether it is water-soluble or fat-soluble, whether it is well metabolised, whether it tends to bind to protein in the body. All of these things are considerations that you take into account when you decide how to go and biomonitor for a chemical or if you can biomonitor for a chemical. In the case of this, the perfluoroinated compounds, the other persistent organic pollutants that are part of the Stockholm convention, these chemicals tend to be things that we look for in blood because they tend to hang around in the body a long time. A lot of them tend to be fat-soluble, although not the PFCs — they tend to bind to proteins. Those are ones that we typically look for in blood.

A lot of other chemicals, things we think about in terms of consumer product exposures — the phenols and phthalates, the PAHs as I discussed, some of the pesticides that are currently used — tend to be relatively short-lived and they or their metabolites tend to be excreted in urine relatively rapidly. If we are looking for those, we look at the urine, but again that only tells us about very recent sorts of exposures. Then there are other

categories of chemicals that depending on the specific chemical and their characteristics you might look for in urine, you might look for in blood, and they have differing periods of time over which that would be informative to look for those.

One quick example if we are looking at biomonitoring data. This is actually data that was part of a study we did in conjunction with Entox on firefighters at airports in Australia, and it was published earlier this year. We compared the levels that we saw in the firefighters to levels that we know are typically found in the Australian population. The scale on the left is a logarithmic scale, so every line is tenfold higher than the one before. There is a real difference here between these two groups of individuals. We can look at that and say, 'Yes, the firefighters seem to have elevated exposure compared to the general population'. The biomonitoring data gives us a very clear picture of this.

We can also look at this data in a health effects context with respect to the levels that have been measured in animal studies. This is an example here. This is a level that was measured in animal studies — this was a monkey study — where there was no effect of PFOS found. We can look at that, and now we can do some quantitative comparisons of how the levels we observed in the general population and in the firefighters compared to that level in the animals. The degree to which you are below that level is important, and it is something that you would like to be as low as possible relative to those kinds of studies. But it does provide some context in terms of the levels that we found were not at a level where we were seeing effects in animals, for example. They were well below that. This is a no-effect level in the animal tests. It gives us some additional context interpreting those biomonitoring data from those individuals.

Mr McCURDY — Just on that, America has a standard, doesn't it?

Dr AYLWARD — For blood?

Mr McCURDY — Yes.

Dr AYLWARD — No. To my knowledge, nobody has actually set a level for blood, although this kind of comparison has been done for the perfluorinated compounds by the European Food Safety Authority. Health Canada, the Canadian environmental agency, also make comparisons like this, but it is quite informal right now with PFCs in part because I think people feel the science is still evolving on the issues.

I am just going to sum up strengths and limitations of biomonitoring. It does provide information about aggregated exposure from all routes and sources, which is very helpful, especially when you have a complex situation where you do not have a full understanding of where the exposure sources are. It provides biologically relevant measure exposures, so you really are measuring what is inside the body, which is relevant to what might happen in response to that chemical. It provides information about exposure for both a population and also for an individual. The limitations are, of course, that biomonitoring does not identify a specific exposure source, so it is most informative when you are using it in conjunction with environmental measures as well: 'We see the chemical in people. How does it get there? Let's look and find out what the pathways are'.

Information about past exposures — you do not get information about that for chemicals that are very short lived; you only get information about that for persistent chemicals. It does not allow prediction of health effects for individuals, so while we can study a population, look for associations and maybe come to a conclusion that that is a cause-and-effect relationship, although not always, for an individual, it really does not provide information that allows you to say, 'Aha! That health effect is associated with that chemical'. It really is much more complicated than that generally on an individual basis. With that, I will finish and let Professor Mueller speak.

Visual presentation.

Prof. MUELLER — I am Jochen Mueller. I thought I would use my first slide to introduce myself because I grew up near our own little Fiskville. I grew up on a farm. I actually did an apprenticeship as a farmer. When I was in my early 20s there was a big scandal and dioxins were discovered from a cable waste incinerator 3 or 4 kilometres from my parents' place in paddocks that were still associated with this. I think in those days the media did not have very much to write, so they scared everybody like mad by talking about dioxins and Seveso, which was a big incident in the past. That really left a big mark because from that moment on I wanted to study

dioxins, and that is when I went to university and studied for the rest of my life these persistent organic pollutants.

The government of my state actually spent $20 million — and I am not sure whether I should say this openly in the parliamentary inquiry — to dig out some of the soils, carry them into the forest and bury them there. I think they actually released more chemicals in the process of digging it out. But they did not know, and it was probably a decision driven by media and the population. It was a really scary period for the people of our town, and it led to me studying POPs for the rest of my life. This is an article that was published in *Der Spiegel*, which is a big German outlet. So this is me, and since then I am studying dioxins. My wife sometimes makes jokes about whether I could do something useful with my life!

My assigned task here is — this slide is a cut-and-paste from what you sent me. I was asked to provide an overview of the work of my team that we do on dioxins and other persistent organic pollutants, and I thought it really was much more about perfluorinated chemicals, so I am talking more about perfluorinated chemicals, but there is a bit of a touch on dioxins in where we go. Then there is the current research and most recent evidence on the effect of human and environmental exposure to POPs. Now, I understand Brian Priestly gave a big overview of the health effects of PFOS and perfluorinated chemicals, and this hearing is too short to talk about dioxins, so I will actually only touch briefly on this. I will now jump to question 3, which is 'Current approaches to monitoring exposure to POPs and how this is evolving'.

Very briefly, in answer to question 1, an overview of the work of our team, as I said, I have studied dioxins since the 1980s — or certainly the early 1990s — and nobody really cared about dioxins in Australia. I actually put a proposal to the Victorian government in the mid-1990s and I was told there was really no interest. Then Australia signed and ratified the global treaty on persistent organic pollutants, and I was like this little tree in a big rainforest where the big brother just fell over and I could grow. In 2002, because there was this sudden need for anybody with some experience in dioxins I led seven or eight of the national dioxin programs. Then we used what we did there to also run the national programs on brominated flame retardants, and it got us into the perfluorinated chemicals, because you need colleagues who say, 'Hey, should we analyse your samples also for perfluorinated chemicals?'. 'Yes!'.

Another big part of what our research group does is measure chemicals in waste water to measure how many drugs are used in the population, including in Victoria. It is all related to monitoring chemical exposure in the population. To say that we have worked on perfluorinated chemicals since I started a collaboration with Anna Kärrman from the University of Örebro, and we work a lot with the US CDC and the US EPA, and we are involved in a couple of EU projects. All of this is only possible because I had three fantastic PhD students who did all the work, and I took all the credit for it. We get funding from various ARC grants, and we get other funding.

I have this broken up slide, which has been handed out probably in five slides or six slides, but I thought in one slide I would give you an overview of PFC research from our team. First of all, we recently published a paper that firefighting training grounds are a big source of PFCs in Australia if these AFFFs were used. It was really a revelation to me. The cement at these firefighting training grounds is like a sponge. It has sucked up the perfluorinated chemicals, and they slowly come out in the future. For something like PFOS it will take, we estimate, I think, 50 years. In 50 years there will still be half of the PFCs in it, so it is going to be a source in the future. Unless we dig it all out, it will still be a source into the future for many years to come.

We have to be clear that PFCs cannot be removed with normal conventional treatment methods. The only real treatment that works in the removal of perfluorinated chemicals — PFOS — is reverse osmosis, which is very expensive and very carbon ineffective. We only use reverse osmosis in places where there is no water available. It is not really good. Essentially your water source decides what comes out of it. Wastewater streams are therefore a source of perfluorinated chemicals in the environment. In all effluent from all wastewater treatment plants we find perfluorinated chemicals in the 20 to 30-nanograms-per-litre range. This is typical all over the world, including in Australia. Perfluorinated chemicals can be found at very low levels in the drinking water throughout Australia. Now we are talking about the sub-nanogram-per-litre level. I guess nanograms do not mean very much. It is 10^{-9}. Some people would call it bugger all — so very low levels. They are on the low end of the concentration. Drinking water in itself is not a big source for us; food is probably a greater source for us for our general population.

What I am trying to say with this one slide is that PFCs are everywhere. Firefighting training grounds are a source. They can be found in all our water bodies, at least in coastal areas. They have been found out there in the oceans at very low levels. Some PFCs can be found in the air, and the reason they are a POP is partially because some of them can be found in very remote areas. I can assure you that every person — every Australian and non-Australian on this planet — will have some residue perfluorinated chemical levels in their blood, and we would be able to measure it. That really sums this slide up.

Now I am jumping into the human biomonitoring program that commenced in Q3. Part of that is a good news story. With this national dioxin program, the government said, 'Jochen, can you tell us the average concentration of dioxins in the Australian population?'. I think the government wanted everybody in Australia to give 1 millilitre of blood and for us to put it in a big bucket, stir it around and analyse it. We did it almost like that; we got 10 000 de-identified blood samples from leftover pathology, put them into 100 pools, each containing 100 different individuals, we stratified them — stratified means we grouped them by age, gender and postcode, and there was a postcode for this southern area as well — we divided them and then we analysed them.

That was really the start of our human biomonitoring program. It was so difficult to start it that we decided we were going to continue it into the future. Out of this came this program where every two years we collect new samples. Now we are down to 2400 samples. We included a new group for small children. Every two years we collect these samples, and we analyse them and compare them. What you get is a figure like this. On the X-axis you see the age, and on the Y-axis you see the PFOS concentration. Each dot on this figure is 100 different people, and it means an average of those 100 people or a mean of those 100 people. The green dots are a bit different because we broke them up into smaller groups. But you can now see the good news story from this, of course, is that the PFOS level in the Australian population has decreased by probably threefold since 2002 to 2010–11. That is really what the government wants to see. We recognise a problem, we do something about it and here is the result — the levels have decreased.

Mr RAMSAY — Did you do those tests in high-risk, high-range populations?

Prof. MUELLER — No, they are completely random Australian populations. There could be a sample from you in there. They are really random. Lesa already showed you that left dot. We used a little bit of statistics. We tried to go from an average level — because 100 does not really represent how the population is distributed — and we applied other studies from around the world to define the distribution around our mean. I can explain that if anybody is more interested. We tried to do that to be able to compare with samples from individuals. This is again the firefighters — this is the Canadian average population, but on the right there are the firefighters — and these were 150 or so firefighters who actually do not see very many fires other than those where they practice, but they used to take this practice fire out in places like Fiskville to train. These are elevated, as Lesa said. In this study we said, 'Okay, we don't only want to measure firefighters' PFOS or PFOA levels; we also want to measure some biochemical markers that describe whether these have any association with health outcomes that have been elsewhere related to exposure to perfluorinated chemicals'. We did not detect an association between PFCs and biochemical parameters in these, so there was no link that we could see. This is not conclusive; this is just saying that we could not relate the concentration of PFOS in the people to biochemical or health end points that we tried.

To summarise, we are really good at measuring exposure to perfluorinated chemicals or dioxins because they leave this history in the body. By the way, we could show that firefighters who trained more than 10 years ago had much higher levels than those who trained only in the last 10 years, and this told us something — that those who trained with Light Water were much more contaminated than those who trained with Ansulite. Some of you may know these terms; these are the names of the firefighting foams.

Going back here, it is easy to characterise exposure for PFCs using human biomarkers. The effect side is difficult, and this is really my next slide. We have very good available data on the left for exposure. Risk is a function of exposure and how toxic a chemical is. It is a bit like alcohol: either you get more exposed or it is a more potent alcohol, which is like schnapps or whiskey. On the right side there is effect assessment, and that is how toxic a chemical is or what it does.

The problem with, for example, perfluorinated chemicals and even dioxins and other POPs is that they are very non-specific, not like asbestos, which gives you mesothelioma. These chemicals, for example, may give you prostate cancer or may be associated with elevated prostate cancer. I am not saying they are, but if they are, it

would be really hard to find out whether they have caused an elevation. They are non-specific, and the effects that are observed are relatively small and there are wide reference ranges, so it requires large studies. Probably Malcolm Sim has talked about that to you. Exposure is relatively simple, and effect is sort of the very difficult part of this. With this, I conclude. Thank you very much.

The CHAIR — Thank you so much. Perhaps my first question to Dr Aylward: in regard to what you were showing about how PFOS, for example, stays in the body — you both spoke about that, but using your graphs — and other chemicals leave the body very quickly, I know that some people have talked about the PFOS or the perfluorinated chemicals that stay in the body and that the assumption is that, if you have that in your body, say, as a firefighter, you have obviously been using firefighting foam and therefore you would be exposed to benzene and those sorts of more volatile chemicals that do not stay in your body. Would that be sort of a practical conclusion, or could you not really rely on that?

Dr AYLWARD — Again, I think the key for these kinds of assessments would be drawing on knowledge both from experts in biomonitoring and experts in epidemiology but also experts in what people did at the site — the people who worked there, the people who have the historical knowledge of, 'This is what we did; this is how we did it'. If you have those people who can provide you information that says, 'Yes, the people who trained the most with the foams during this time period were also the people who were cleaning out tanks with solvents', or whatever other things that were going on that might lead to exposures, you could potentially draw some parallels, but that is industrial hygiene and occupational knowledge that really requires the expertise of the people who worked at the site and managed the site. That just depends, and it might vary for benzene and the combustion products and the other chemicals that were there, but it would require someone to document and to think carefully about how those activities related to one another basically.

The CHAIR — Professor Mueller, when you said that you cannot find a specific illness or disease with things such as PFOS, is that because of the nature of the chemical or because it is relatively new compared to others — that we do not have enough evidence yet to determine those sorts of things?

Prof. MUELLER — I think that is a brilliant question. I have not got the answer. It has only been 15 years or so since people really recognised PFOS as a chemical that turns up in our bodies, and it usually takes a while to establish such relationships, particularly in epidemiological studies. You need big numbers of exposed people. I am sure Brian Priestly talked a little bit about what the C8 study and other epidemiological studies found. It is really out of my field, and I think the verdict is not out yet on these parts.

I think the main concern at the moment about these chemicals is that they are persistent. There was an old toxicologist, Paracelsus, who said that the dose makes the toxin. If you release a persistent chemical over and over into the environment, you will build it up and at some stage it will become a problem. So we have become a little bit more aware of that. So the primary problem is probably persistence. It is a recognised problem. The toxicology, I think, is not really the big issue at this point, particularly if we turn it around.

The CHAIR — Okay. When you hear that people are not sure and that sort of thing, but because it is talked about a lot, it is on the Stockholm convention, there is talk about banning it, it should not be used, we have changed to different firefighting foams — normally when it is an industrial thing and there are profits to be made, they do not just sort of do these things if there is no concern about what it is going to do to people, and the environment of course is also about people. I suppose that is what I find hard to sort of understand.

Dr AYLWARD — Yes, and I understand that. I think, though, that what Jochen said is actually correct: we are actually getting a little bit smarter. We had these experiences with DDT and with chemicals which by themselves are not terribly toxic in the way they are typically used. You can use them and they are not terribly toxic for people, but they build up and then they cause effects that you did not anticipate because they built up in the food chain, because they persisted for long periods of time and accumulated. So the Stockholm convention was a recognition that persistence in and of itself is potentially a very problematic thing and therefore, as we go forward now, when chemicals are introduced or chemicals are detected, the first question people ask is: is it persistent or does it break down? And if you are finding it widespread in the environment — in the Arctic, in the Antarctic, everywhere you go — that is a chemical that is persisting. It is persisting; it is being transported.

So we have now gotten smarter and although there is always a fight about these things. They have been put on the Stockholm convention principally because of those characteristics. As Jochen said about the toxicology and the epidemiology, it is a difficult undertaking to get a clear — especially in human studies — understanding of

what might be occurring at relatively low exposure levels compared to what we see in animal studies. You can always make a chemical do something if you feed it in high enough doses to any animal. But then there is understanding more subtle effects that may occur in the human population. If you go to the doctor and you have high cholesterol, there are 50 reasons that probably contributed to your high cholesterol. One of them might be a very low level of PFOA or PFOS, but maybe not, and it is impossible to tell that. So those kinds of studies are extremely difficult to look for very subtle effects. For cancer and those kinds of end points it takes decades, because you do not get cancer immediately. It takes time to develop. So understanding those lags — understanding something that we have now come to recognise as potentially problematic, which is because it is persistent. So now we are trying to move a little faster on understanding that when something is persistent and when we start to see it everywhere, that is in and of itself enough to make us decide that it is maybe not such a good thing.

The CHAIR — So it is the alarm bell type of thing.

Dr AYLWARD — That is an alarm bell that we will have seen.

Prof. MUELLER — I would like to go back quickly to my starting slide. A couple of years ago there were dioxins in Sydney Harbour. There were a couple of fishermen giving their children the fish they caught from Sydney Harbour, and they found really elevated levels of dioxins in these kids — like 20 times or 30 times higher than what other kids have — at this point in time. On TV there were mothers crying and saying their babies had been poisoned. And it was really quite tragic, because when I was the same age as these kids my levels in the blood were probably higher, and everybody who is older had 10 times higher levels than their grandchildren will have had. It sounds weird, but it does not worry me. It does not worry me retrospectively. That was how it was. The whole population in the 1960s got huge doses of DDT, dioxins and PCPs because we did not know about these chemicals. Fortunately, we have cleaned up our act. That is not to say that there is no cause-and-effect relationship, but I am not sure whether we are doing a service to some parts of the community to concern them with something when really at this stage there is no evidence that it really causes a health issue, if that makes sense. I think the media needs to take some responsibility for that. I am sorry that I am really bland about this.

The CHAIR — Based on your experiences, I understand.

Mr McCURDY — I think you are right in that sense as well. From what I have heard from you, Doctor, the scary thing about PFOS is that it is persistent, more so than what we know about what it can or will do to somebody down the track. And being persistent, and accumulating as it goes, we are getting higher levels in certain people. And that is a bigger issue than what we know about what PFOS will do to us.

Dr AYLWARD — Well, like I said, it is not that I am saying that it does not cause any effects or that there might not be issues that we discover down the road, but it is the case that we alert on this not because we know there are people who have become sick and that this is causing it but because we know the behaviour of this chemical is problematic. Because of that, we have alerted on it sooner. It did not take 40 years to sign a POPs convention that included PFOS. And because, as Jochen said, it was really about the year 2000 when people became aware of these chemicals, that they were spreading and in the environment, and these sorts of things, and so the action is relatively much quicker.

Prof. MUELLER — With all that I said, it is still important that we take what we know and do the right things to avoid exposure. I really think that what I tried to say was not that it is harmless or something like that. We do not know. I heard stories, working with the firefighters, of the way they worked with AFFF. They were told it was harmless and that was how they treated it, and then at some stage somebody told them something different. I am sure there are people in the room who can attest to that. So it changed. Some people get really confused or really worried about, 'Oh, yesterday I had my clothes soaked in it, and I was stirring the tank myself by hand, and today it is suddenly toxic'. Really this is very confusing. I think we need to address the issues.

Mr McCURDY — I think that is where we have at times got off track in this inquiry in that PFOS and the firefighting foam is all about Fiskville, but in Fiskville, yes, there were firefighting foams used, but it was actually more about what was being burnt and used at Fiskville by this muck truck that was bringing fuels, cheap fuels, for people to burn. If you look at the effects that that had on people, more so than the firefighting

foam, it seems to far outweigh what we are hearing about PFOS. You have obviously got experience as a child. You were saying you had different areas in your country that had the same circumstances.

Prof. MUELLER — I cannot really comment on what was burnt on these trucks. It depends how close you are and what the protection of the people was at the time when they burnt it. I mean, it is really difficult. I do say combustion products, in soil, they leave a record. It is just that in people they do not leave a record. But you may be able to find out some of the chemicals that were emitted from these. For example, dioxins, if they would produce dioxins. It is peanuts to do a study on looking at soils around the firefighting training ground. What will it tell you? I am not sure. But there are things it can tell you about nasties. Even there, scientists are much better now to do this.

The CHAIR — Yes, but I think there have been other chemicals found in the soil and the water. A lot of that is fairly well documented and researched. I guess the emerging thing is about the PFOS and the PFOAs. Who wants to feel that they have not done everything possible to avoid terrible things happening into the future? Maybe the media is about scare tactics, but I think for us it is about making sure we can do everything. I would hate in 20 years time to say, 'Hey, I wasn't part of a committee that made a recommendation to protect people'.

Prof. MUELLER — Absolutely. But we have to be clear. You asked Lesa whether PFOS is a good marker of being exposed to other things. But it is difficult, because PFOS is not a volatile chemical, let us put it that way. It is not a very volatile chemical, whereas solvents and combustion products are very volatile chemicals. Inhalation is becoming the major route of exposure for these other chemicals that get combusted, whereas for PFCs inhalation typically is not a very prominent exposure pathway. Does this answer your question?

The CHAIR — So it is more in terms of eating, is it?

Prof. MUELLER — I do not know actually. I still do not know exactly how firefighters got exposed. We have been discussing this a bit. But inhalation of combustion products from a fire is probably unlikely to be the big source of exposure to perfluorinated chemicals. Therefore you have a different exposure in time and pathway. That means that using PFOS as a marker for 'How much have I been exposed to other chemicals?' may not be that valid.

Mr RICHARDSON — Just a question on risk management and if PFOS and PFOA are bioaccumulative. We have seen examples in Queensland of Oakey and in Williamstown of remediation and risk management. I just wanted to get some comment on what the statutory authorities and bodies should be doing and what the private sector should be doing where we have instances of accumulative PFOA and PFOS? I would just like to get your thoughts on that, if that is possible.

Prof. MUELLER — I am a bit involved in Oakey, and I work a little bit with Williamstown. Oakey is an extremely particular case. I find it the most incredible case. It is sort of the arid Australia case, where you have a source somewhere in the corner, then PFOS disappears from the face of the earth, goes into the groundwater, and then there is this arid town of Oakey, which needs water. Everybody has to water their lawn. So they pump it up at the speed of light and water their lawns, and it resurfaces, depending on how you suck it up there.

I said to the government that I think in Oakey it is not just about drinking the water there. Because that was the initial idea — that it is just drinking the water — but then I saw these kids playing in a waterspout. When I was out there and collecting some samples I thought, 'God, I come back and my shoes will be contaminated, and I cannot go into my lab anymore with these shoes because it will result in a false positive'. I felt there that it leads to this recontamination.

I think it is an unusual case. But there needs to be another water supply. There should be another water supply probably for these people. Then the simplest thing to do — and I say this from my gut; I do not want anybody to use it against me — is, I would say, hose it all out, and hopefully at least you will get this surface contamination reduced. If you do not want to move the people, I think you have to do something about the surface. That is really what I think, yes.

Dr AYLWARD — More general remediation steps, more generally.

Prof. MUELLER — The system is contaminated there. You cannot anymore take the site out in Oakey. The only remediation that is really feasible, apart from digging it out, is trying to create barriers for it to move, I

think. There are these new products, they are absorbent materials, available, but it is really expensive. The more widespread your source is, the more expensive it is. I started with Maulach, where they dug it out, I think it was. But PFOS — sorry — and dioxins are very different. They do not move, dioxins; PFOS moves.

Mr RICHARDSON — What is driving that risk management that is being undertaken? The fear of drinking water is how it bioaccumulates. Is that a risk management strategy for future potential health studies or effects that might be learnt down the track? If we do not take this action now, we might be setting ourselves up for future concern — is that driving that? If we are talking about a completely different water source, that seems to be a risk management strategy that is removed from there being no concern at all, but then where that falls in terms of toxicity — —

Prof. MUELLER — I think governments and scientists together have to come up with some kind of guidelines or some kind of values that are acceptable or not acceptable for people to use for different purposes. I think that is in process; I understand that is in process. That will decide what people should or could do with their water. I am afraid they will have to make some decisions about cut-offs — what are acceptable groundwater levels, for example, to use for certain purposes.

Mr RICHARDSON — With the animal works and studies, Lesa, could you give a little bit more detail on that investigation into the animal studies on PFOS and PFOA?

Dr AYLWARD — This is not an area that I really consider to be an area of my expertise. I am familiar with some of the literature, with the studies that have been done and some of the assessments that have been done. I think that Professor Priestly probably gave you a pretty good overview of that information. I would like to, probably, defer to what he had to say about that, because the specifics of the animal studies and the specifics of the responses is a pretty big body of literature, and it is not an area I would say I am an expert in, so I would prefer not to give you an off-the-top-of-my-head opinion about the specifics of the animal effects and how they might translate to human effects and those sorts of things. I think that other witnesses you have had are more qualified to do that for you.

Mr RICHARDSON — But your comment about it being evolving, it is still a moving feast in that sense?

Dr AYLWARD — Yes, I think particularly with respect to human studies, and this is true not just for PFOS and PFOA but for lots of chemicals, where as we become better able to measure exposures at lower levels in humans, better able to do larger studies, the field of epidemiology, especially environmental epidemiology — —

Epidemiology in the chemical realm really started with occupational. So you had workers who really had very elevated exposures, and you could go and look at those workers and say, 'Ah, in this type of working environment, in these workers who are exposed to these substances, we see this cancer', and it is quite specific or we are pretty sure it is related to it. In that situation people are exposed to levels that are hundreds maybe even thousands of times what we deal with when we are talking about environmental exposures to chemicals.

The study of health effects where we have much lower levels of exposure in the general population but many, many people exposed, that is a very complicated undertaking. We have gotten much better at it, but with PFOS and with other chemicals as well it is actually very hard to achieve certainty — let us put it that way — to say, 'This chemical causes this at this level'. That is a very difficult level to achieve in terms of knowledge for chemicals. We do our best to rely on the other information we have — persistence, things that we see in animal studies, these kinds of things — to draw conclusions that are protective without having certainty about the fact that there are or are not specific health effects occurring at the given exposure levels in the general population. I do not know whether that is helpful or not.

Mr RICHARDSON — Yes. Thank you, Lesa.

Prof. MUELLER — In this slide, which I did not show, I tried to summarise the epidemiological effects on the left, which were typically at levels that we are rarely exposed to, or workers or cohorts, and then on the right side are toxicological studies in animals. They are usually done to actually get effects. They are not done at those levels that the normal population is exposed to, because scientists do not have that much time. These right-side studies, they are really working at orders of magnitude, at higher levels, with controls, than these left-hand studies, if that makes sense. Then people try to bring these two things together. These are some of the

end points that are found to be associated with very high levels of PFOS — I think it is PFOS; it could be PFOA, actually.

Dr AYLWARD — Yes, there are probably both in there.

Prof. MUELLER — Yes, it is mixed.

Mr RAMSAY — Thank you both. I was going to ask you a set of questions, which I think you have probably covered, so I will get down to the nitty-gritty in relation to the current inquiry this committee has been tasked with, and that is what to do with a facility that has supposedly high levels of PFOS in relation to its water. Testing has found levels — whether they are high or low I am not sure yet, even with your presentation, I have to say — of PFOS, whether it is in animals, in water or in soil. We do not have a standard here, so it is hard to judge in relation to our own national regulation requirements in relation to safe levels; I guess we look to international standards or the Stockholm convention or something else. Given what you know around the firefighting facility at Fiskville and the reasons for which it was closed, which was seen as PFOS levels in the water and potentially in some neighbouring land, would that be enough to satisfy you that you would have a permanent closure of the facility? Is that an unfair question to ask you both?

The CHAIR — I guess we asked you to come over on the basis of your general knowledge, knowing that you do not have specific knowledge of Fiskville. We understand if you cannot answer that question. I think that was the understanding when we spoke about the context in which you were coming, which was really to inform us about your areas of expertise.

Prof. MUELLER — We were actually wondering whether there is blood data from Fiskville, because I heard there was blood data, at least in the making, but whether it is out there or not — —

We cannot say anything about that. We have not seen any blood concentrations. Have you seen blood concentrations?

The CHAIR — There have been tests. It is not public knowledge — those results.

Prof. MUELLER — Okay.

Ms WARD — The site is reported to be around about 12 times what the recommended safe level is. That is what has been found in the soil and water.

Mr RAMSAY — There has been water testing —

Ms WARD — And soil testing.

Mr RAMSAY — and there has been blood testing. They are different in nature.

Prof. MUELLER — I do not know these results. The Dutch have a level in surface water that is ridiculous. It would ban rainwater, essentially. There are different levels out there in the public domain, and I think Australia is in the process of deciding on something. I hesitate to give you any — —

Mr RAMSAY — Can I put it another way, then, because it was an unfair question given you have not perhaps had access to some of the testing results from the samples? Are there other firefighting facilities that you are aware of internationally that have been closed because of certain levels of PFOS within the water or soil?

Prof. MUELLER — There is more than that. There is a whole town in Sweden. It is only a Swedish report, and I fortunately had a Swedish post doc. We did one of the studies. There is, I think, really elevated levels in the whole village, and it is a big village, related to contamination. It is really unfortunately only a Swedish report so far, and I am sure they closed that down.

I know there is remediation of sites going on in the US. It is only hearsay but I heard that it is massive remediation by the Department of Defence. I have no evidence or proof, but I heard there is lots of remediation going on.

We had this discussion at another firefighting training ground that is not in Oakey and is not in Williamstown. We have done some work for Airservices Australia. The question is really where to start and how far to go. There has to be some kind of balance in where you start and to make your efforts worthwhile.

Mr RAMSAY — The question was really phrased on the basis of your graphs, where you have shown that for the public at large, I think you used 100 samples, most of the sampling was well below any sort of line where it might have affected animals. I think it was down to 100 where it was affecting potentially an animal line of about 10 000 nanograms. Is that right? I am trying to remember.

Dr AYLWARD — Right.

Mr RAMSAY — I am working on the basis of at want point do governments spend a considerable amount of money in relation to remediation and closing facilities if in fact the general populous graphing is showing well below unsafe levels of PFOS in — —

Prof. MUELLER — Governments have to do more than just decide on the basis of science. The science at the moment might say that it is not worth doing a remediation from all we know, but you have to listen to your people as well. I think that if there is no absolute answer for you, no scientist will stand up and say here, 'I can assure you that this will never be a problem for those people'. As a government you may have to do something that is a compromise, I think, between what concerned citizens and so on want and what is in your best — —

I do say that people should not be any more contaminated than necessary, if that makes sense. I am not giving you the answer you want, I know, but I am not saying this means you should be able to use sites as long as you are under this no-observed-effect level threshold. I do not think that is the answer I can give you. Sorry. Would you agree with this?

Dr AYLWARD — I think my answer might be a little bit different. I think the blood level information is one piece of information but also understanding the specifics of the site. I did some reading about the site, which is probably a very dangerous thing, because I have not looked at it in detail. You have wastewater that is on-site somewhere in dams. You have to understand that is contaminated water. Will it move? Is it contained? Can it contaminate an aquifer where people draw their drinking water? There are a lot of things to consider, and understanding what might happen in the future to what is already there informs remediation choices and understanding how the site might be used going forward.

It is likely that you probably do not need to put a fence around the site and say, 'For the next 10 000 years nobody walks on this site', but at the same time you might have to think about how someone might want to use the site and make decisions about what to do about what is there to minimise the transfer — the leaching, the movement of the material that is there — or remove it if you need to do that and treat it in another way. But those are the kinds of decisions that have to be made on a site-specific basis, and they have to balance, as Jochen said, the needs of thinking about future pathways for contamination to spread or contact people and the resources that are available.

This is something we always talk about. Resources are always limited. You cannot spend infinite amounts of money, time and energy on everything that comes up, and so understanding the most worrisome pathways and outcomes based on the specifics of the site — the opportunity for the material to move, the opportunity for people to contact it — and doing the most practical things possible to limit that or remove those threats is really where the balance between what we would love to do and what we can do sits.

The CHAIR — Just because of the way it moves it seems to be insidious. Can you actually contain it without decontaminating or remediating, or do you have to get rid of it?

Dr AYLWARD — It depends on the site. It depends on the geology of the site. There are things like, you could put a cap in place which keeps water from entering into contaminated soil and leaching through it. That is something that is done at hazardous waste sites in various places or places where you are worried about contamination. But it depends absolutely on the specifics of the site and the specifics of the chemicals that are involved, and that is not something where I can tell you the right thing to do.

Ms WARD — Sure.

Dr AYLWARD — Environmental engineers deal with different types of problems at different sites everywhere, and there are possibilities for managing, containing and looking at things.

Prof. MUELLER — And we do studies on binding it in the soil, so we are mixing it with something and putting it back in there.

The CHAIR — We have heard of that —

Prof. MUELLER — From Ravi Naidu?

The CHAIR — but I think it has been in small areas, not on acres or hectares and hectares.

Prof. MUELLER — Yes, that is right.

Ms WARD — That would not be something you would necessarily be able to do at Oakey.

Prof. MUELLER — We are putting in at the moment for a grant where we look at whether at airports you could essentially dig a trench and fill bags of this material into it and dig it out every 20 or 30 years or something and it contains it. It is an idea. The question is what it does to the groundwater flow, what flows around it. But there are ideas that we are testing. I think these ideas should be considered as a way to do something. Because even if you dig it out, you put it somewhere in a landfill, then you have your problem in the landfill, and actually in some places landfills do not allow such materials to go.

Ms WARD — Thank you. That was really informative. With the graph here, it is for adults. How would that change necessarily for children, or would it change at all?

Dr AYLWARD — In terms of — —

Ms WARD — These are assessing adults, and you referred to a study that started to encompass children, so how would these numbers reflect blood samples for children or amounts in children?

Dr AYLWARD — Why don't you talk about it?

Prof. MUELLER — So these are children.

Ms WARD — No, I understand.

Prof. MUELLER — In the general population there are no children firefighters.

Ms WARD — No, that is right.

Prof. MUELLER — And in the general population the children are lower at the moment.

Ms WARD — Yes. So what do you do in instances where children are at this level?

Dr AYLWARD — I do not know that we have seen children at that level.

Prof. MUELLER — Yes.

Dr AYLWARD — But, you know — —

Ms WARD — So how does that reflect with that line on your graph — the 'No-effect level in animal tests' line?

Dr AYLWARD — I guess I am not sure that I understand the question.

Ms WARD — Okay. My concern is about children who would be testing and having this kind of result that you see in firefighters or higher. What would be your view?

The CHAIR — There was a primary school just nearby.

Ms WARD — What would be your views on children with those amounts?

Dr AYLWARD — You know, as we have said, we like to see as little as possible, and so if you find elevated levels in children, it means that you need to figure out where people are getting exposed and make changes in order to reduce that from happening. We do not have any way to remove it from the child once it is there —

Ms WARD — No, that is right.

Dr AYLWARD — or the adult, and so it is all about figuring out how the contamination is occurring and intervening in a way that makes sense, you know, in a way that is going to be effective.

Ms WARD — And removing the source of the contamination or the people from the source of the contamination.

Dr AYLWARD — Removing the source or removing the connection between the people and the source.

Ms WARD — Yes. I think that is an important point — removing the connection.

Prof. MUELLER — But you should still try to make these kids grow up happily and not be worried 24/7 that they will die of cancer because they have a little bit elevated PFOS concentrations. I think if they were my kids, I would just live a happy life with them. I would try to, you know, and I think — —

Ms WARD — But you would want to remove your children from the source of the contamination.

Prof. MUELLER — Absolutely, I would try to make them not eat any more popcorn from a wrapper that is coated with PFOS.

Ms WARD — Are you able to say at all what numbers of PFOS levels in blood you would be concerned at, or would you just sit with this graph?

Dr AYLWARD — When we do these kinds of assessments there is no bright line. It is not a switch: if you are at 1.9 you are fine, and if you are at 2.0 you are dead. It is always a continuum. We try to keep the margin as great as possible. As I said, even in studies with adults and even in the animal studies, we do not have clear answers about what the effects might be, so the answer is we try to understand the environment, we try to understand the sources, and we try to reduce levels of exposure — especially if you have seen elevated exposure, then you really want to take action.

If you look just like everybody else in the population as a society, we decide to take action. For example, we have put PFOS on the Stockholm convention and we have removed it from things that are being used, and in fact levels are coming down in the general population. But you work with what you have and you make the best decisions that you can. But in terms of what number — —

Ms WARD — There is no trigger.

Dr AYLWARD — In terms of what number is the switch between good and bad or okay and not okay, I do not think we have that. We do not really have that for any chemical. We do our best to do a consistent assessment across chemicals and do these kinds of things, but there is no switch, no bright line. We try to be protective and take the best steps we can.

Ms WARD — Jochen, your analysis with the PADs was really interesting — the analysis with the PADs of the run-off and so on. You talked about running off for a number of decades, that there would continue to be PFOS leaching out of the concrete and going out. Is there a way to estimate how far that leaching could travel? Would it be contingent to rainfall, water?

Prof. MUELLER — We are working right on that, but of course it depends on the soil type, the rainfall. Around airports it is usually sandy soil, so it travels faster, because the particular coastal airport sites, they are filler material. It is what it seems like — it goes faster.

Ms WARD — So you would hope for soil that has got a lot of clay in it?

Prof. MUELLER — Yes. It is a matter of time and of the properties — the groundwater flow speed. Sometimes groundwater flows in kilometres per year, others flow in metres per year. It matters, all of these things. I am new to this hydrology actually.

Ms WARD — We are new to the whole thing! We have spoken briefly today with a couple of other people about the West Virginia study, and it was of 47 000 people. Do you think that that study is a good indicator of the possible effects of PFOS in your system, of heightened levels of PFOS in your system?

Dr AYLWARD — The West Virginia study, the C8 project and study, that is directly related primarily to PFOA, not to PFOS, and there are differences in how the two chemicals act, at least in animal studies. I have just now reached the level of my expertise, because again I am really not an expert in the detail of the toxicology, but there are differences. Certainly it provides an indicator that you can see elevated exposures occurring in general populations because of, in this case primarily, water exposures. Yes, the studies there are providing really interesting information that I think is relevant to understanding the health effects of these chemicals.

But again, in general those effects are not effects where you stand up and say, 'Oh, my God! We've got to run screaming from this'. They tend to be relatively subtle, and they are all health effects that have other risk factors as well and other reasons that they occur. It is part of a larger picture; we try very hard to not contaminate people and not contaminate the environment with these chemicals. When it is, then we have to try to take steps to reduce especially the contact between people and the source, but also to prevent that from spreading further.

Ms WARD — I have a sentence and I am interested to know your thoughts on it, because I am not quite sure what it refers to and I am hoping that either of you could enlighten me. There has been a claim made that individuals tested have PFOS values within the background range of the general population. Do you know what the 'background range' refers to? Do you know what that is?

Prof. MUELLER — Yes. I would say this here is whatever — —

Ms WARD — So you would classify that goes up to about what? Would 18 be the background range?

Prof. MUELLER — We can actually give you a publication which has — —

Mr McCURDY — Like the national average?

Prof. MUELLER — It is an average of 2400 people or a subsection of those 2400 people, and you can get that for multiple years. We have the latest data for 2014.

Ms WARD — That would be great.

Dr AYLWARD — And then based on that we have also estimated what — —

If you go to the doctor and have your cholesterol measured, there is an average cholesterol level. But then also some people are above that average, some people are below and they define a normal range, which includes about 95 per cent of the population, unless they do not really want you to be below this point . But that range is higher than the average — some people are above, some people are below, but they are not outside the normal range. So when we do these pooled studies, we get estimates of that average. But if somebody comes in just above that average, it is not easy to know immediately based on that whether they are actually elevated or just part of the upper half of the population — the general population was lower. We have done some analyses based on other populations so that we can take those average values and estimate what the typical upper bound is likely to be in Australia.

Ms WARD — So that is the background range, and that is not the background range?

Dr AYLWARD — Correct.

Prof. MUELLER — That is right.

Prof. MUELLER — This is age controlled, so we take the population for the same age. We give an age and for PFOS even a gender-specific average, because women between 20, or 15, and 50 have lower levels than men.

Dr AYLWARD — In the general population.

Mr RAMSAY — I suppose what would be handy for us is to get some tests and put that in the data for, say, Fiskville career firefighters as against volunteers as against the local community, and test it against the Australian average and see what the elevation is.

Prof. MUELLER — That is what we do in Oakey. That is what we have done with the firefighters. Yes, the problem is really what you do with this information. This comes back to some of Lesa's talk. What benefits do people actually have from knowing? My PFOS level is 55.5. It is not the Olympics. Where does this really take you?

The CHAIR — With our terms of reference, one of the things is to look at justice for victims. A person with a higher level of PFOS may not be a victim, but into the future there might be an autoimmune disease. At some stage there might be a connection. This is what we have to look as well.

Prof. MUELLER — What I recommend, and not only in Fiskville but everywhere, is that when we do such things at least we should collect samples and put them aside at least until we know what we are actually doing. I mean, here in this case we can do PFOS and we can give you the results, but you should think a little bit, 'What do we do with these results? Should we give them also cholesterol and uric acid?'. This is what we recommended to the Department of Defence we should do. Are there things that we can actually say something about: 'Hey, by the way, you have higher cholesterol levels. See your doctor and do something about it'? Then we give somebody useful information. With PFOS alone or PFC levels alone, people have to be really clear that knowing this really does not help them at all with understanding their health. This is really the quintessence of Lesa's talk: we can do all this and it really tells us we have to do something about this person, particularly if we know there is still current exposure, but it does not really help this person. It may concern the person more — unless it is low, and then it is great.

The CHAIR — That is true.

Prof. MUELLER — We wish it would be low for everybody.

The CHAIR — Thank you so much for coming in.

Witnesses withdrew.