COMMISSIONER: Welcome back. We return to topic 16, High Level Waste Storage and Disposal and we welcome from the United States Professor Rodney Ewing from Stanford University. Counsel.

MR JACOBI: Professor Rodney Ewing is a mineralogist and material scientist who has conducted extensive research into the effects of radiation on minerals. He's a professor in the Department of Geological Sciences at Stanford University and the Frank Stanton Professor in Nuclear Security at the Freeman Spogli Institute for International Studies. Professor Ewing has held leadership roles with several research societies and advisory boards, including as the current chair of the Nuclear Waste Technical Review Board which is responsible for the ongoing technical review at the US Department of Energy's activities related to the management of spent nuclear fuel and high-level radioactive waste.

He has authored or co-authored over 650 research publications in minerology, geochemistry, material science, nuclear materials, physics and chemistry, and his achievements have been recognised with over 30 fellowships, awards, medals and honorary doctorates, and the Commission calls Professor Rodney Ewing.

COMMISSIONER: Thanks for joining us this morning, or this afternoon for you, Professor Ewing.

PROFESSOR EWING: Yes.

COMMISSIONER: Can I just start with an acknowledgement? I understand you're speaking for yourself in the evidence this morning.

PROFESSOR EWING: Yes, that's true, and I want to emphasise that although I'm the chair of the Nuclear Waste Technical Review Board in the United States, my comments are today are entirely my own personal views on these topics. The Board position can be found in our letters and reports which are on our website.

COMMISSIONER: Fine. Well, let's start. I think you'll appreciate that one of the areas that the Commission is examining is the feasibly of deep geological storage for used or spent fuel and in that, one of the very few, if not the only, operational facility at the moment is WIPP. I understand that you really had a bit of a front row seat in the WIPP development, that you were part of the National Academy of Science Committee that looked at the development of WIPP over a number of years. I think you were also part of the faculty of the University of New Mexico.

PROFESSOR EWING: Yes.

COMMISSIONER: Can we start with what was the incident in February 2014 and what radioactive substances were released in that activity? If you could just walk us through the accident and what happened after the accident.

PROFESSOR EWING: Right. Actually there were several accidents at WIPP. Prior to the release of radioactivity on 14 February there had been an accident in which one of the underground hauling trucks had burned, and so in many cases people look at most of the accidents mainly as evidence for a conclusion that there is really a lack of a safety culture in the operation of the Waste Isolation Pilot Plant. To the point of the accident on 14 February where there was - - -

COMMISSIONER: Can I interrupt there? The burning of the vehicle, was that related to any radioactive materials or was that a - - -

PROFESSOR EWING: There was no radioactive release associated with that event. I only mention it because it reflects, I think, one of the major conclusions of studies of the accident that is a lack of attention to safety aspects, which comes in some ways from the two cultures, mining cultures and the culture of operating a radioactive facility, and so I there it's important to look at both accidents as illustrative of the level of care that was being taken at WIPP at that time.

COMMISSIONER: Okay. Let's move on to the next incident then, please.

PROFESSOR EWING: Yes. The release of radioactivity on 14 February 2014, the cause I think now is well established. It resulted from mixing compatible materials in one of the drums. The incompatible materials were nitrate salts and organic material. The WIPP waste are low-activity materials, material contaminated with transuranium elements, mainly plutonium, and so the level of activity is low, but there are pretty strict considerations about what can go into the drum, and one combination of materials to be avoided would be a mixture of nitrates with organic material.

And as it happened, organic material was introduced - actually it was kitty litter - introduced to absorb some of the liquid. There are residual liquids in some of the waste and this kitty litter, being organic, reacted with the nitrates. It's an exothermic reaction, heat is generated, and the lid popped off one of the drums. The activity that was released travelled probably 1,000, 1500 feet, through the underground workings to an exhaust shaft. The exhaust shaft carried the activity another 2,000 feet and then from the exhaust shaft at the surface, the activity could be detected just a little over a half mile away from where it was released into the atmosphere. The level of activity was quite low from this single drum, but still there was exposure to, I think, 22, 23 workers at very low

levels.

COMMISSIONER: When you say "very low levels", can you be more specific?

PROFESSOR EWING: I'm trying to recall the exact figures and I can't. They're posted on, I think, the new website, but the highest level was still below, I think, the regulatory requirements, something like a chest x-ray, and that was at the highest level.

COMMISSIONER: At the highest level. And the consequences to the environment and the facility itself?

PROFESSOR EWING: Well, the consequence for the facility is that the model WIPP began to operate clean, and so the very serious consequence, not from a health perspective but in terms of operations, was that now the facility was contaminated with radioactivity and if you're operating a nuclear facility you'd rather that not be the case.

COMMISSIONER: And so presume there was a considerable clean up before it could become operational again?

PROFESSOR EWING: Yes. I haven't had the details presented to me of the clean-up, but my understanding is that it's moving forward and the latest estimates of when WIPP will open again are by the end of this year.

MR JACOBI: To the extent to which that particular accident was a product of the materials that were being stored, I understand that WIPP stores a variety of mixed contaminated waste. Is that right?

PROFESSOR EWING: That's correct.

MR JACOBI: Perhaps if one was to extrapolate that out and think about what the implications of that particular incident are for used fuel or spent fuel management, I'm interested in the extent to which the causes of the incidents that you've described at WIPP might be relevant to used fuel or spent fuel disposal.

PROFESSOR EWING: I wouldn't, in this case, make a direct technical connection between the release activity from what in the US we call transuranic waste and the technical issues associated with storing or disposing of spent fuel or high-level waste. The lesson that I would take from this is that really it's very difficult in your safety assessments, which extend over very long periods of time, to be sure of the result, and that's not a criticism of the people who do these assessments. That's just a statement of the challenge of

projecting physical and chemical processing over long periods of time, say hundreds of thousands of years.

In the case of the emplacement or the excavation of rooms and the placement of the waste, we have a case of a fairly controlled system. There was an accident. It was human error, failure to establish and follow safety protocols. There were mechanical failures associated with the release through the ventilation system, which is being replaced. So it's really a classic example of small mistakes cascading into a larger event, and I think the relevance to spent fuel is that when we do safety assessments for spent fuel, high-level waste, we have to expect the same types of incidents, that is, events that are very unexpected, and so I think there's even now, in my mind, a heavier burden on the review and the execution of the safety analysis.

Now, with the accident at WIPP we have the advantage that we're there. We can see the accident; we can measure the radioactivity; we can clean up WIPP; we can take the necessary corrective actions. But with geologic disposal over long periods of time, no one will be there during the operational phase. The operational phase comes actually after we close the repository and walk away from it, and realising that, that no one will be there, that there's no corrective action to be had 10,000 years into the future, I think we have to think very carefully about the safety case analysis and in particular, be alert to assumptions about the safety that may drive us to more optimistic conclusions than we might have arrived at otherwise.

MR JACOBI: I want to come back to deal with particularly the scenarios that need to be considered in the safety cases in a moment, but I just want to pick out just a particular part of something you just said. We're talking about this question of the direct technical leak and you described a difference between transuranic wastes, as they're named in the United States, and we we're talking about in terms of spent or used fuel. Perhaps if you could expand on why there might or might not be a direct technical link between the events that occurred at WIPP with respect to transuranic wastes and corollary with that with a way that an accident might emerge in a used fuel facility?

PROFESSOR EWING: The biggest difference, the obvious difference, is in the physical state of the waste and the composition. The transuranic waste in the United States refers to waste generated by our defence program, materials that are contaminated by transuranic elements, mainly plutonium but also a little bit of, say, americium, and so these are lab coats, materials from experiments, just the (indistinct) of the activities, the defence activities. So they're large volume, they're very low activity, the waste is put in plastic bags and then in drums, essentially 55 gallon drums, and sealed.

Those drums can be handled, most of them, directly. There's a small category

of this waste has to be handled remotely because the activity is just a little higher. So it's low concentrations, low levels of activity, mainly alpha emitters, and alpha emitters have very short range, alpha particles, sometimes microns, recoil nucleus, even less, so that makes it - therefore, it can be handled more easily. In contrast, spent fuel is simpler, it's uranium oxide, UO2.

After irradiation only about 4 per cent of the uranium has been converted to fusion products, so from a material science point of view it still looks like spend fuel, it's maybe a little fractured, it's suffered from radiation damage and thermal excursions, but it's mainly UO2 with just this 4 per cent of the fusion product elements. But these 4 per cent of fusion product elements have increased the level of radioactivity of (indistinct) and the types of radiation that comes from those fusion products is not only alpha decay events associated with transuranium elements, but there are beta and gamma irradiations and these can be very penetrating sources of radiation, so one could not take a spent fuel assembly and put it in a metal can and handle it safely, you would get, within minutes, a really lethal dose of radiation.

The good news is about spent fuel is it's much simpler than the transuranic waste, but from a radiation point of view, from the radiotoxicity point of view, it's much more difficult to handle and it's much more dangerous. These fusion product elements, many are short lived. Strontium and caesium have half lives of 30 years, but there are longer fusion products such as technetium-99 which has a half life of 200,000 years, iodine-129, I think a half life of roughly 16 million years. So you have long life fusion product elements that can contribute to the activity, plus you have plutonium and transuranium elements that contribute to the radioactivity.

MR JACOBI: I just want to perhaps round out that discussion in this way, that is, I understood the position that had been expressed by the review board in a paper that it had produced in June 2011 was that there remained a need for geological disposal of spent fuel in the United States on all reasonably foreseeable basis, and I understand that there's been consistent recommendations from your Blue Ribbon Commission. I'm just interested to understand the extent to which anything that's occurred at WIPP has changed the view that geological disposal remains a preferred view for the disposal of used fuel in the United States.

PROFESSOR EWING: I would say, speaking for myself, that I'm still convinced that the disposal of high level waste and spent fuel in mined geological repositories certainly can be done and done safely. The footnote I would add to that, and I think we should have this footnote in mind in view of accidents in all of our activities, that it is possible to do it poorly. When I say I'm confident that I'll be able to get home in my car tonight, that's not to say

that maybe I wouldn't be in an accident due to some negligence.

I think the take-home message from WIPP is the need for really extraordinary vigilance in the safety analysis, given how difficult it is to anticipate the behaviour of materials over long periods of time, but I think at the same time, mainly based on progress around the world and different rock types and with different strategies I think it can be done and demonstrated in a way that would be convincing to the public.

MR JACOBI: I just want to come back now to deal with the safety case discussion that I think we started earlier, and I'm just interested to understand, first of all, having regard to the way that safety assessments and safety cases are now being performed in the United States and also in Europe whether in your view there has been emerging from that experience preferences for how those processes are undertaken, and whether you have a view as to whether there are some of those approaches that have proven to be more or less successful than others.

PROFESSOR EWING: On the issue of whether they're more or less successful, of course it's hard to say because the success is judged during the operational period, which is far into the future. You could say that if you get a licence you've been successful, but I'm not sure that's the question that you're posing. There are really some fundamental issues to be dealt with when one thinks about the safety case. In the US, the approach has been to have a quantitative, probabilistic assessment, a procedure that grows out the safety analysis done on nuclear reactors and project that quantitative, probabilistic risk assessment over periods of hundreds of years.

And that's a big jump because not only do you have to do it, you have to do it in a way that's convincing, so in the US I and colleagues have argued, we're quibbling over various aspects of the safety analysis approach. In Europe, let's just say in other countries, and this will be a broad generalisation, there's been probably less reliance on probabilistic risk assessment but greater reliance on a more deterministic approach over shorter periods of time and a more qualitative approach for the longer periods of time.

By "qualitative", I mean following some simple rules: avoid areas with volcanic activity, earthquake activity, eliminate some of the problems by the sighting process. If natural resources are in the area and you extract in the future drilling, such areas would be less desirable than an area that, as far as someone knows, there's no economic resources to be exploited, and obviously the same will apply to avoid tectonically active areas or avoid areas of volcanism.

Not because they might lead you down a path to not being able to comply with

the regulation but because it will cause you to do the type of analyses that are very difficult to do; that is, predicting the probability of a volcanic event or earthquakes. So those are the two viewpoints: a very quantitative approach extended to great periods of time versus a quantitative approach more deterministic, maybe more scientifically based, for short periods of time and then qualitative findings criteria that puts you in the right region for the purpose of geologic isolation.

MR JACOBI: Am I right in understanding that when you refer to a shorter period of time over which that deterministic approach is conducted with respect to the European example, we're still talking in the periods of perhaps a thousand out to about 10,000 years? Is that right?

PROFESSOR EWING: Probably in that range, yes. I find out this quite a lot and my personal view now is one that surprises me; that is, as I look at particularly spent fuel and high level waste, actually the risk highest in the near term. The near term might be 10,000 years or it might even be just 5000 years. So a more reasonable approach might be to rely on engineered barriers for these initial but shorter periods of time and then have criteria for the actual geologic site that will always tilt you in the right direction in terms of safety; that is, water should move slowly and there should be plenty of opportunity for absorption of radionuclides onto the surfaces of mineral clays. The conditions should reduce the solubility of radionuclides, not enhance the solubility.

So based on, I would say, very careful study and a lot of work, I think now probably we can have a fairly short list of desirable geologic criteria, all of which will move us towards a stronger safety case but not require us to do quantitative calculations over hundreds of thousands of years.

MR JACOBI: I just want to pick up something that you were talking about right at the start in terms of when one conducts the safety analysis we've heard in earlier discussions the need to develop a reference case and then also a range of scenarios for the purposes of making analyses of the probabilities of things not working in accordance with the best estimate of the evolution of the facility. I'm just interested to pick up that you spoke of the need to be realistic - I think was the expression - with respect to the potential for particular scenarios; that is, is the implication that you need to look at a much wider range of scenarios than perhaps we had first thought in considering issues other than the reference case?

PROFESSOR EWING: From my side, I think that's not necessarily the implication; that is, there is the belief that we describe all scenarios - captured behaviour system - and then we do our analysis. But what I point out is not at (indistinct) but in many industrial systems that's what we do, we do a fault tree analysis, we consider all the scenarios, and it's not unusual that something

happens that's a little different than we expected - the wrong material was mixed in the waste package. So human error. People make mistakes. It's actually not a surprise. The exact event is a surprise but it's not a surprise that something goes wrong.

Again, this is my personal thinking, I'm more and more inclined to spend time imagining what I will do if there's a mistake in the analysis rather than trying to have a complete analysis. This goes in some ways back to the very early days where multiple barriers figured so prominently in the strategies that countries developed for disposal. The multi-barrier system is a way of thinking where you say to yourself, "If the waste form doesn't behave as well as I thought it would, then I have the waste package, I have the overpack, I have the geology." So multiple redundant barriers are ways of mitigating unexpected failure no matter the cause.

I think more thought could be invested in that area. I say that now - just in the last year my new hobby is reading about accidents: accidents on the battlefield, accidents with aircraft and so on. Really the person I'm referring to is the works by Charles Perrow and his description of the normal accident. It's very important that word, "normal". It makes one realise that actually planning has to be for the accident, not to demonstrate that there won't be an accident. If you change your thinking along those lines I think that you will have an effect on how you go about how one addresses a safety analysis.

MR JACOBI: Am I right in understanding, having read your recent published article in Nature, is what you've described - I think what you say there is that accidents cannot be easily predicted but a system designed with failure in mind can mitigate the risk?

PROFESSOR EWING: Right, exactly.

MR JACOBI: I just want to take advantage, just for a brief time, just of your particular knowledge and expertise in material science. I'm just interested to pick up with respect to the safety analysis how significant a deep understanding or characterisation of the materials that are being disposed of is in ensuring the safety within the disposal facility and in the safety analysis.

PROFESSOR EWING: This hits upon an important issue and we can relate it to spent fuel. One can imagine two approaches: one would be to have rather detailed knowledge of the spent fuel, and that's not easy to come by because it's for radioactive facilities so its study and characterisation are not so common and certainly very extensive to operate. But as part of a safety strategy one might say, "Well, I want to understand the material science of spent fuel, how it harms over time and this will be part of my understanding on which I develop the safety case." Another approach might be to say, "Well, that's very

time-consuming and expensive. If I assume that the spent fuel never gets outside of the canister, then I only need to know a lot about the waste package." So one might have a strategy that really ignores the properties in the spent fuel but focuses on the properties of the waste package over time.

Those are two very different approaches. The cost of one versus the other will be very different. I think it would be very time-consuming to develop in some cases the knowledge of spent fuel that might be required. But that's a choice one could make, or one could say, "Well, seeing as I want to have multiple barriers, actually I'm required to do both. Just in case the package fails, I want to understand where I will be with the spent fuel." That can be a very costly strategy but it's certainly one that's consistent with the concept of multiple barriers.

MR JACOBI: I've read in some of the safety analysis, particularly the one from Finland, that it spoke of the idea that for their analysis to be conservative in fact they gave no credit to the value of the UO2, that is, the spent fuel pellet, to in fact protect the fuel. What I'm trying to think through is to the extent to which you really need to make an analysis of the evolution of the spent fuel over time, if you're essentially not giving it credit in the first place in your safety analysis.

PROFESSOR EWING: That's certainly, I would say, reasonable approach, except that remember the spent fuel is part of the system, and if you're worried about accidents, if you asked the question that way, then it's not a matter of making a conservative assumption, it's a matter of whether you understand the system that you're dealing with. One could have said it here, "Why do I need to know what's in your 55 gallon drum, because it won't burst open," so it's a matter of taste, I would say.

Conservative assumptions can also have the effect of blinding one to physical and chemical processes that may be very relevant to the long-term behaviour of the system.

MR JACOBI: I just want to take a further step with respect to thinking about used fuel, and that is that we've understood that there are not only different types of light water fuel but depending upon the way that the light water fuel is used in the reactor there may be differing levels of burn up and as a consequence different constituents of fission products. I'm just interested just at a very general level of the extent to which it's necessary for the purposes of thinking about geological disposal to have a very clear understanding of those issues of variability, different types, different sorts of cladding, different burn up rates and so on.

PROFESSOR EWING: In fact, there are quite a variety of fuel types and then

with each fuel type there are different levels of burn out, and the amount of burn up, it's not just the fact on the inventory of radionuclides you have to deal with, it's the issues such as the integrity of the cladding. One may or may not rely on that to some degree in the safety assessment. The degree of burnout, high burn up fuels, will be hotter when they're put into the repository, so the thermal (indistinct) will be different.

I think all of this has to be thought through carefully, but I point out that actually during the last several decades there's been a considerable amount of work on spent fuel for which a pretty solid basis for the safety assessment, but my advice would be that as you see different types of fuel coming into a facility one must ask, "How different? Different in what way? What is the impact on the materials (indistinct)

MR JACOBI: I thought I would change topics for a bit. I want to come to the ultimate question of the relationship between technical issues and community consent, but I just want to first deal with the role of the US Nuclear Waste Technical Review Board and first to understand what it does and its independence, but I want to come in a minute to thinking about the significance of such bodies. Certainly, an Australian wouldn't understand particularly what the Nuclear Waste Technical Review Board does. Could you give us some insight about that?

PROFESSOR EWING: The Nuclear Waste Technical Review Board was established in 1987 as part of the amendments to the Nuclear Waste Policy Act, and their significance in the US was that that's when Yucca Mountain was selected as the one site for which we will continue our activities. The Nuclear Waste Technical Review Board has as its charter by law to review the scientific and technical validity of DOE activities related to implementing the Nuclear Waste Policy Act, and that's for spent fuel and high level waste.

As an example, the transuranic waste at WIPP are not part of the purview of the board, it's just spent fuel and high level waste. Of course, in the US we have (indistinct) and so that's a large enough job. We're a separate federal agency, we're very small, we have 11 board members who are proposed by the National Academy of Sciences and they're from a list proposed by the academy, the members are selected by the president. Then we have a small staff of 10 to 12 professionals and administrative who provide essential technical support to our review process.

We operate by having public meetings, three public meetings each year would be typical. For each of our meetings, we try to select topics and focus on scientific and technical issues related to those topics, and then through letters and reports to the secretary of energy and to congress we make our views known. We're not a licensing agency, we're not part of the NRC, so we're not

asking whether DOE should get a licence, we're really focused on the technical and scientific underpinnings of DOE activities relating to repositories, transported waste and so on.

MR JACOBI: I'm not understanding that the board is independent.

PROFESSOR EWING: Yes, because we're a separate federal agency, so we're independent from DOE, the Nuclear Regulatory Commission, EPA, and we try to provide objective advice. I should also say the 11 members of the board, this is a part-time position. Everyone has a day job, a few a retired, but most people like myself have other jobs. At the moment, I think, except for one person who is retired, we're all have academic affiliations.

We represent a broad range of disciplines, seismology, geochemistry, hydrology, nuclear engineering, material science and so on, and we are a mixture of expertise. Some board members have extensive experience with fuel cycle issues and others have very little, but it turns out that good scientists and engineers looking critically at any range of problems I think can point to important issues and help move the process forward.

We value very much the fact that we have public meetings, and at our public meetings we always allow the public to make comments. This is important to the public because their comments become part of our little record, as part of the minutes. Now our meetings are web cast, so that becomes part of the permanent record. I think we fulfill a very important role, but we're not the only body doing the same. Going back to WIPP as an example, during the period when the project was developing, the National Academy of Sciences had a committee that was constantly reviewing WIPP.

The state had a separate very small agency, the EEG, the Environmental Evaluation Group, constantly reviewing DOE activities. I think we all look back on these times, we realise how important it was to the public to see multiple groups reviewing these activities, so it's not just one review group and you're done, but different groups serving different purposes, sometimes overlapping purposes, that can add a lot to public confidence in the process.

MR JACOBI: I just wanted to pick up on one aspect. When we've spoken to regulators, we have spoken to them about how they test and assess evidence, and I'm just interested how an independent board such as yours goes about thinking about this question of testing an assessment of what are quite complex scientific calculations or projections or estimations.

PROFESSOR EWING: We do it on several different levels. Very often we're lost in the details. We will take a small topic in terms of the overall program, such as cladding, and we will look at that in detail, we will have meetings

where we may invite outside experts in to also listen to the Department of Energy to present research results, and then this will form the basis of our activities, say, on a narrow technical issue. Very recently, in the US the topic of deep bore hole disposal has come up, as it has around the world.

In this case, the board held a two day workshop not only inviting the Department of Energy to present their ideas, but we brought experts from around the world dealing in various aspects of deep bore hole disposals, and this is looking at the broader picture, and then that was the basis for a report to the secretary of energy and to congress. I should say, all of our reports are available online.

MR JACOBI: Can I just pick up one aspect. I understand that the board is not a licensing authority, but I'm just interested to the extent to which the assessments and the information that you subsequently provided to congress and indeed to, as I understand it, the implementers, ultimately has an effect on the licensing process either by the implementers changing what they're proposing to do or the NRC asking a particular question.

PROFESSOR EWING: That's tough to know what our effect is. I guess my personal hope would be that our technical and scientific review results in a stronger licence application, that is, if we find weaknesses in the scientific approach or a lack of data, or the analysis isn't complete, we draw that certainly to the attention of the Department of Energy and I believe they take our view seriously. Sometimes they disagree with us, and that's fine, but other times this leads to additional work and I think that additional work adds to everyone's sense of confidence about, say, the licence application.

We're not in the business of saying, "That looks safe," that's for the regulator. We're in the business of saying scientifically, "Well done," or, "That looks right," or, "That result isn't consistent with what we know from a larger body of scientific literature."

MR JACOBI: I want to ship the discussion to dealing with a report, or some of the issues that are raised in a report, published by the board in November 2015 about processes for selecting a site for deep mine geological disposal. I'm just interested, first, in picking up a concept that's dealt with in there, which is that if one has a range of potential prospective geologies, that is, at the outset of contemplating geological disposal, whether there's a better course in developing criteria to address technical suitability.

PROFESSOR EWING: Right. I have the report handy because I think that with this report the board and its staff have made an important contribution. There are many reasons for doing the report, but I think one important reason in the US, you will appreciate that, is we struggle to move forward, and so it

would be a normal and prudent thing to look at other national programs and ask, "How did they go about sighting the repository? What were the important elements of either of their successes or failures?"

This is a report that's very much a social science study and one that I think can offer guidance to everyone who begins this process. When we ask the question, "Well, how do other countries manage?" one of the very interesting parts of the answer was the issue of this criteria, because if you're going to go forward we need to know to choose between the different sites. I think the world hasn't yet appreciated yet fully this report, but by compiling the criteria what we saw was if you have a single host rock that list of criteria specific to that host rock were very different than a set of generic criteria which you would need if you're going to declare clay, salt and granite.

There are also a category of criteria, exclusionary of criteria, some short list of things that you just don't want around your site no matter what, and this might be tectonic activity, volcanism, natural resources and so on. The report actually sorts through and discusses the criteria in those three categories, and I think by reflection on such criteria it makes one pause if you have several different rock types in your country.

Comparing them may be very difficult because the rock type, looking around the world, dictates the strategy for the engineered barriers, and so separate criteria for the geology would be hard to apply across the board because you would have different strategies for your engineered barriers. For me, the personal message, the message I take away, is that if I had several different geologies probably I would look around the world and ask myself, "Which of the national programs presents a compelling case or is close to the geology that I might have and therefore could present a compelling case?" and then I would pick the host rock, and then for specific host rocks I would have very specific criteria.

That would simplify the process a little bit. Another approach would be to say, "Do a safety assessment on each of the rock types with their engineered barriers," but the difficulty with that is that in the early stage of this activity you don't have all of the information you need to do the safety analysis, so it would be a rather crude analysis.

MR JACOBI: I just want to come on to dealing with the relationship between the assessment of technical suitability and the consent based process and the interaction between the two processes that's dealt with in the document. I'm just interested in whether you have a view about when this question of geological suitability is best considered in relation to the consent based process.

PROFESSOR EWING: I think the major contribution of this report is the concept that in terms of selecting a site one has to pass through two filters: the technical filter with the criteria defined by whatever means; and the social filter, and the order may differ from country to country or from strategy to strategy, but what's clear is you have to pass through both one or the other.

The social filter could be a consent-based process, but from our reading of other national programs and how that's done, certainly in my view it seems that consent-based process means very early engagement with the communities, an engagement that's substantive to the point that you're discussing, the technical criteria. So I'm surprised to say that, in the sense that when I began my career and first entered this particular field, I thought my job was simply to get the science right and move on.

So if you wanted a better waste farm, I developed better waste farms, and what I noticed was that nothing that I did scientifically had any impact, and there are a number of reasons for this, but what I've come to appreciate is that in this particular activity it's the scientific and social impact, the scientific and social filters that matter. So it's not enough for me to do something scientifically, publish a paper and put it on my résumé. I have to be able to understand how that fits into the safety analysis and I have to be able to explain that to the affected public, which would be the local community and, in the United States, the state agencies.

The WIPP project actually was a good example of a lot of public engagement. I described the Academy Committee, the state agency EG. In the beginning the state of New Mexico was certainly not enthusiastic about the prospect. It took some time, more than a decade, to move the technical and social discussions to the point that politicians and people outside the community, but still within the state, began to see value to the project.

MR JACOBI: I just want to pick up on something that's, I think, dealt with in the report - hopefully my page numbering is the same as yours - at 33, which was the interaction between technical suitability and social suitability and how they fed one another, and I'm just particularly interested with respect to the consent-based process, the need to actually undertake technical and scientific analyses in order to provide assurance in order to then obtain the social consent and indeed, then to continue to move through the process. I'm just wondering perhaps whether you might be able to expand on what's dealt with in relation to that issue.

PROFESSOR EWING: So I'll use the WIPP as an example again. So the Academy Committee were mainly charged to do daily activities, and so we would have open public meetings DME scientists would come and make presentations and then there would be vigorous scientific technical discussion

(indistinct) but then also the state agency and NGOs would be given the opportunity to answer questions, and so it was a very open process. The discussions were very technical, but the public was there.

I had just a personal story, the experience that a local community member, very fearful of radiation, had a question, but of course the question wasn't phrased in a way that it could be put into the scientific discussion, and so after talking to her, I repackaged her question - probably it was hard for her to understand it at that moment - and asked and then tried to understand what the answer would be, and then after the session at a break, then I made my best effort to explain what the technical and scientific answer was and I think over time, this happening many times, it has a positive effect.

It has a positive effect on the scientists in that we have to answer questions and we're not always as critical as we should be, and so questions from the public really sharpen our thinking. By learning how to answer the questions, of course that's the way we build up credibility and trust which makes the consent-based process - it moves it along, let's say. So there's a very close connection between the technical and the social, and the more you can mix them, as difficult as it is in practice, over time it's to everyone's benefit.

MR JACOBI: Could I take that a step beyond that and come to the topic of its relationship to siting? It's the observation that's made that if you can resolve by a simple process and establish the technical suitably of a site, you may have a less substantial challenge in terms of meeting the social acceptability filter as it's described in your report. I'm just wondering perhaps whether you can expand on that.

PROFESSOR EWING: With all these technical aspects, it's inevitable that the safety analysis grows into an opaque ball of interconnected strands, and so for the WIPP site, the Academy Committee repeatedly asked for the simple analysis; that is, we're not saying skip the complicated analysis, but if, having done the complicated analysis, then one must be able to transfer the essential aspects to a story that can be presented with confidence and credibility to the public. And so - I hope I'm answering your question - I think we can get away from a pretty elaborate and complicated analysis, but if something is really safe we should be able to make that case to the interested and affected public.

And that case is made not only by its veracity, but by the personal interactions that you have with it. It's very much like selecting a doctor. Of course you want someone who is very competent, very experienced, but we all have our preferences based on how we interact with a person, and so I think there's a large element of that in the technical and social interactions related to the consent-based process.

MR JACOBI: The report also reflects upon the international experience with attempts to site geological disposal facilities. I'm interested, perhaps as a final question, to pick up on any views you have as to what the key lessons are that have been learnt from those consent-based process.

PROFESSOR EWING: So there are two. The first is it's essential that the implementing agency, the implementer, have trust and credibility, and so that affects how the implementer moves into a community, how it interacts with them. Trust is something that you earn over time and it's a very human activity.

The other lesson, looking at the programs, that's important is how - well, in the report we call it the power - how the power is distributed. That depends very much on the different forms of government. In Sweden, the municipalities effectively have a veto and that changes in a major way the dynamic as compared to a federal system of government where the federal government might say to the state, "We're going to put a repository here," and I think from my reading, what I take from the report is, before you get into the process the rules have to be very clear as to who has the final say; if a community has a veto, when can they exercise that veto; how would they exercise the veto, and so on. So the rules should be laid out at the beginning.

COMMISSIONER: Professor Ewing, that's incredibly helpful. I very much appreciate the time that you've taken with us this morning, and also for the preparation of this. It's been a very useful part of our Commission process. So I thank you very much for your time.

PROFESSOR EWING: I'm happy to help and good luck.

MR JACOBI: Thank you.

COMMISSIONER: Thank you very much. That concludes the open sessions for the Royal Commission.

MATTER ADJOURNED AT 8.31 AM ACCORDINGLY