COMMISSIONER: Good morning and welcome to the Nuclear Fuel Cycle Royal Commission, topic 7, Expansion of Exploration and Mining. Today we will hear from Heathgate Resources, the Environmental Protection Agency, BHP Billiton. There also has been a change on the front bench. Mr Jacobi, counsel assisting is on planned leave for the birth of his second child and I welcome Mr Christopher Handshin. Christopher.

MR HANDSHIN: Thank you. South Australia currently hosts significant uranium mining operations and is thought to contain around 25 per cent of the world's known uranium deposits. The commission's terms of reference require an examination of the potential for an increase in exploratory mining activities, extraction and milling processes from a regulatory economic and environmental perspective. As part of earlier public sessions, the commission has heard that some geological studies and surveys suggest that there may be significant and as yet undisturbed resources in areas of the state which have not yet been subjected to any comprehensive exploration. The question for the commission is whether it is feasible for industry participants to explore these sites and in the event that proved deposits of economically recoverable radioactive mineral resources were located, develop new operations or expand existing ones to mine these sites.

Following on from evidence received at previous public sessions, the degree to which industry participants, government and research organisations can potentially collaborate to facilitate and promote efficient exploration and mining activities ought be considered and the commission intends to explore this issue in a later public session as part of topic seven in mid-November. The focus of today's evidence will be on the status of uranium mining in South Australia today. In recent years there have been significant developments at some of Australia's most substantial mining operations at Olympic Dam and Beverley. At Olympic Dam, BHP Billiton's approval to expand its operations to include open pit mining has not yet been acted on and there has been a reduction in the tonnage of produced uranium oxide over the last two financial years. Beverley and its satellite mines have been put in to a care and maintenance mode by operator Heathgate Resources and attention diverted to the Four Mile Mine operated by its affiliate Quasar Resources.

The circumstances both local and international which have brought about these events need to be identified so that there can be informed discussion and analysis of the prospects of expanding existing mining operations or establishing new operations. These topics raise multidimensional questions, including the potential local and broader community benefits and detriments of increasing exploration and extraction activities, the economic incentives and barriers to doing so and the potential environmental impacts. The relevant characteristics of current mining techniques, including open cut, underground explosive, in situ leaching and heat leaching and their respective benefits and disadvantages, including waste streams and their management must also form part of the commission's inquiry. At previous public sessions held at Port Pirie, the commission heard evidence concerning the environmental impacts of historical radioactive mineral mining and processing practices and the lessons that have been learned from that past. Today's public session will explore more recent environmental management practices within the mining industry with a view to understanding the currently accepted methods for assessing, addressing and monitoring the impacts of uranium mining within the state.

This morning's first witness will be Dr Andrea Marsland-Smith of Heathgate Resources Pty Ltd. Heathgate Resources owns and operates the Beverley and Beverley North uranium mines which are located approximately 520 kilometres north of Adelaide in South Australia. Beverley which commenced production in late 2000 is Australia's first commercial in situ recovery mine. Uranium mining activities at both Beverley and Beverley North were suspended in early 2014 and the mines are currently in standby. Dr Andrea Marsland-Smith is a geologist with 23 years minerals industry experience with both Australian and international companies. The last 13 years of her career have been focussed in the uranium exploration and mining sector and she has held a variety of senior geological and management roles. In 2008 she was awarded the AMEC prospector of the year for the discovery of the Four Mile Uranium deposit. Currently she is the manager of regulatory and compliance and directs Heathgate Resources state and federal government relations and regulatory approvals.

COMMISSIONER: Dr Andrea Marsland-Smith, welcome. We have heard that Heathgate has considerable experience since 2000 with in situ recovery mining. And the areas that we would like to start and explore initially will be in situ mining and exploration which are quite clearly linked to our terms of reference. So perhaps to start, in the broader sense, can we understand the method of in situ mining and the aquifers, the work that you do to characterise the geology and broadly work us through the process of in situ mines.

DR MARSLAND-SMITH: Sure. So first of all, going to first principles we need to undertake the exploration process for an in situ recovery amenable deposit. Those requirements prescribe that the ore body is hosted in a permeable sandstone and is under the water table. Because it's that groundwater that we use as our mining solution. So once that resource is discovered, we delineate the resource to some detail, to know where our high grade areas are versus – leachable versus non-leachable areas and I will just go to slide four – slide five, which shows you what these deposits look like under the ground. So ISR leachable resources are <u>not</u> commonly referred to as roll fronts and this is what they look like under the ground. Up at Beverley and Four Mile and Beverley North, our roll fronts are between 120 metres and

280 odd metres below the ground. You will see they are like U-shaped or C-shaped ore body morphologies. How they form is we have the Flinders Ranges next to the Frame Basin which is a package of sedimentary layers and the northern Flinders Range is very enriched in uranium as we all know, particularly in the northern Flinders Ranges area. So what happens is the rainfall percolates through the Flinders Ranges, picks up the uranium from those hard rocks, like the granites where the uranium is hosted and at neutral pHs almost like rainwater pH, leaches that uranium because uranium is very mobile. Picks it up and pushes it out in to the sedimentary basin and when that groundwater carrying that uranium reaches a reduction zone, meaning an area that is enriched in carbonaceous matter, like leaf litter or where you might have some pyrite in the formation, that uranium reduces which means it comes out of solution and drops out in to that sandstone.

This happens over time, so a million years this process happens time and time again which is why you get to see this ore body morphology that looks like the front of a wave basically. Where the most rich part of the ore body lies is in what is called that redox front roll nose area. And that is the area that we target in our mining process because it’s at the front of that roll. It is the most easily extractable part, whereas at the back of that C-shape the upper limbs and lower limbs, whilst there’s still uranium in those, they’re caught in clay, so they don’t mobilise as quickly. So we have what is called a roll front with limbs and a roll, or a nose area. So once we define where our roll and a nose is and where the limbs are, then we start looking at, well are there multiple stack rolls because these can occur in five to six different layers, as you imagine, just with a wave that you see at the beach with the froth at the front of that wave. So we use drilling primarily and down hole, bore hole logging. So we send probes down our drill holes to measure the gamma radioactivity and the grade of the uranium down hole and some other things like porosity, where the water table is, so we understand exactly where that is. And then we progress to installing a well field.

So our well field comprises of water wells, as you would imagine because we are going to use the groundwater in that system to circulate through to our plant. So we install wells. If you just go up to the next slide. Yes. This is a picture of the process, and you'll see in the picture to the top lift we have our roll-front host within our sandstone ore body. To understand how that's going to leach, we undertake several studies understanding the porosity. We do pump testing in the field to understand flow paths; groundwater gradients; where the regional groundwater flow is going to go; what is the groundwater quality like, so we have to understand exactly what the baseline groundwater characteristics are; and how is this ore body confined, is it confined by clay layers, is it not.

So in the Frome basin we have our ore bodies currently confined by impermeable clay layers above and below the ore body, and then we then progress to the wellfield design stage. So the wellfield design stage is when we look at the shape of that roll-front and design the wells to fit exactly over that roll and nose area that I was talking about previously. And so in the top right-hand corner you'll see a picture that just shows as an aerial photograph of what a wellfield actually looks like, and you'll see a number of points with lateral pipelines heading out to them. They are all the wells that we install over a wellfield. Those wells are spaced normally 30 metres apart, but again, it depends on the width of that roll-front.

The two pictures to the left there show you how the flow paths of these well configurations occur. So you can choose to have five spot patters where we have an extractor in the middle and we have our injectors, which is going to use as putting the mine solution into the ground, around the outside. So those configurations are set specifically to maintain the fluid flow in the vicinity of the wellfield. Once you start having asymmetric configurations then you have to do some more modelling around how is your fluid flow going to look underground once you start circulating. So all of that is done by very high level, hydrological modelling and flow modelling with input parameters such as the porosity, what we know about the groundwater gradient, the pressures at which we're going to flow the wells at, et cetera.

So once we've established our wellfield then we connect our pipes up to a plant. If you just go to the other slide. Yes. So you'll see particularly in Heathgate's operations we have three plants in the area. We have two satellite plants up in the Beverley north area, Pepagoona and Pannikin. We have the Beverley plant down in the centre of the slide. The wellfields at Four Mile, for example, are just wellfields and they are plumbed up to the Pannikin satellite plant where the fluid goes to and gets part processed and then that part-process fluid is trucked then to Beverley for the back end part of the process which is drying and packing. When we operated Beverley our wellfields were right next to that Beverley plant. So we plumbed those wellfields straight into Beverley and that took care of the whole process.

If you go back to that other slide then, Lucinda. Thanks. So going back to the left-hand slide showing that cross section of the process, you see we have an injection well and a recovery well or an extraction well, and as I said, we have a multiple array of these. So once the wellfield is plumbed up to the plant and the whole system is closed in terms of the pipework, we start circulating the groundwater that exists within that mineralised zone. So the groundwater comes out via the recovery well and goes to the satellite plant and that's when we condition that groundwater to lower the pH and we also add an oxidant to that fluid.

It comes back from that plant into the injection well, as you see in that slide, all again pumped using submersible pumps down these water wells. So that's what we use to push the fluid around, and they're all controlled by a control room. The pressures are constantly monitored, the flow rates are constantly monitored, to ensure that each injection well is communicating directly to that extraction well. And then as that conditioned groundwater moves through the formation, through that ore body, it's pulled towards the recovery well, pulled out, and that uranium is then in solution which goes back to the satellite plant and through then the recovery process.

The recovery process comprises of an ion exchange process where the fluid is put through a number of iron exchange columns which you can see in the picture, those three columns that you see. So it's basically like a water softener and the water softener contains these resin beads which you see in the picture next to it. Those resin beads essentially absorb the uranium out of the fluid onto it. So the uranium sticks to those resin beads and then that that resin bead slurry can then be transported anywhere you need to get it transported for back in processing. So with our process, we truck it back through our resin trucks back to Beverley, which you can see then in that bottom area for all that back end drying, thickening and packing process. So that essentially is the process. Yes.

COMMISSIONER: We might unpack some of that now, Mr Handshin.

DR MARSLAND-SMITH: Yes.

MR HANDSHIN: You made reference, Dr Marsland-Smith, to drilling and probing activities as part of the stage of identifying the nature of a deposit that you're working with. I just want to go back to a step before that and get you to explain some of the general techniques that are used in the initial exploration processes.

DR MARSLAND-SMITH: Yes. So it's very important to understand the regional geology, and so the way that we have approached that methodology is using all of the available data to us, and that includes publicly available geophysical data such as magnetic surveys, gravity surveys, electromagnetic surveys, all to try to characterise where our host rock occurs and how is it in relation to impermeable layers. Heathgate specifically has undertaken very high-resolution seismic surveying to get a very detailed pictured of the basin, and that was the first of its kind done for this type of deposit in the world, I think, about three or four years ago, so that was leading into the Four Mile permitting. So we have a very good regional picture of the geology is looking like.

From there, we obviously drill a lot. So we've drilled in excess of 14,000 holes in this area, and use borehole logging to characterise and detail the geology down every single hole. The resolution of data is 2 centimetres. So you imagine over a 300 metre hole we have 2-centimetre resolution of the geology down the hole. So we very accurately understand where there may be small clay layers that may divert flow. So we understand that ahead of time before we start flowing through wells. From there, we also take core samples and understand the mineralogy of the uranium before we look at what type pH we need to lower the groundwater at, et cetera, how much oxidant we need to put in. So the mineralogy of the uranium and how that uranium is in relation to other minerals in the ore body has an effect on those forecasts.

MR HANDSHIN: In what way?

DR MARSLAND-SMITH: So if you have more reductant in the formation there may be a requirement to use more oxidant in the dosing stage, because the reductants, or the organic matter, competes for reagents along with uranium. So the organic matter will utilise all of the reagents in the groundwater before the uranium is liberated. So you need to understand that before you start your operation, yes.

MR HANDSHIN: But some of the data that you've referred to that's deployed in this exploration stage of the process is that generally available data or is that data that's been collated by Heathgate as part of its commercial operations?

DR MARSLAND-SMITH: Yes, we've spent the last 15 years, we've deployed almost every single geophysical method to try to understand is there one single geophysical method that can map our deposits and the answer is no, but the answer to the question is it's a combination of all of those data sets combined, so it's almost like data mining and not one piece of data is going to lead you to the answer, but if you look at it holistically and use innovation in looking at how you can integrate that data and we use organisations such as CSIRO, we collaborate with universities to innovate in that area to try to see if we can have a method that can remotely detect where these deposits are.

MR HANDSHIN: Yes. What kind of collaboration are you talking about, what's involved?

DR MARSLAND-SMITH: Yes. Again we've got a 15 year database of every geophysical method known to man undertaken and - - -

MR HANDSHIN: In this particular area?

DR MARSLAND-SMITH: In this particular, yes, and we also have a very big database of drilling data which calibrates all of this data, so we understand if there's an anomaly in the electromagnetics, an electromagnetic high, which may indicate a saline part of groundwater we can then drill that and test that to see if that's a channel or a sand that's hosting some water which may be a target, so with CSIRO for example they recently published a study over Honeymoon mine where they reconstructed the paleo-hydrogeology, which is the historical – how the landscape looked back 30 million years ago because how it looks today was not how it was then and so in understanding what the regional groundwater flow was back then will help us target where we need to drill in the future years and so they have some proprietary software that helps us - we use our data and we co-operate in ways like that.

MR HANDSHIN: It's clear that having access to high quality data is essential to the process.

DR MARSLAND-SMITH: Yes.

MR HANDSHIN: Are there currently programs such as the UNCOVER program that are designed to make this kind of information more accessible to prospective operations?

DR MARSLAND-SMITH: I think it's also about when you are doing an investigation making every single drill hole work for you, so the UNCOVER program does that in terms of if you're putting a probe down the hole you need to measure four things, not one thing because it's a waste of money and time if you have to redrill that hole again to measure another parameter, so I know that that's where the value of those programs lie.

MR HANDSHIN: Is Heathgate involved in the UNCOVER program in any way?

DR MARSLAND-SMITH: We were in the initial stages in the borehole logging field, but we have our own R and D arm as you'd appreciate, so whilst we participate in those programs we also run our own.

MR HANDSHIN: Is access to high quality information in your view one of the barriers to further exploration in the state?

DR MARSLAND-SMITH: Yes.

MR HANDSHIN: What can be done to improve both access to and the quality of the information that's currently available?

DR MARSLAND-SMITH: What can be done to improve it? It's really when companies gather information maybe reducing the time for which that becomes publically available is probably one area that there's an opportunity to look at and particularly in areas where companies have held tenements for quite some time, beyond the standard five year period would be my response to that.

MR HANDSHIN: What issues does long term proprietary rights over tenements create?

DR MARSLAND-SMITH: Those tenements are probably held for not just uranium exploration, so they'd be multi-commodity tenements. People who were interested in just uranium can't get access to that ground. Similar to the petroleum industry. They can take tenements over the top of a mineral tenement, so they can co-exist. I think the uranium tenement or the tenement system for uranium could adopt a similar system than what we have for petroleum and geothermal leases, so a system where we can unlock some more ground for the purpose of uranium exploration.

MR HANDSHIN: One of the other matters that you've raised is perhaps the more practical side of things namely the drilling.

DR MARSLAND-SMITH: Yes.

MR HANDSHIN: Is that a capital intensive component of the exploration process?

DR MARSLAND-SMITH: Yes, it is. On average each delineated hole will cost around 15 to 20 thousand dollars, so we have a basin of 5800 square kilometres, a drill hole is this wide, so to try to pinpoint a roll-front of that size that I showed you earlier is quite a challenge, but without that drilling you can't get information about the geochemistry of the formation and, Lucinda, if you just go to that roll-front map you'll see that in relation to a roll-front there's the sand that is around, you'll see some darker areas and some lighter areas and it's that change in character of the sand that we look for in our exploration, so when we hit an oxidised part of the sandstone we know there's a cell that's come through here somewhere and so where is our roll-front, where's the front, so drilling is the only method that delineates that in the field.

MR HANDSHIN: Are you familiar with the PACE program?

DR MARSLAND-SMITH: Yes.

MR HANDSHIN: How do you see that as incentivising further drilling activities?

DR MARSLAND-SMITH: It certainly helps junior companies get out there on the ground and look at new areas that may be perspective for roll-fronts, so instead of having to find foreign investment it helps them get on the ground to do some preliminary work and it doesn't take too long if you have a

Robustel program to understand what we call the redox state of the sands are, which is this system, it doesn't take long to determine that.

COMMISSIONER: Can I just go to the slide where you've got the four mines?

DR MARSLAND-SMITH: Yes.

COMMISSIONER: Can you explain the current state for those mines?

DR MARSLAND-SMITH: Yes. Beverley commenced production in 2000 and ceased production in around December 2013, having produced approximately 16 million pounds of uranium during its lifetime. The average production rate for Beverley was around seven to eight hundred tonnes per year on average. In August 2008 seeing that the resource at Beverley was limited, and you can see we did some exploration to the south and to the east of Beverley, found some small deposits, but they were not in very permeable sands and they were more difficult to extract. Nonetheless we put wellfields over those areas and they are still there for another day to redress if the uranium price goes north of $70 a pound.

COMMISSIONER: It's currently at 40, isn't it?

DR MARSLAND-SMITH: It's about 35.

COMMISSIONER: 35.

DR MARSLAND-SMITH: Yes. Seeing that future for Beverley the company then started looking at other exploration programs in the area, so Heathgate has been exploring since 2002 and in 2005 the Four Mile deposit was discovered and that's particularly the Four Mile east and west deposits and then, just as a matter of course, in our normal exploration programs we found Pepagoona and the Pannikin deposits which lies in and around those Pepagoona and Pannikin satellite plant areas, on the Heathgate side of the boundary. You will see that Four Mile northeast ore body, that's just recently been discovered so it wasn't known that all the deposits were connected at that point. So nonetheless, Beverley's production time was coming to an end and so we refocussed our efforts up in to the Beverley north deposits, which was Pannikin and Pepagoona and we applied for extended mine lease in 2008 and we started production in 2010/11 on those areas.

COMMISSIONER: What do they produce per year?

DR MARSLAND-SMITH: They produced only for around two to three years and produced around a million pounds each, one to 1.5 million pounds each per year. So we still have some ore to the east and west of Pepagoona which transgresses the lease boundaries, as you can see in that diagram and so we are currently looking at how we mine across those lease boundaries and we are working through those approvals currently. So then Four Mile was subject to some litigation which was resolved earlier this year and then more recently Quasar bought the remaining equity in that project from our joint venture partner in September.

COMMISSIONER: Quasar in relation to Heathgate?

DR MARSLAND-SMITH: Quasar is a subsidiary of General Atomics, just like Heathgate is a subsidiary of General Atomics. Heathgate is the service provider for all its operations to Quasar.

COMMISSIONER: Right.

DR MARSLAND-SMITH: Yes. So Four Mile then was put in to production in April in 2014 and is still in production now. That operation is essentially well fields linked up to that Pannikin satellite plant. Currently Pepagoona is off line, we are not using that plant at present but we have plans to reinstate that plant in the coming year or so pending some infrastructure modifications to be able to increase our production through that area.

COMMISSIONER: So it's an issue of infrastructure not uranium cost? Uranium price, I should say.

DR MARSLAND-SMITH: Yes, it's infrastructure and – well, it's always uranium cost because we don't want to make a loss, so it is break even or profit but because we already have a lot of capital invested in this area, it's easier for us to put on lower cost or marginal well fields that may not be economic to put in to production in a greenfields area, if you had to put in all the capital to start.

MR HANDSHIN: Can you provide us with any more detail about the nature of the infrastructure developments that are being undertaken?

DR MARSLAND-SMITH: Yes. So it's really about – it's two things with ISR, it's grade obviously and flow. So your plants are your limiting – how much you can flow is your limiter. So if your grade is dropping, you can increase your flow and maintain that same head grade. If your flow starts diminishing because your wells are not producing as well, or there is constraints in your plant, then your head grade needs to compensate which is something you can't control really. S it's flow is the main thing that we look at. So if we want to increase production, it's usually an increase in flow capacity which means putting in more of those IX columns, bigger pipes, the whole – at the beginning of a project, you have to assess what flow rates you think you might go to and either build to that or build to what the price currently determines that you need to flow at because you'll produce this in 12 months and then have no future. So it's all a balancing act between flow rate and your future projections to how you want to develop the ore body.

MR HANDSHIN: Have you got a timeline for the completion of those developments?

DR MARSLAND-SMITH: We are working through that currently.

MR HANDSHIN: Can I just pick up on one thing that you mentioned a moment ago, in the context of bringing operations at Beverley to suspension.

DR MARSLAND-SMITH: Yes.

MR HANDSHIN: And you referred to the price of uranium needing to reach in the order of $70 a pound to make it commercially feasible again. Do you see any indications that the market might be trending in the right direction in that respect?

DR MARSLAND-SMITH: Heathgate takes a very long view and as you've seen, we have operated Beverley from a $7 a pound price through to current day to the heady prices back in 2006/7. So we are committed to the long term but we do have an expectation that the price will support our ongoing investment in this area and operation.

MR HANDSHIN: Are there any other broader economic commercial or regulatory factors for example that could influence what Heathgate did at Beverley in the short to mid-term?

DR MARSLAND-SMITH: It all comes back to; I think bipartisan support for uranium mining. We don't invest in states that don't support uranium mining because we don't see what the need to explore, if you can't mine that asset. So because we are producers, that is our end game, so it is highly essential for us to keep having that bipartisan support and that is the top of the tree for us to continue our investment in SA.

COMMISSIONER: Can I just explore, and if this is commercially sensitive you will let me know but what – do you have a production goal per year? I know it is clearly linked to the uranium price but I just want to get a sense of where you are now - - -

DR MARSLAND-SMITH: Yes.

COMMISSIONER: - - - where you have been and subject to price, where you might want to be in the future, based upon the deposits we see just here on this particular screen?

DR MARSLAND-SMITH: Yes. As - - -

COMMISSIONER: In the broader sense.

DR MARSLAND-SMITH: In the broader sense, yes.

COMMISSIONER: I'm not interested to try and compromise - - -

DR MARSLAND-SMITH: Yes.

COMMISSIONER: - - - commercial issues.

DR MARSLAND-SMITH: Look production is not going to go down from where we are at currently, so we currently produce around two million pounds a year with the current infrastructure. So to - - -

COMMISSIONER: And that is exported?

DR MARSLAND-SMITH: Yes. So in order to increase that production, we have to do modification to the Beverley plant as well because Beverley initially was only rated at around a million odd pounds a year production. So there's a number of things that we need to upgrade and we're looking at that now and working through those - - -

COMMISSIONER: So goal is two million pounds a year - - -

DR MARSLAND-SMITH: That is - - -

COMMISSIONER: - - - or around about?

DR MARSLAND-SMITH: That is where we are at the present time.

COMMISSIONER: Right.

DR MARSLAND-SMITH: So we are currently working through, as we speak, our plans for the future and there is a number of issues that we need to look at. In the Four Mile lease we have about 40 million pounds out of an inventory of say around 60 to 80 million pounds. That is currently permitted for extraction. The other pounds are not; they are in a different geological formation and so they need to be looked at in terms of permitting again. So we have still got a way to go to be able to understand if we can extract all of these resources in this lease.

COMMISSIONER: Yes.

DR MARSLAND-SMITH: Part of the Four Mile west deposit is in dry rock, so there's no water around, so it cannot be extracted using our current concept of ISR, so there is new technologies that we need to look at, if we are to extract - - -

COMMISSIONER: Is that a substantial resource?

DR MARSLAND-SMITH: That's about 20 million pounds, so that's Beverley, so that would be at a million pounds a year, around 15 year's production. So there is a number of issues to work through but currently we have around 40 million pounds to produce and at current rates, they will – if we don't increase production, will be around a 10 years of production but again, that's all dependent on flow rate and how these wells produce because each well field is different. You cannot predict how a formation is going to flow in the end. You can have a good idea, but the proof is when you actually start flowing.

COMMISSIONER: Does anybody in the world at the moment currently produce this from a dry rock? I'm talking about the west deposit. I mean, are techniques available to do that?

DR MARSLAND-SMITH: There are some deposits in the US, you know, that you can raise the watertable locally in order to use that. There are other techniques such as borehole mining. That's a new technique, but not used. There's obviously open-cut mining. You know, so there's a lot of different things and options that we need to assess and also work with government on, you know, how the permitting of that would go. Yes.

COMMISSIONER: Right. Okay. So apart from uranium price, in terms of the investment environment, you're comfortable that there's not much else - I don't want to put words in your mouth. Are there any things from a State government perspective that might be undertaken to further incentivise the company to increase production or to increase exploration?

DR MARSLAND-SMITH: Again, coming back to the partisan support, having a regulatory system that is supportive of different ideas in uranium milling and mining, so whilst this might be an ISR project for now, we may need to transgress into some other option, so being fluid enough to consider those options.

COMMISSIONER: Do we have a system, in your view, that is so characterised?

DR MARSLAND-SMITH: Yes. I think so, yes. You know, as with any project you have to demonstrate that you're not going to affect the environmental values outside of your mine lease should you undertake an extraction method X, Y, Z, and that's always - you know, we're committed to that process.

COMMISSIONER: That might be a good time for us to talk about some of the concerns that we read in submissions about in situ pollution.

DR MARSLAND-SMITH: Yes.

COMMISSIONER: Kris?

MR HANDSHIN: Can we perhaps go back to the configuration of the wellfields and the use of water from obviously groundwater resources?

DR MARSLAND-SMITH: Yes.

MR HANDSHIN: Can you tell us a little bit about the process of groundwater characterisation that you use and what it tells you about the water that's currently being used for Heathgate's activities?

DR MARSLAND-SMITH: Yes. Before you start an ISR process and formulate your monitoring regime and your closure strategy you need to understand what the water quality is obviously. So we use - and every other operation, Honeymoon, et cetera, does, and a lot of other mining operators - use the guidelines called The Australian New Zealand Guidelines for Fresh and Marine Water Quality. So we take extensive groundwater samples from every single water well available that we have. We even drill specific water wells for understanding groundwater quality. It's not only mining aquifer that we grab samples from. We get samples from above and below the mining zone, kilometres away from the mining zone, and understand if there's a variation in the water quality.

So at Beverley, and all of the deposits in that Frome basin region, the water quality is classified as industrial and is of no beneficial use or environmental value in accordance with these water quality guidelines, and that is on the basis that the water has too much fluorine in it and also radon. So it's not usable for stock use. It's not usable for any other use now. So the water quality there is of no beneficial use apart from mining.

MR HANDSHIN: Is that the water occurring in its natural state?

DR MARSLAND-SMITH: Yes.

MR HANDSHIN: Are the currently technologies available that would allow the manipulation of the water's composition to make it usable for other activities?

DR MARSLAND-SMITH: There amount of investment to change its original water quality from a non-usable quality to a usable quality would be not feasible, I don't think. Yes.

MR HANDSHIN: I just wanted to perhaps pick up on the second issue, which concerns the use of a reagent solution in the recirculation process. Perhaps I should clarify that the operations at Beverley and Four Mile involve an acid leaching process. Is that right?

DR MARSLAND-SMITH: Yes.

MR HANDSHIN: As opposed to an alkaline process?

DR MARSLAND-SMITH: Yes.

MR HANDSHIN: Can you tell us what the acids that are used in the process are?

DR MARSLAND-SMITH: Yes. So as I said, we grab the groundwater from the pore spaces within the sandstone that is in and around the uranium ore body. So it's already got natural uranium in it anyway, and radionuclides and base metals. So when we circulate that to the plant for reagent addition, we use sulphuric acid, H_2SO_4, as the acid, and we use peroxide, H_2O_2, which is the oxidant. Now, all of those elements that make up those equations are already present in the groundwater. So we specifically choose H_2SO_4 because the groundwater already contains sulphates, and that's extensively documented in our baseline water chemistry data. So we're not adding any element that's not already part of the groundwater elemental makeup and that's, you know, an important part of our process.

MR HANDSHIN: But a high concentration.

DR MARSLAND-SMITH: It increases the concentration. So it lowers the acidity of that groundwater.

MR HANDSHIN: And that solution with the reagent in it is pumped through the aquifer?

DR MARSLAND-SMITH: Yes.

MR HANDSHIN: Is that right?

DR MARSLAND-SMITH: Yes.

MR HANDSHIN: Does that give rise to a risk of the mining solution perhaps disbursing beyond the confines of the mining aquifer, and if so, how do you guard against that risk?

DR MARSLAND-SMITH: Okay. So inherent in a wellfield design is making sure that, again, what I said, those injectors are hydrologically communicating with your extractor. So that's the first level of insurance, that you have connection and you're not injecting into somewhere else where you're not extracting concurrently from. We have a team of hydrogeologists on site which monitor the pressures of all of the pumps in every single well 24/7, and if you're injecting 1 litre you have to extract 1 litre to keep that wellfield balanced. That is the key to keeping your fluids in and around the wellfield area. So you can imagine if you put 2 litres in and only take 1 litre you're over-pressuring and there's a risk that the plume can migrate out.

If a pump goes down we rebalance the wellfields. We always - rebalancing, relooking at it, remodelling and adjusting well flows to make sure our wellfields are balanced. Another thing over the top of that is as the groundwater is circulating through the aquifer and going to the plant, we take out what's called a bleed, which is maybe 1% of the total flow of that system, and that maintains a low pressure sink around the wellfield. So when we are operating a wellfield we're overriding the local hydrogeological gradient. So we're actually overriding the natural groundwater flow system in that vicinity of the wellfield, and so that bleed helps us keep that - you imagine, fluids flow from a low to a high. So if we've got a low pressure sink over the wellfield due to this bleed then the fluids essentially contain in that area.

Around the wellfield too we have an extensive ring of monitor wells, which are again water wells. We have wells in the mining aquifer themselves around. So around 250 metres odd from the wellfield there'll be monitor wells that we grab water samples from the mining aquifer. We also have monitor wells above and below the mining aquifer to ensure that we don’t see any migration of mining fluid above or below, but again we have clays above and below and that’s also what contains the solution above and below.

MR HANDSHIN: Are they known as aquitards?

DR MARSLAND-SMITH: They are known as aquitards, yes.

MR HANDSHIN: The monitoring system that you use does that enable you to regulate both lateral and vertical dispersion?

DR MARSLAND-SMITH: Yes, and there has been on occasion where you'll see maybe sulphates elevate in a monitor well. It gives you that feedback to tell you that or there's an issue and you need to pull back your fluids, so the monitor well ring, the lateral monitor well ring, is designed for that purpose and, yes, you pull back your fluids, get that feedback from your monitor well. It's not a non-compliance and it's not a breach of your lease conditions, that's the purpose of the lateral monitor network.

COMMISSIONER: Can you just tell us what happens to the one per cent that you bleed off, what happens to that water?

DR MARSLAND-SMITH: Yes.

COMMISSIONER: Presumably that is higher in concentration minerals than the normal groundwater.

DR MARSLAND-SMITH: Yes, it is a little bit, but the uranium has been taken out and along with all of our processed water that bleed water is then put into our evaporation ponds and we evaporate as much water as we can because what we don't want to do is dispose of more water than we need to, so it goes to the evaporation ponds along with our processed water, the plant wash down water. It evaporates off and what's left in those ponds gets disposed in the old wellfields, abandoned wellfields at Beverley and then, as I said before, each litre you put in you have to take a litre out of an aquifer, so at Beverley when we dispose of this residual water that we can't evaporate into those abandoned wellfields we also take a litre out downstream out of that same aquifer, which is fresh water, to use back into our process, so it's a continual water recycling system.

MR HANDSHIN: What is it about the Beverley wellfields that makes it an appropriate site for the relocation of the waste stream?

DR MARSLAND-SMITH: Beverley is basically a bathtub, it's called a paleochannel. You probably would have heard of that terminology, but it's essentially a clay bound channel filled with sand and it's very stagnate. The groundwater movement is very, very slow. At Four Mile for example the groundwater flow is around 10 to 20 metres per year, which is very slow, but at Beverley it's around one for example and that's because of the stagnate nature of the system. It's not open to any groundwater recharge, so it's just this body of water and sand that's contained with this clay layer. The clay is very thick and so the likelihood of any excursion outside of the paleochannel is almost non-existent and so we have mined out areas at Beverley that are already affected and so we're disposing into affected or altered state groundwaters already, so - - -

COMMISSIONER: I just need to go back. I see we still get rain in the Flinders so what happens to the water that washes off if you say there is no recharge?

DR MARSLAND-SMITH: Yes.

COMMISSIONER: Can we go back to that?

DR MARSLAND-SMITH: Yes.

COMMISSIONER: You've got all those ranges there, presumably the water still comes through.

DR MARSLAND-SMITH: Yes.

COMMISSIONER: What happens to it?

DR MARSLAND-SMITH: Because the Beverley channel is so confined, it's 120 metres below the surface, so it gets minimal recharge. I suppose like (indistinct) gets no recharge, but very limited. The rest gets pushed into the Eyre formation which is below the Beverley aquifer.

COMMISSIONER: How deep is that?

DR MARSLAND-SMITH: The Eyre formation is around 200 and 300 metres depending on where you are in the region and how much vaulting is going on, so the Eyre formation takes a lot of the recharge off the ranges which is why you see those deposits where they are because those deposits are a direct result of groundwater recharge, but it's carrying uranium, so that in essence is evidence that we have a lot of that recharge happening. Those deposits are still being remobilised and moved as we speak because we still have the groundwater coming through, so in a million years' time our wellfield would have moved a kilometre down the way, down gradient. The basement underneath the basin, which is the Mount Painter fractured rock aquifer, also takes water. That aquifer is over pressured with respect to the Eyre formation and so that water comes into the fractured rock aquifer and moves its way up into the air formation, which is a very permeable extensive sandstone, and then that water goes through the air formation and discharges down into the frame basin area.

MR HANDSHIN: Presumably at Beverley in the location of the waste deposits you maintain some sort of monitoring program?

DR MARSLAND-SMITH: Yes.

MR HANDSHIN: Does that carry reporting requirements with the EPA for example?

DR MARSLAND-SMITH: Definitely, yes, so the whole system again is surrounded by a very extensive ring of lateral monitor wells. Also above and below the Beverley aquifer is monitored and reported on a quarterly basis to the state authorities, both EPA and DSD and Department of Water and Natural Resources. That information is also reported biannually to the Federal Government.

MR HANDSHIN: Can I just go back very quickly to the issue of the reagent insulation?

DR MARSLAND-SMITH: Yes.

MR HANDSHIN: Can you give us an idea of the sort of volumes of sulphuric acid and peroxide that are used in the process of leaching?

DR MARSLAND-SMITH: I'm not an expert on that part, so I'd have to take that question on notice, but I can say that on average - because it just depends on the size of the wellfield. If you have two wells you'd imagine you don't need as much reagent as opposed to if you had a wellfield comprising 40 extractors and 70 injectors, would be a different story, so it's just a case by case basis, but on average for every metre cubed that we circulate we get around 10 to 20 kilos of uranium extracted, but in terms of trucks and volumes of sulphuric acid I would need to check and get back to you on that.

COMMISSIONER: Lucinda, can we go back to this slide here please? Can you just walk us through what happens when the wellfield's finished?

DR MARSLAND-SMITH: Yes.

COMMISSIONER: What do you do?

DR MARSLAND-SMITH: Yes.

COMMISSIONER: How do you monitor what's happening below after you've completed your work?

DR MARSLAND-SMITH: Yes. Once we turn off the wells the area reverts back to its natural groundwater gradient status, so the groundwater will move according to that gradient, so we understand that gradient and where the water will go and the water will move very slowly as I said, about 10 to 20 metre per year.

COMMISSIONER: You take out all of the apparatus I presume? You wouldn't leave it there.

DR MARSLAND-SMITH: Yes, so all of that comes out.

COMMISSIONER: It all comes out.

DR MARSLAND-SMITH: The wells are cemented up, so we absolutely isolate the aquifer off to any other aquifer in the region, so - - -

COMMISSIONER: When you say "cemented" is it cemented down to the aquifer itself?

DR MARSLAND-SMITH: Yes. Yes, and all through that open area where the submersible pumps are, so the pumps are taken out, the wells are cemented up. All the surface infrastructure is taken out and the beauty of ISR is that all of that infrastructure just lays on the ground, so you just take it away, you don't need to dig up pipes or anything like that and then obviously you have mining plume left in the ore body, so that plume will move into, in accordance with the groundwater flow velocities, fresher rock and so to give you an idea of how far the plume moves over time in about seven to 10 years the plume would have moved around 95 to a hundred metres from the wellfield through fresh rock. Over around a hundred years that plume would have moved around a kilometre. Now what happens to that water when it moves through fresh rock. It's called a process of natural attenuation and it's really just a word for the rock wants to equilibrate that ground water back to its original status. So we have a higher acidic groundwater moving through the fresh rock, and inherent reactions that happen between the water and that fresh rock and particularly it is the clays that do the work in the fresh rock. Buffer that groundwater and bring that pH back up to neutral pHs. And so that is the process of natural attenuation and all our modelling shows that in a hundred years, it is totally back to groundwater, original groundwater quality. Within the seven to 10 year period, you see the movement of the groundwater back to sort of pHs of four, three to four, five occurring. At Beverley we have wells - monitoring of well fields there and we certainly see those trends in our in-field monitoring. As you appreciate, we do a lot of reactive transport, hydro geochemical modelling to understand how the natural attenuation is going to work at each site.

MR HANDSHIN: There was 11 or 10 years ago, some contention about the concept of natural attenuation - - -

DR MARSLAND-SMITH: Yes.

MR HANDSHIN: - - - and whether it was a legitimate science phenomenon. Can you tell us how the technology or research has developed since that point in time and where there is a consolidated international perspective about it?

DR MARSLAND-SMITH: Yes. There is a consolidated international perspective about it. And I will just go back to the first – one of the first principle proof that NA or natural attenuation works is that if that process was not happening, we would not need to redose our groundwater each time it goes through the cycle because if the rock is not doing any attenuating, or there's no reactions happening, then that fluid would only need to reduce the acidity once and it would be for the next two to three years wouldn't need to dose any more. But because there's that reaction going on, we need to dose every single cycle that we recirculate that groundwater.

MR HANDSHIN: Presumably that would in part be due to the processing operations though wouldn't it?

DR MARSLAND-SMITH: No, it's exactly what's going on. It is those clays wanting to get that groundwater back to neutral pHs, so we have to keep lowering it and keep putting in conditioning agents to lower it because of that phenomenon that's going on. So when you turn off and stop dosing that's what process is going on when it's moving in to that fresh rock. So in the states, 95 plus per cent of operations are in drinking water quality aquifers. So they have to consider enhanced remediation in those circumstances. At Beverley the beneficial use, environmental value of our water is industrial, so natural attenuation is an accepted methodology for closure of ISR mines in this scenario.

COMMISSIONER: If you were to expand exploration - - -

DR MARSLAND-SMITH: Yes.

COMMISSIONER: - - - is there any impact in terms of the amount of water that you need? Is that a restricting factor for you?

DR MARSLAND-SMITH: No, not really. We use rotary mud drilling for – because we are in unconsolidated sands and we need to – we are in a sedimentary basin, when you drill a hole you need to keep the hole open once it's drilled, so you can put your geophysical probes down hole to measure your parameters. So you need water for that process. We mix water with some drilling mud to keep the holes open and it's a standard process in petroleum exploration - - -

COMMISSIONER: Yes, understand.

DR MARSLAND-SMITH: - - - as well.

COMMISSIONER: Where does that water come from that you use?

DR MARSLAND-SMITH: We just use local water bores, that are shallow bores, work with the pastoralists and/or we'll drill our own and because there are some other aquifers, shallow aquifers that have very salty water but nonetheless water that we can access for that purpose.

COMMISSIONER: So it's not a restricting - - -

DR MARSLAND-SMITH: No.

COMMISSIONER: In terms – if I might, in terms of future exploration, where is Heathgate at the moment in relation to that? Is that something you are continuing on, or is that – because of the uranium price at the moment, it's in a bit of abeyance or how do you manage that?

DR MARSLAND-SMITH: The answer is yes, we have programmes ongoing all the time. So we haven't really ramped back because of the uranium price, it's more we're busy developing a project right now. What is – we don't want to grow so big that we can't develop our projects at a cost benefit price.

COMMISSIONER: Yes.

DR MARSLAND-SMITH: So it's more around what are we doing at the time that requires our resources to focus on things. But nonetheless, we always have around one to two million dollars worth of exploration expenditure a year. Collectively over the last 15 odd years, we've invested more than 160 million dollars in exploration and that is what has led to the discovery of what you see today. There is no doubt now that further out in to the basin is now where we need to look at and that poses it's own challenges in terms of where do you start looking, apart from – because where the deposits are now, we are fairly – in terms of an exploration model, very logical places to look. Whereas now we are faced with the challenge of – well, where else do we look in this wide region and so we are again working with CSIRO, as I mentioned earlier, to help us target towards where we need to have a focus look.

COMMISSIONER: The annual exploration that you – budget that you referred to a moment ago is that used for both greenfields and brownfields exploration?

DR MARSLAND-SMITH: We don't really discern between the two. Brownfields for us is almost getting to, well where's our next well fields going to be. So because the roll fronts are so – it's not like a gold seam where you can chase it along a fault for kilometres. To find a new deposit away from the current system is totally greenfields exploration.

MR HANDSHIN: Can I just ask one question in relation to the possible expansion of in situ mining in the state; in particular as you move away from the Frome embayment, does that raise potential issues of the use of better quality groundwater as part of the in situ process?

DR MARSLAND-SMITH: I think every time – each project needs to be assessed according to its own groundwater quality, so if there is a requirement to do active remediation then we would look at that and work with the authorities on that issue. So it's not – it's really the groundwater quality determines what closure mechanisms you are going to employ.

COMMISSIONER: Can I just hypothesise for a little bit, if the price of uranium went to the $70 that you were talking about, what increase in activity might you expect in this facility? I mean if there was a stable price of $70 per pound, what might it do to employment? To export? Or is it pretty much a sort of two million pounds operation almost irrespective?

DR MARSLAND-SMITH: Yes. The resources are always limited, so we don't have unlimited resource so we need to find more resource to be able to see us through. If the price goes up, we want to maximise the production during that time of course, we need more resource. So that is our focus right now. Yes, just - - -

COMMISSIONER: I am just trying to get a sense of - - -

DR MARSLAND-SMITH: Yes.

COMMISSIONER: I am trying to get a sense of answering the terms of reference, which talk about an expansion of mining opportunities. Now you have talked about the environment being satisfactory - - -

DR MARSLAND-SMITH: Mm'hm.

COMMISSIONER: - - - and that we have bipartisan support, so both of those conditions are pretty much met by your evidence. I am just trying to get a sense of what might the rosiest picture be, moving forward as a potential opportunity for the State.

DR MARSLAND-SMITH: Yes.

COMMISSIONER: And I think your point is well made, that there is no infinite resource available to the company, but I'm just trying to get a sense of -

you know, if we had the most positive price for uranium that we're likely to see in the next decade or so, what impact do you think that would have on the operation itself in terms of output, job opportunities, in the broader sense?

DR MARSLAND-SMITH: Yes. Notwithstanding an expansion of the resource, you know, we would probably increase production a few orders of magnitude, but again, it just depends on our cost per pound at the end of the day.

COMMISSIONER: Yes, of course.

DR MARSLAND-SMITH: If you employ more people that affects that. So you might have a $70 a pound price, but it's all offset by that operating cost. So it's that balance.

COMMISSIONER: And the order of magnitude of two or three times, does that mean an order of magnitude of a couple in terms of workforce?

DR MARSLAND-SMITH: It would need to translate to something like that, but not a direct correlation.

COMMISSIONER: Not direct.

DR MARSLAND-SMITH: Yes.

COMMISSIONER: Yes, understood.

DR MARSLAND-SMITH: So, yes, we're very good at keeping our workforce at a level that sustains our production at any one time. Yes.

COMMISSIONER: Yes. I understand. Could you give us an idea of the size of the workforce at Beverley, for example, when it was operating?

DR MARSLAND-SMITH: At Beverley, when that was operating, it was around 80 people, and so on site at any one time there would've been around 40. Currently we've got a total workforce of around 155 people and, you know, about 80 of those are cycling through the mine site.

COMMISSIONER: Is it logical that there are other ISR deposits throughout the State?

DR MARSLAND-SMITH: Certainly, and in my view, it will take people who have the expertise and the understanding of these systems, that knowledge base, to filter through, which will result in successfully planned exploration programs. So, you know, we need to look at how we can better teach this type of uranium exploration at university, for example, or even just indu34stry workshops, to get some more information around how we explore for roll-fronts. There's no such program here, so we actually send all of our key professionals overseas to get their training, and that has actually directly led to the success of our discovery here. Yes.

COMMISSIONER: Is it realistic with the scope of our operation that we could have such a training facility established in the State?

DR MARSLAND-SMITH: Yes. I don't think it needs to be large or funded, you know, to any large extent. Honestly, it's probably just an industry workshop as a start, and to get the world's leading experts over to start disseminating around the science of roll-fronts and, you know, the interpretation of the downhole logging systems and how does the gamma radiation work and how do you interpret that to find ore bodies, and how do you look at that redox, as I was talking about before.

MR HANDSHIN: In the absence of that kind of development, is it your view that it really is going to take, at the moment, an ISI miner to find other ISR deposits?

DR MARSLAND-SMITH: It would be my guess, yes, you know, but it's not a hard thing, you know, but again, it's just getting the knowledge out there to understand how to look for them. Yes.

MR HANDSHIN: There's just one more question that I forgot to ask when we were talking about Beverley and the monitoring that's in place there. Have you got a timeline over which that monitoring is going to continue, and is that part of a closure or decommission plan?

DR MARSLAND-SMITH: Yes. So as part of closure we have a seven-year commitment to continually monitor how that natural attenuation is progressing, as well as other environmental, you know, flora, fauna requirements, but we have to establish a trend and demonstrate that the natural attenuation is working before the end of that seven-year period expires. If there is no demonstration then we need to go back to government and work together to work out exactly what is the next requirement. So initially it's a seven-year time period where we demonstrate natural attenuation is working, and next year at Pepagoona, for example, we have plans to put in well arrays to start that process off. So we do it ahead of time, not just at closure. So we're proactive in that area to try to understand prior to the actual requirement in our approvals to undertake those studies.

COMMISSIONER: I might just have one final question, I think. In your evidence, I think it was 14,000 drill holes?

DR MARSLAND-SMITH: Yes.

COMMISSIONER: And a 15 to 20 K drill hole?

DR MARSLAND-SMITH: Mm-hmm.

COMMISSIONER: Is there anything on the horizon that gives you confidence that you might be able to significantly reduce the per drill hole cost? Is there any technology that's - - -

DR MARSLAND-SMITH: We are constantly looking at that because that's cheap. A production well costs around 80 to $100,000 a well. So it's those cost savings that we constantly do look at and, you know, things like do we manage the consumables ourselves, you know, as apart from the drilling contractor, and things like that, but certainly - - -

COMMISSIONER: That's in the margin, I suspect.

DR MARSLAND-SMITH: - - - that's the stuff, yes. But any advance I drilling - and I know that UNCOVER program was looking at logging and drilling at the same time and utilising - you know, so there's less time taken on a particular drill hole. So it's those things that we look at all the time too and we have similar developments in that space.

COMMISSIONER: Is there an active service mining industry here in South Australia?

DR MARSLAND-SMITH: Well, we only really use drilling contractors because our whole operation is just drilling wells and that's it, and some poly welding of poly pipes and a little bit of construction in terms of plan modification, but it's not haul trucks and we don't require mining services like, say, Olympic Dam would and that extent.

COMMISSIONER: Okay. Dr Marsland-Smith, thank you very much for your evidence.

DR MARSLAND-SMITH: Thank you.

COMMISSIONER: We'll adjourn until 11.15 when we'll have the Environmental Protection Agency.

ADJOURNED **[10.48 AM]**