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DAVID REDFORD

DAVID REDFORD WAS BORN ON THE 30TH JULY, 1936 IN NIPAWIN, SASKATCHEWAN AND RECEIVED HIS EARLY EDUCATION IN GARRICK. HE ATTENDED THE UNIVERSITY OF SASKATCHEWAN AND OBTAINED A B SC WITH HONOURS IN CHEMICAL ENGINEERING. HE THEN SPENT THREE YEARS IN THE RCAF BEFORE RETURNING TO THE UNIVERSITY OF SASKATCHEWAN TO COMPLETE A PH D IN PHYSICAL CHEMISTRY. ON HIS GRADUATION IN 1967, HE WAS HIRED BY THE ALBERTA RESEARCH COUNCIL (ARC) AND CAME TO EDMONTON. IN 1969, HE WAS ASSIGNED TO A PROJECT INITIATED BY THE CANADIAN SUBSIDIARY OF FINA. THEY HAD A LEASE ACROSS FROM GREAT CANADIAN OIL SANDS (GCOS/SUNCOR) AND WANTED TO DO A SMALL PILOT. THEY DID NOT GET GOOD RESULTS AND THE PILOT WAS ENDED. REDFORD SPENT THE REST OF HIS CAREER IN OIL SANDS RESEARCH AND RESEARCH MANAGEMENT, INITIALLY THROUGH THE RCA AND, THEN, JOINTLY, WITH THE ALBERTA OIL SANDS TECHNOLOGY RESEARCH AUTHORITY (AOSTRA). IN THE EARLY DAYS, MAURICE CARRIGY AND REDFORD WERE THE ONLY ONES DOING OIL SANDS RESEARCH AT RCA. REDFORD VIEWED CARRIGY AS HIS MENTOR AND FRIEND. CARRIGY WAS A TRAINED GEOLOGIST AND REDFORD AN ENGINEER AND PHYSICAL CHEMIST, AND THEIR KNOWLEDGE AND SKILLS WERE COMPLEMENTARY. REDFORD REPRESENTED ARC ON THE ADVISORY BOARD OF THE PETROLEUM RECOVERY INSTITUTE, WHICH WAS CHAIRED BY DR. GEORGE GOVIER. REDFORD PUBLISHED MANY PAPERS AND HOLDS A NUMBER OF OIL SANDS PATENTS. AFTER HIS RETIREMENT, HE TOOK ON SOME CONTRACTING WORK AND CURRENTLY TEACHES A GRADUATE COURSE ON OIL SANDS AT THE UNIVERSITY OF ALBERTA.

Date and place of birth (if available): 1936, Nipawin, Saskatchewan

Date and place of interview: February 5th, 2013; David Redford's home.

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Consent form signed: Yes

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Initials of Interviewer: AD

Last name of subject: REDFORD

AD: It is the 5th of February, 2013 and it's 1:20 p.m. and I'm in the home of David Redford and doing a Petroleum History Society Oil Sands Oral History Interview. David, thanks so much for agreeing to be interviewed for the project.

REDFORD: It's my pleasure.

AD: Now, would it be possible for you to tell me where you were born and the date of your birth and then just give me summary potted biography, broad strokes because then we'll get into the detailed questions after. So, could you begin?

REDFORD: I was born in 1936 in a little nursing station in Nipawin, Saskatchewan. It was the middle of the Depression. And, my father had taken a homestead out near Garrick. There really wasn't anything there. And, I guess, my mother was able to get into the nursing station in Nipawin, Lady Grey Nursing Station and that's where I was born. I took my education in Garrick and my Grade 12 in Choiceland which is just a neighboring community. And then, I went on to the University of Saskatchewan where I did my BSc in chemical engineering. I graduated with honours. While I was there, I joined the Air Force. So, I was what they called ROTP, Royal Officer Training Plan. So, every summer I would go down east with the Air Force and, when I graduated, I was posted to Clinton, Ontario. So, I spent the next three years as a stationed telecommunications officer in Clinton, Ontario. And, during that period of time, I was back at the University of Saskatchewan. Dr. Pepper who was one of the professors I really admired at the University of Saskatchewan, he said, "Dave, what are you going to do?" And, I said, well I didn't really know. And, he said, "Well, you know, if you want to come back. I can find some money for you." So, I did.

In 1963, I came back and did first my Masters and then my PhD in physical organic chemistry. While I was doing that, I was interviewed by the Alberta Research Council, Dr. Steve Creighton and then by Dr. [Ernie] Wiggins. And, I came up in 1967 to the Alberta Research Council. First of all I was working on a number of synthetic organic chemistry projects, sort of basic research. But then, there was a call out to get some help with tall oil at the Hinton pulp and paper plant. And, that plant had been designed on the basis of company called St. Regis, which was a company out of Georgia. And, Georgia Pine and Pine from Alberta were very different. So, ours has steroids in it which protects the tree but the problem is that when tall oil is produced it has this material in it. So, you get an acid/alcohol reaction, esterification reaction and the net result is that a whole bunch of your tall oil appearing as a gunk in the bottom of the distillation still. So, they said, "What can we do about it?" So, we worked on that project and we actually developed a process by which it was liquid, a liquid extraction process to remove that material from the tall oil. And then, you could easily distill the tall oil. So, it was quite a successful project.

AD: You then went on to work for AOSTRA?

REDFORD: Well, not immediately. I was actually just sort of in that process working on the tall oil project. We had to build a pilot plant for the process and were operating it. And, I was project leader on it. And, Dr. Creighten came in and said, "We've got this project with Canadian FINA and things are not going very well, and they want some help. Would you like to work on it?" And, that is when I really got involved with oil sand. Now, I did know the term "oil sands" because you can't be at the Alberta Research Council without knowing the term "oil sands".

Dr. Clark, it was really his report, the Clark Report that resulted in the formation of the Alberta Research Council. Because, the government said, "Look, we need somebody to advise us on technology and on science because we're not scientists. Many of us are farmers or lawyers or what have you, and we don't have that kind of background. And, this is really a good report that we've got from Dr. Clark." And, that resulted in the formation of the Alberta Research Council. So, right from the first oil sands project, this was the base of the Alberta Research Council. But, research at the Council had not really been very active, really since the days of Dr. Clark. It had resolved mainly into part of the geological evaluation of the resource. And, Dr. Carrigy was the principal person involved at that time. When Dr. Creighten came to me, this was the first time we actually looked into a recovery process. And, we went up to the FINA project. I was very familiar with it. I made many trips up to the project. And, that's when I really got involved with looking at in-situ recovery.

AD: Can you tell me a little bit about the FINA project. Who was involved? What kind of bitumen recovery/separation were they doing? Just, give me some details?

REDFORD: Well, Shell Oil had a little lease north of there called Muskeg River; had done a process which they had developed where you did hydraulic fracturing at the base of the deposit, and then you put in caustic solution. And, you steam-stimulated the producers and you emulsified hot emulsification of the bitumen and produced it at the producers. FINA was attempting to duplicate it on their lease.

Now, the other thing is that the Shell lease was very shallow as was the FINA lease. Both leases are now in mining or being mined. The Shell leases were principal to the Shell mining project and the FINA lease was subsequently sold to Suncor, and they built a bridge across the river and the ore is being transported across the river; so, really, not very suitable sites for in-situ recovery. But, the view of FINA was, well, we know we can recover it by mining. But, we want to see if we can develop new technologies so that it can be recovered in-situ. Part of this, and you will see this throughout the history of the oil sands and in-situ recovery, is that oil companies, what do they know? They know how to drill wells. They know how to produce oil from wells. And, that is their starting point. That is where they want to work from. It's really been a breaking out of that mold that has resulted in the in major advances in in-situ recovery.

But anyway, FINA tried to do it and it didn't work. So, they came to us and we said, "Well, we have some ideas. We've developed some ideas." We tried those ideas. We got them to work initially over a short distance. But, when we went to a larger distances, they didn't work. And, one of the big problems was it is very shallow. And, so, eventually we got surface breaks. Like, they would just break up through consolidated material. So, it would just break up through the surface. So, after all the money was spent, we abandoned the project.

AD: So, who provided the funding for that?

REDFORD: FINA.

AD: FINA.

REDFORD: It was the sole FINA project.

AD: And, they contracted your services and perhaps others from the Research Council of Alberta?

REDFORD: Yes. I was project leader and I had a team of about three or four that were working on it.

AD: What year was that?

REDFORD: That would have been '69.

AD: So, very, very early.

REDFORD: It was 1968, '69 when I recall vividly being at the FINA project in 1969, in January of 1969. That was a very cold stretch. If you look even here in Edmonton that is a record cold stretch and one morning it was down to -62 F at the site.

AD: Wow. So, you can imagine the difficulties that Great Canadian Oil Sands had at that period.

REDFORD: They were right across the river when we first started. I think they started in '67. And, it was very shortly after that I talked to them. We knew them quite well. The question was, "Well, what problems do you have in the plant?" And, they'd say, "We've got problems in every part of the plant." And actually, they said at one time, I was talking to them and I was telling them about the situation at the plant out here, Sherritt Gordon and I said, "I live next door to the engineering manager and he told me that at one point they were given six months where the plant would be closed down to get it working. And, he said, "You know, we were told exactly the same thing." You've got six months to get this thing running or we're going to have to shut the whole thing down. So, they had lots of problems, lots of problems.

AD: So, when the FINA project ended what did you then go on to do with the Research Council?

REDFORD: Actually, I think I almost immediately went into a little project up at Super Test which was running a project close to Grande Centre. It was just south of Grande Centre. This is in the Cold Lake oil sands deposit. But, there it was not a recovery project; there it was a problem with breaking the emulsions. Now, these are different emulsions than what we were trying to produce. What we were trying to produce at FINA were called oil-in-water emulsions, which have low viscosity. But, the problems they have on the surface are water and oil emulsions which are very, very viscous. So, we had a lot of problems with it. I think I've got that the other way around, they are oil-and-water emulsions and the others are water-and-oil emulsions. Anyway, they had lots of problems primarily because oil and water at those temperatures are almost the same density. And then, you've got it in a very tight emulsion and you're trying to separate it. But, that's when I really started to use my chemistry background, and we actually developed surfactants and we actually manufactured surfactants that would break that emulsion. So, that was a good side.

AD: Breakthrough. Did you have a lab then at the Research Council of Alberta building on the U of A campus? Or, did you actually work on-site at that point?

REDFORD: Well, all of the time we were never on the University of Alberta campus. Where we were at what we call the Clover Bar Research Labs; now the Clover Bar Research Labs was specifically set up for contract research. The idea was that you have all of this expertise in the Alberta Research Council and we should be able to find some way of making that expertise available to industry. So, that was Dr. Wiggins' concept. And, he went with that concept and hired Dr. Creighten and they established the laboratory at Clover Bar. Now, one of the original projects at the Clover Bar Laboratory, and one of the reasons why it was built, was for a very large pilot plant along with a very nice research building. I think the research building won an award the year it was built, was because of the Peace River Iron Ore project. And, this was the leeching project for recovery of ore from -- low quality ore such as Peace River.

AD: That didn't go ahead?

REDFORD: It had a kind of an unfortunate background. What comes out of it is a powder. So, they went into a lot of powder moulding. That came directly from the powder moulding that was

being done at the Sherritt Gordon [plant] with nickel. So, there was kind of a transfer of that technology. And, that part went very well. But, for an initial project, they decided to go to Ontario working on scrap metal. The concept was, if we can prove that it works here on a commercial scale, then we can extend it to an ore like the Peace River ore. But, unfortunately, there were a lot of design defects in the plant. And, that led to failures. One of the big failures for instance was they mis-designed the holding tanks which hold acid. These acid tanks just split right down the middle and all the acid went pouring out, and into a nearby creek. It was kind of an environmental disaster and so all of the financial losses there led to the process not extending beyond it.

AD: Would it be fair to say that the Research Council of Alberta was really looking at economic diversification for the Province and using resources, a range of resources, in different ways and bringing them into production?

REDFORD: I don't think you could say that of the Alberta Research Council. I think you could say that of the Province of Alberta, which wanted to use the Alberta Research Council as one of the vehicles for achieving that. But, if you look just at the Alberta Research Council, its primary function and you had to distinguish the Council from the employees of the Council. And, the Council was just that, a council to government. So, it was set up as an advisory to government recognizing that government is not composed of people who have expertise technically or scientifically. And, they felt they needed that. So, they were set up as an advisory to government. With the discovery of oil in '47 and the expansion beyond that, they had more money.

So, the Research Council expanded at that point. But, to a large extent, it was doing basic research, it's true that it was working to some extent on ideas, better ideas for aspects of Alberta; controlling hail, hail suppression, hydrology, finding out where all the hydrology was in the Province so that the farmers could safely drill a well and expect to get potable water from it. Geology: that was a big factor. Let's define the resource and then industry will be able to exploit the resource if we know what the resource is that is there. So, no I don't think that it was set up as a vehicle to diversify industry. I think really, it was with the Lougheed Government and with the Conservatives coming into power and that as and I think remained one of Peter Lougheed's objective all through is life, was the diversification of industry within the Province. And, he saw the Research Council as one vehicle where that could take place.

Now, if you were going to diversify industry then you had to make this tremendous resource which had been developed in the Province, the technical know-how, the knowledge and expertise that existed in the Alberta Research Council available to industry. And, the vehicle for making it available to industry was through this project research and development contract research group.

AD: So, can you tell me a little bit about that and also your role with respect to that?

REDFORD: Well, I was hired directly to that group. So, I knew right from the first that was my role. And, I liked it. I loved it throughout the years. I liked the challenge. I'm a problem solving person, maybe that's why I went into engineering in the first place. But, I was not one of these

people who wanted to get into one area of research and research it to death so that I knew the infinite aspects of it and that alone. After a few years, I was quite happy to go on to something else and look at something else and look another problem. And, that fit very nicely into what PR&D, what Dr. Creighten had in mind. So, I think that was one of the reasons I was hired.

AD: You mentioned the FINA project, now when did you next work with oil sands?

REDFORD: Well, following that actually not too long after the Super Test project, Texaco came to us. And, they had a project going south of the airport at Fort McMurray. And, they knew that we had worked on the FINA project. They knew that I had certain expertise by that time. And, so, they contracted us onto the Texaco project. And, actually, the Texaco project is where I developed most of the patents that I have, were on the Texaco project. We developed quite sophisticated experimental programs; even if I look back at some of the results today, they are pretty profound those results. And, I look back at them and I say, yeah. Even then, I didn't realize how far reaching some of them were.

AD: Do you want to talk about that research and the discoveries?

REDFORD: What we were really looking at was -- I can go back to the fundamentals of in-situ recovery?

AD: Go for it, absolutely.

REDFORD: You've got what we call the conundrum. Bitumen by its nature, by definition, is immobile in in-situ conditions. If it's immobile, no matter how much you push on it, it's not going to move. And, if you want to get something into it, you're going to have to change it before it will move. But, in order to change it, you have to get something in there that will cause it to change. So, how are you going to do that? If you try to inject something, it won't inject because the bitumen is immobile. So, it's what we call a conundrum of in-situ recovery. To make it mobile, you have to change it. To change it, you have to get something in there to cause the change. And, those are contradictory. So, what we worked on in those days was hydraulic fracturing. You could get hydraulic fracturing and just so happens that in the oil sands, because of the depth, fractures are horizontal; most other fractures are vertical. But, these fractures are horizontal.

Now, if you could get those fractures horizontal, you could develop those fractures into hot communications and then you could get recovery taking place away from that hot communication. So, that is what most of the work was involved in; it was work we did with Texaco. It was successful in the field at short distances but it was not successful at longer distances. But, that was primarily due to the fracturing aspects. But, most of the patents were in that area. We had developed what we called an inter-well vertical steam stimulation process and, subsequently, Shell developed an almost identical process for the Peace River oil sands called pressure-cycle steam drive. The concept behind both of them is identical.

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AD: Now, is there any precedent for doing this? Was there an early generation of trials internationally? I seem to remember something in Russia?

REDFORD: No, no. This is entirely different.

AD: This is entirely different?

REDFORD: Yes. I don't think there were any precedents for it. My only precedents would have been the work of Shell at the Muskeg River project. That's where we got into horizontal fracturing. Now, you must realize there was no such thing as horizontal drilling at this time. But, it's interesting. I presented a paper on this whole concept in California and Los Angeles at the American Society of Chemistry. And, there was a person there by the name of Don Anderson and he went away. He worked for Chevron. He went and he came back and he said, "Well, why don't we just assume that we can get a pipe through." Now, they know how to drill. Why don't we just assume we can get a pipe through and I'll use that hot pipe as my initial communications? The annulus around it will get hot and then I can use that to get communications through and I can use this process that Dave has developed to expand from that out into the reservoir. And, yeah, that led to what is called the HAS Drive process - heat, annulus and steam drive process. It never saw the light of day until horizontal drilling came along and then it was tested.

AD: So, in other words these were tested in the labs and you were working at the basic chemistry level, the components of bitumen. And, you spoke specifically about the oil and water. But then, of course to go from that step, which is in the lab, and you figured it out, to actually going out and building a plant is a hugely lengthy and expensive process, right?

REDFORD: You're at the heart of what a lot of the problem is when you do it in the lab. But, except for the breaking of emulsions and the formation of emulsions, I would say, yes, that was chemistry. And, that was done at the chemistry level. But, beyond that, we were actually looking at taking a piece of the formation. Oil sands, you have an advantage. You can just go up to the mine and mine oil sands. If you're working with another type of formation, only the samples you can get are core samples. Here we could get as much mined ore as we wanted, and Great Canadian Oil Sands was very happy to give us different kinds of oil sands. So, we would take that oil sands; we would pack it into what we'd call a physical simulator. Now, it probably was not a good term, it's a physical test cell. Because, we're not actually simulating the field, we're simulating a small section of the field, and then we're carrying out a recovery process in that small section, and see what happens. So, it's a bit beyond what you're referring to as a chemistry aspect. It's an engineering aspect and it's studying the phenomena that are taking place. How does it advance off of that communications path? Interestingly, later on, one of the engineers from Texaco did a study based on pore volumes. And, he said, "If we plot the pore volumes for a field project it almost follows, identically, the values that you got in your test cell."

AD: So, the reality in the field corresponded with the simulation, what you were able...

REDFORD: What was going on in the test cell, yes.

AD: Now, who was working on that team with you at that point?

REDFORD: I had quite a few technicians. I had some engineering help. Bill Kay was working as an engineer on the project. But, I think I was pretty well the only scientist that was on the project. I was the project manager. Later on, when I went on to the AOSTRA, Dr. Peter Toma took the project over. And, he worked with Texaco for a number of years after I left the project.

AD: So then, what was the next project that you got involved in with the oil sands?

REDFORD: Then, AOSTRA was formed and, as we discussed when I was talking a bit about it last time. Dr. [Clem] Bowman really had a number of goals in mind. He wanted to muster the resources of everybody for this major problem. So, he wanted the resources of the universities and for that he set up the university research programs all across Canada. He wanted the resources of the industry. So, we set up joint projects with industry. He wanted a central information center so that all of this information could be readily available to everybody. So, he set up the oil sands information center. And, he wanted to muster the resources of the research institutes, particularly the Alberta Research Council. So, he set up a contract with the Alberta Research Council. It, in effect, became the in-house research organization of AOSTRA. And, that project grew to about 60 people of which right from the first, I was the engineering manager of that project.

AD: You told me an interesting story about how Clem was hired. Do you want to talk about that?

REDFORD: Well, I didn't realize this myself until we were having an honorary dinner for Clem. Clem was actually personally hired by Peter Lougheed, which seems amazing to me but he actually had Clem come up to Edmonton and interviewed Clem and saw in Clem the tremendous qualities that he had. And, he saw that Clem could achieve the goals that he wanted to achieve. And, so he personally hired Clem.

AD: So, that era of the Research Council and AOSTRA really was a realization of Premier Lougheed's vision for diversifying the Alberta economy, but also giving the oil sands the research and funding, and the partnership vehicle with the companies to be able to flourish.

REDFORD: Well, the way it was always told to me was he said, "Look, we've got all of this money coming in from conventional crude. We have all royalties coming in and land sales coming in from conventional crude. But, it's limited. It's going to start going down." We have this huge resource out there. Everyone knows how much is there because of the work of the Alberta Research Council. We know that we have one of the largest hydro-carbon resources in the world, if not the largest. But, it's all in-place reserves. It's not proven reserves. We don't know how to produce the in-situ material and that's the largest part of it. And, the economics for the mine material is questionable. We've got these two plants that are going. Great Canadian Oil Sands only was allowed to go because it was the smallest bid, 40,000 barrels a day. And, Syncrude, we spent a lot of money, put a lot of money into that to get that project to go. So, we need to improve the economics. Now, you can prove your economics by price or you can improve the economics by better technology. So, he said, "Why don't we take some of this revenue that we've got coming in from the royalties and invest it the

development of the technology which will make the in-situ recovery possible and make the mine material economic."

AD: So, when was AOSTRA established?

REDFORD: I think, 1974, something like that.

AD: So, the economy was still very strong?

REDFORD: Yes.

AD: Not too much money was being generated through GCOS/Suncor at that point and basically Syncrude was just beginning to be organized. The relationship between the companies formalized and, of course, they were making representations to hearings so that they would be given the go-ahead. Did you have any involvement with any of that?

REDFORD: Not with that representation. But, I think you may be a little off on Syncrude. Syncrude was one of the bidders for the original project.

AD: Yes, yes.

REDFORD: When they lost that bid and they lost the bid primarily because they wanted to build a 100,000 barrel a day plant. If they couldn't build 100,000 barrel a day, they said it wasn't economical. And, it was felt that that would interfere too much with the market for conventional crude. So, they went with the 40,000 barrel-a-day plant. When that happened, they retrenched and they set up a research lab on 17th Street just down from Clover Bar, just down from our plant. And, Clem Bowman took over as the one in charge of that research. He was moved out from Sarnia and took over in charge of that research establishment of Syncrude. So, Syncrude never really moved away from it. Then it came back when the government was more favourable to further oil sands development.

AD: So, then, tell me your roles and responsibilities within AOSTRA?

REDFORD: Once I took over as engineering manager of the project with the Alberta Research Council, then, it was to expand the effort and move on into a lot more test cells, larger test cells. Diversification of the approaches and we actually hired a lot of people to do fundamental research, so that it built up a lot of surface chemists, a lot of other abilities in fundamental research in that group. We were quite a broad-based group as far as the understanding of the oil sands, all aspects that could be leading to problems with tailings ponds; all of those aspects in that group. As I said, we were essentially the in-house research organization of AOSTRA. We were 100% funded by AOSTRA. They called the shots but they did it on the basis of not directing the research but directing the areas of research that we wanted to take place.

AD: So, in terms of AOSTRA, can you give me an idea of either the annual budget or accumulatively in its lifetime, how much was expended in oil sands research?

REDFORD: About $700 million.

AD: $700 million.

REDFORD: I think at their peak period they were spending about $60 million a year, $60 million to $70 million a year.

AD: And then, the partners with industry on specific projects.

REDFORD: I forget the minister at that time. But, when he made the announcement he was going to spend a $100 million a year. That was his goal. And, where he got the $100 million from I don't know. It starts with a "D" but I can't remember.

AD: I'm sure you will later.

REDFORD: Yeah. Dr. Bowman and some of the others, but I think, particularly Dr. Bowman, felt you can't really spend that kind of money profitably.

AD: [Aside, "Interesting. The tow truck has arrived. A deer has arrived; rural living."]

The interview pauses to allow the AMA to tow Adriana's vehicle out of a snow bank. The interview continues about half an hour later.

REDFORD: And, I guess some others had the same view. But, Dr. Bowman said, "No, look. What we're going to do is we're going to do this right. We'll spend the resources that need to be expended to get the results." And, that was the growth of the whole concept.

AD: To spend that much money on research, visionary on the part of Premier Lougheed, but how did this compare with other jurisdictions in Canada? Do you have any sense of that?

REDFORD: Well, it was certainly far and away the largest expenditure for a single project or single effort anywhere in Canada. And, you could see that in the university research program. We had no trouble getting entries from right across Canada. We had people working in Newfoundland in Memorial University. We had people at McMaster. We had people in the University of Toronto, Waterloo, McGill. All of these universities had contracts with AOSTRA through the university research program. And, this is just exactly what Dr. Bowman wanted. He did not want to limit it to giving out funds as another avenue to, say, Alberta universities. He didn't want that whole aspect. He wanted the best ideas to come out of universities and we'll support those. The best ideas to come out of industry and we'll support those. So, he went to industry and said, "Come to us with proposals." Sometimes there was a two-way street to make sure that those proposals were innovative and directed towards something new. But, it was industry that was bringing those

proposals for it. It was not AOSTRA saying, we've got all the answers. There are lots of people out there with ideas. Let's canvass the whole field and come up with those ideas and we'll support good ones. And, I think, that's one of the real admirations I have for Dr. Bowman, and I think a lot of people in industry and a lot of people that I've talked to also have that real admiration for Dr. Bowman. Because, it could so easily have become a situation where he supported the people that supported the government or had "ins" with the government or whatever. No, none of that. He wanted good ideas and he was prepared to listen to anyone. It might be far out but he was prepared to listen to those ideas.

AD: Were there parallel research establishments with the companies? I mean, because there were partnerships with respect to specific research. And, so, what would the research establishments at Suncor, Syncrude and Imperial Esso have looked like at that point?

REDFORD: There was some. But, I think they grew as a result of AOSTRA's effort really. I take the research effort at Shell in Houston, Dr. Stiegelmar was the principal person behind it there, and some very sophisticated research. And, he had done a lot in thermal recovery. But, it caused them to direct that towards oil sands, not just thermal recovery and conventional or heavy crudes, but towards oil sands. I think Esso itself ended up building its lab in Calgary, which was probably a direct result. Then, Petro-Canada, of course, and you don't know whether that was as much an influence of the fact of AOSTRA, or the fact that it was a Canadian effort to build up expertise in something that was very important to them.

AD: Now, you ended up being moved to Calgary. When did that happen?

REDFORD: In 1981, '82. I went down to Calgary. So, initially I was still on the payroll of the Alberta Research Council and then I was seconded to AOSTRA, and I went down as engineering manager in Calgary. Now, at that point, we had already got quite a number of joint projects with industry. And, I had already been working as a consultant on one field project that was called the Canterra project. That's another project I worked on at the Alberta Research Council. So, it seemed natural that they would move me down as engineering manager. And, actually, I hired quite a lot of the staff that came on as engineering managers; they needed that because now they were in joint ventures. And, this was a different approach that Dr. Bowman took. He didn't take the approach of giving a grant for this project or a grant for that project. He said, "No, no, no. I'll join with you 50% in a joint venture." Now, if you're in a joint venture even if the other person is the operator, you have to manage your investment, and, you manage that investment by having technical people serve on the technical committees, and having people serve on the management committees. If you're going to do that, you have to have those kinds of people in your organization. That's why I was taken on as engineering manager to build up the engineering expertise that could serve on these committees.

AD: So, what was the name of the Calgary unit and where did it operate?

REDFORD: We initially operated out of the Energy Resources Conservation Board building. We had one floor in the ERCB building in Calgary.

AD: Just, again, for clarity and the sake of understanding the history, with Clark and the Research Council, so much of the research had been happening in Edmonton through the university and in Clover Bar. Why that decision to shift some of that research capacity to Calgary? Do you have any idea?

REDFORD: But, it's not really research capacity; it's management capacity. And, when you're in a joint venture, you have to be able to have meetings with your joint ventures partners. So, every day I would walk down the street and have a meeting at Canada building and the Shell building or one of the other buildings in Calgary, with the joint venture partners. So, that's why it went to Calgary because that's why all of the other oil companies eventually gathered in Calgary. We had a lot of oil companies in Edmonton at one time. But, they all deviated to Calgary because they needed to be together because of the joint ventures that they were involved in.

AD: Now, your job changed dramatically, then, because you were still at the lab and managing research and doing research yourself. But, in Calgary, you were doing things differently. Do you want to talk about that? What your role and responsibility was?

REDFORD: Yes. I would say that while I was still doing technical work in that sense and building up my team, most of our studies were engineering studies at that time. So, I was putting my innovative aspect to it and saying, "Have you thought of this or have you thought of that. That's a very interesting study but what about this? What about that?" So, it moved very much to research management, almost all research management rather than actually doing research. At that point, I ceased doing research as such and moved entirely into research management.

AD: And, so you were involved in brokering the deals with industry for the contracts as well as then working with a research establishments in universities?

REDFORD: At that period of time when I was in Calgary I was not working with the universities. But, I was working with the research establishments. We would often go to Shell labs in Houston and they would show us through everything there, work they were doing, how it fit into the project they had way up at Peace River; all of those aspects, yes.

AD: So, again, looking at it historically, the 1980s was a time of recession. The National Energy Program, the world recession, the low price of oil per barrel; all of that and Syncrude and Suncor were not doing well. And yet, this intensive research was happening. Do you want to comment on that and give me any insights?

REDFORD: When I first went to Calgary, of course, that was not the case. The collapse in Calgary came after I had returned to Edmonton. But it's true, we continued with those efforts throughout that period of time. It was a very good thing that we did. I just have to commend the government for that. First of all, we were in it. But also, they were still willing to put in those large amounts of

research dollars through those years. And, it was the look of the future. We're going to come through this and it's going to be a brighter future on the other side, which it was.

AD: Now, in that period, there were some major breakthroughs in in-situ recovery and SAGD. Do you want to talk a bit about that because, of course, you did some significant research at the front end of that.

REDFORD: What quite a lot of people don't realize is that, about that time, during that time, it was early 80s I guess, Dr. Carrigy went to the Soviet Union to Belarus, which was part of the Soviet Union. And, there, they had had for quite a long time a mining approach to recovering oil sands, in-situ bitumen really, not oil sands. Now, they have a little different situation than we had. They have a very competent rock above their bitumen, bituminous sands. They have a very competent rock below bituminous sands. So, they said, "Let's put a shaft down; we'll run tunnels out from that shaft. Below the sands, we'll run shunt tunnels out above the sands. We'll inject steam in from above and we'll collect bitumen from below." Now, they used a technology which is called, Slim Well Technology. This is very small wells that can be put in cheaply. It was used in the chalk formations in Texas; again, for the same reason, to get access. And, the reason for having the tunnels above and below is that we can put in cheaply a lot of wells. We don't have to drill them very far and we'll make them quite small so they don't cost as much to put in.

They used conventional mining drilling techniques. As we did, they had drills that they could take down in their mines and drill in. Normally, they would be used for setting blasting or what have you. These were used to put in wells. So, they had like a pin cushion approach; these little wells coming from the top and all these little wells coming from the bottom and it worked. They injected low-pressure steam in the top and they collected the bitumen at the bottom. It actually ran down into the tunnels; they had a trench down in the bottom of the tunnels. It ran down the trench and they pumped it up to the surface. Well, Dr. Carrigy was there, saw the operation and he was convinced that this was something that would work. He came back and we could never persuade the industry that this was a viable way to go. The industry is used to drilling wells from the surface. That is their bread and butter. That is what they'd always done. You could not convince them that you could get access from shaft and tunnels even though Dr. Carrigy had seen it.

We used to have a saying in AOSTRA, Dr. Carrigy was the vice-chairman and Dr. Bowman was very open to new ideas and Dr. Carrigy would always say, "Yes, but what is the cost?" He was the parsimonious one of the group. I guess you have to have one. But, the strange thing is, when he got going with this idea of shaft and tunnels, he was the driving force. He was the driving force behind it. Without Dr. Carrigy, we never would have had the UTF, the Underground Test Facility. We saw it through until we said, "All right, if you won't join us we're going to do it anyway." So, we built the Underground Test Facility. We were the operators. It was the only project where we were the operators of it. But, we were the operators and he said, "Well, we're going to go ahead and do it."

AD: And, so where was it built? Describe how it operated?

REDFORD: It was built northwest of Fort McMurray; actually, almost straight west of Syncrude, where Syncrude is. Well, one thing that government had done in foresight is that they had retained certain leases in different parts of the Athabasca deposit. And, I think, the other deposits too. But, in particular, they had retained certain leases and they had not given them out. And, the idea was we might need those sometime for our own experiments. Now, this probably goes back to the Social Credit era when this was done. Very far-sighted because we came along and we wanted to do a project, we didn't have to get a lease. The government already had a lease. So, they said, "All right, you can go ahead and use that lease." Now, it wasn't a particularly a good lease; as it turned out, it wasn't a bad lease. It didn't have any bottom water. But, it wasn't particularly thick. It didn't have the best of oil sands. But, we could do it. So, that's where we put it in.

Now, just to show you how far and wide we went with technology,I guess you'd call it a "drilling rig" which was designed to put in the missiles - the ICBMs. You would drill this thing way down in the ground and then they'd put the silos for the ICBMs so that, when the Russians shot over, they couldn't destroy us before we could destroy all of theirs sort of thing; mutual destruction. Anyway, I'm just trying to think of the diameter -- very, very large and we used these to drill the shafts down. And, then, we put in casing in those shafts just like you would in an ordinary oil well. It's amazing to look at it. This huge thing that's about 15 feet across or more and, yet, it's going in just like an ordinary well. And, we pumped cement down the middle and followed it through and cemented it on the outside, just like you put in an ordinary well. Then, we went down and dug through from there. But, that rig was designed for missile silos.

AD: When you can borrow a technology? So, when did that test facility prove? I mean, what were the achievements?

REDFORD: The whole concept was duplicating the concept in the Soviet Union. That is, if you can get close to the oil sands, you can drill into it much cheaper and you can get much better access. Now, as it turns out, by the time that had happened, horizontal drilling had come along. So, whereas in the Soviet Union they'd had to use this pin cushion approach with Slim Hole technology, we were now able to use horizontal drilling. But, we did the horizontal drilling from underground. And, all of that technology was developed by AOSTRA. We hired people to work on it, people who had built drilling equipment. But, we paid for it all and we developed all the technology for drilling from underground. Now, about that same time, Dr. Butler joined us. He took over one of the managers in Edmonton, and he had brought with him his concept of steam-assisted gravity drainage. Now, he had developed that when he was with Esso and he wanted to do it in Cold Lake. The irony is that it would not have worked at Cold Lake because the Cold Lake Formation is just not suitable for it. And, that's subsequently being proven. So, they came with AOSTRA and he said, "Well, why don't we try this technology." And, he said, "On top of that, we now have horizontal drilling so why don't we try it from two horizontal wells - the twin-well concept." So, it was Dr. Butler's idea. It was his concept. But, it was AOSTRA that proved it into reality. So, we went in and drilled these two horizontal wells at the bottom and, then, developed it with the concept of getting communications between the two wells and then expanding the whole chamber out beyond that. The strange thing is one of two things: the Athabasca Deposit is ideally suited for steam-assisted gravity drainage because

it is a fluvial deposit. That means there are all kinds of vertical permeability, so that there is nothing really to stop it; if it comes to a small shale lands, it will go around it and continue on up the reservoir. The coarsest material is at the bottom and it is really highly-permeable at the bottom; it's a very high permeability. And, everything has to go through that high permeability. So, here it is at the bottom, right where your horizontal wells are. And, so, it develops up above that. But, the other thing is coming from underground you've got complete control of your operation because everything is flowing down to you.

AD: Gravity assisted in other words.

REDFORD: That's right. This flowing-down gravity formation and it's flowing down into your objection stations, which are below. And then, we just pump to the surface. So, you're isolating the production entirely from the movement to the surface, and, that was one of the key factors why it was so successful. Nobody saw that in advance. It was in retrospect that people saw that was why it was so successful. Beyond that, when it was proven that you could get these amazing recoveries and reasonable steam/oil ratios of about 2 or 2.5, you got these amazing recovery rates. And, ultimate recoveries were really very high. Then, people said, "Well, we're the oil industry. We do everything from the surface." And, directional drilling had developed so much more at that time. Why don't we try it from the surface? But, it took a long time before they could duplicate those control conditions that we had from underground to the surface.

AD: So, when did it go from a test facility to full industrial production?

REDFORD: I think like we did two tests, essentially. We did a test which was just 50 metres long. That was just a proof of concept test which was very successful. I guess that would be the "Eureka" moment. And, everybody looked at all this material coming out and having been through all of the other experiences with in-situ recovery, and you see this amazing amount being recovered and it just keeps coming and coming and coming. And then, we said, "Well, we've got to show that commercially; we will not make enough with just 50 metres." So, we did a lot of engineering work. A lot of good, really excellent engineering studies still used today and came up with 500 metres.

AD: Scaling up in other words to industrial...

REDFORD: And, we built a test with three pairs of wells, at 500-inches long and that was essentially proof of concept. It did work commercially. We got almost the same results with the larger but, of course, we're now producing. We've got the same production per metre with the larger ones as we did the small ones, which showed that the whole thing was commercially viable, and that their engineering was good because we had to increase the size of our wells. There were a number of very detailed engineering concepts that had to be implemented.

AD: And, all done by the AOSTRA team?

REDFORD: Yeah. It was all done in-house, all done in-house by AOSTRA, yeah. And, some of those people like Dr. Neil Edmonds and Harbir Chhina and Mike McCormack and these people. They are all out there now running successful projects in industry.

AD: In industry. So, it was the training ground for the...

REDFORD: Oh, it was and that was part of it, what Dr. Bowman wanted. That's why he wanted to expand his whole effort right across the country. Just get everybody involved and let's train a whole cadre of people at all levels in oil sands technology and science.

AD: So, you compare the mining companies that are Suncor, Syncrude and all of that expands in terms of actually doing the strip mine operation and then, of course, the various other components of those traditional plans. It requires less front-end investment, SAGD operations. Am I correct in that?

REDFORD: Yes, you are. I wouldn't say that it's not a substantial investment because it is. The horizontal wells don't come cheap, twin horizontal wells; especially the way the wells have to be equipped to be effective. Now, you were earlier asking how long did it take? Well, it didn't take long for first commercial projects. I think it was, what, '94, when we finished what was called the Phase B test. It wouldn't take long after that, I think about 96/'97, you were seeing the first moving out from that. First of all, it was just an expansion on the lease we were on because we brought in a number of partners eventually because AOSTRA was being wound down. It went over to Devon, I think was the name of the operator that took over. And, I suppose they just expanded some of the operations.

Then, Petro-Canada on a neighboring lease expanded in the McKay River project, started to expand its operations. It moved across to Firebag which is a huge project and on a much, much superior lease. I think they went up to about 100,000 barrels a day. It was really a major expansion. But, it was all through that period of time that there was failures too. Through that period of time, that people began to realize, if you're going to do this right, you've got to get the control that they had in that Underground Test Facility. And, that brings expense in. But, it's worthwhile expense. Because, unless you do that, you don't get the kind of recovery rates, you don't get the kind of ultimate recovery, and you don't get the steam/oil ratio that you get, if you got that kind of control.

AD: So, it's interesting there is a parallelism here that the Research Council of Alberta under Karl Clark was involved in research off and on. And, I mean, I know that during the 1930s, of course, the Research Council ceased to exist as a research entity. But, nearly 30 years of research was required before the Blair Report basically proved that you could produce synthetic oil from the oil sands and that it could be done economically. I mean it was a feasibility study, really, the Blair Report. And that then, of course, it took time for industry to come to the table and actually begin operations. But, that ten years or more, how many years would that research have taken, then it was there to be capitalized when the new royalty regimes and taxation regimes were negotiated between the Provincial Government and Federal Government that 1993 to 1995 period?

REDFORD: You're talking about the surface?

AD: Yeah.

REDFORD: You were referring earlier to the in-situ and the capital investment. And, there are a couple of aspects to that. If you follow the charts, even right up to today, on upgrading and bitumen production, you will see during the mining area in-situ production of bitumen and upgrading are parallel.

AD: Really.

REDFORD: And, beyond that time the parallel with the mining, but they're not parallel with in-situ. So, you have integrated companies that are producing even for the mining operation, they have their upgraders right there. In the case of Shell, they have the upgrader at Fort Saskatchewan. They still are using products from there back in the mine. It is an inch-graded operation and as I think in the notes I gave you, about 45% of the capital and operating costs is in that upgrading. Not refining, because that's where a lot of confusion is in the press. It's in the upgrading process and the stabilization of the products after upgrading. Now, with in-situ, you have smaller companies and Petro-Canada's not a small company but a lot of small companies, like Cenovus and Devon and a lot of these other companies. All they know is producing bitumen. They are production companies. They don't care what happens to their product as long as they can sell it. And, the result is that that product is going onto the market as bitumen, not as upgraded so-called synthetic crude.

AD: And, to go back then, if there hadn't been that era of AOSTRA research with respect to in-situ recovery and SAGD, those companies couldn't have existed.

REDFORD: No.

AD: That you still needed the integrated companies that could do all three things.

REDFORD: Yes, that's right. But, it's there that, as a government, as a society, we did not step in and say, "Look, sure you can produce that bitumen but you have to be able to convert it." Instead, companies on the Gulf Coast, they go, "We already have the refineries. Why don't you just ship the bitumen down to us and we'll do all the upgrading." That's where you see this divergence taking place. And, you can see it in the curves. One raw bitumen production is going up but conversion is not, to synthetic crude, is not taking place.

AD: We're moving into the next era. And, I want to get back to that but I want to go back to... you mentioned that you were in charge of the AOSTRA information center and that you did presentations not just of academic papers. Do you want to talk about little bit about that?

REDFORD: Well, actually when I was at the Alberta Research Council, shortly after AOSTRA was formed, they asked the Alberta Research Council to set up an information center. So, the information center was under my direction right from the start. Then, it came back later and took it

over also. So, then, I went to Calgary and then I came back to Edmonton and, at the time that I came back to Edmonton, I was truly in research management. First thing I did when I came back to Edmonton was carry out a technical audit of all AOSTRA's operations. And, it's really through that technical audit I know how AOSTRA operated. I think a lot of people were very surprised at how a government agency could operate so successfully and so -- what would be the right term?

AD: Efficiently? Effectively?

REDFORD: No. Without political influence or without undue influence from certain sectors, industry. AOSTRA, truly, if you looked at almost all of those projects there was good, sound, scientific reasons why they went into those projects. They did not work but that's the way research is, isn't it. I tell my students sometimes we learn more by our mistakes than from our successes. But, we tried them, right? And, they went ahead because of AOSTRA. Those tests went ahead because of AOSTRA. And, out of those tests, we learned an awful lot. But, they all went ahead, good, solid scientific reasons why they went ahead. They had goals and objectives and good reasons why they should go ahead. And, doing a technical audit, that was very satisfying and I think it was very satisfying to AOSTRA. I think Clem, who was the one that wanted this technical audit would -- I think he was pleased with the results, and pleased that they had gone the way that we had.

AD: Are you encouraged to publish in academic journals but also then you did other outreach communication activities. Do you want to maybe talk a bit about your scientific publications and give us an idea of what those were and the journals?

REDFORD: Well, I did a lot of -- in the early period they were all scientific publications. But, actually, quite early I think when I was with AOSTRA I was already on the AOSTRA project, I got involved with Venezuela. And, we actually went to Venezuela, Marcy and I and the kids went down. I worked in Venezuela at the PDVSA [Petróleos de Venezuela], the research establishment in Venezuela. I was there for five months on research. And, it was part of the effort of I would say AOSTRA but actually, there was directions coming from the government too. Peter Lougheed was very interested in getting internationally involved. And, that was part of the effort. So, we were reaching out to the other huge bitumen deposit which is Venezuela. And, so, I was down there. And, there were people after me who also went on exchange to Venezuela. So, coming out of those types of exchanges, then I got more involved in writing papers that were involved with those aspects. And, I also wrote an article on a technical audit, though I don't think it's published. It only went to AOSTRA and how to properly carry out a technical audit. If you go to the literature, there's very, very little on technical audits. And, I was fortunately able to get some of the material that is there and then built on that to do the technical audit myself.

AD: Now, how long were you in Venezuela?

REDFORD: Well, that first trip I was there for five months. No, there was a trip there earlier because I was down with the Petroleum Society of CIM. We had a joint venture at a -- we had a First Oil Sands Symposium was here in Edmonton. That was a long ways back and it was through

the Petroleum Society, so I went down to Venezuela as part of the organizing committee with that, and we did jointly with Venezuela and the Petroleum Society. Subsequent to that, I was down for five months on secondment to PDVSA, the Venezuela Petroleum Company. And, then I've been down half a dozen times since then with AOSTRA, primarily with AOSTRA. After that, after I had done the technical audit, then I was taken on as manager in Edmonton. So, at that point I had all of the international activities, the information center, all the university projects and, later on, the evaluation of new projects. And, all the international activities were under me at that time. So, subsequent to that. I really did a lot of travelling.

AD: Well, give me an idea of what you did; any papers, presentations that you did?

REDFORD: I don't know that I could give them off-hand.

AD: Well, just one.

REDFORD: Typically what we would do, there was two kinds: we would go to giant symposiums which were put on, say, with China and Australia, and we would give technical papers. That was our contribution to the proposal. Sometimes we went to the larger conferences like the World Energy conference which was in Buenos Aires and I would give a paper there. That's the one where we showed that our proven reserves had increased from something like 30 million barrels to ,I think at that time, it was 224 billion barrels, largely, due to the development of AOSTRA, the technical input of AOSTRA. Because, the price hasn't increased that much, it's just that the technology had improved so much. But, also, I would join trade delegations. And, I used to say we were the honey. They would take technical people like myself and from universities, maybe from other research institutes, and we would be the honey.

We would give these technical talks that everybody would come out to. And then, there would be all of the people who were selling, co-rods, we were selling co-rods. There would be people selling valves, whatever was Canadian technology that was available for sale. And, they would go along and they would be making all the deals. And, some of these trips would go on for like -- when we went to India and Pakistan, that was over five weeks we were in India and Pakistan.

AD: Were these just Government of Alberta...

REDFORD: No.

AD: ... ventures? They were Canadian joint?

REDFORD: Yeah.

AD: Federal/Provincial...

REFORD: Yeah.

AD: ...ventures.

REDFORD: They were usually under the auspices of -- I forget the federal department.

AD: Trade or commerce?

REDFORD: Yes, yes.

AD: So, I mean, your career has taken you from the lab then into engineering management. And now, of course, it's international outreach and potential international trade.

REDFORD: Yes, very much so. The other aspect of these which really hit a center in the trade was more consulting than anything. At this stage, I have a background probably equal to not very many and the broad aspects of all aspects of oil sands, particularly the in-situ recovery of oil sands. So, they would take you around. There was Pakistan, there was Argentina. They would take you around, show you the fields. And, they'd have these particular geological characteristics and they'd say, "Well now, how do you think we could get this one out." So, you'd talk to them, "Well, you might be able to take this approach and you might be able to take that approach." And, I found that very interesting because I'm a bit of a free thinker and I like the challenge and I like looking at things from different ways. So, in a sense, I was doing consulting work at that time but not really getting paid as a consultant.

AD: Because, you were government?

REDFORD: I was part of -- yeah, part of government and part of the delegation that was going there. And, that was part of the "honey" really that they were looking at this expert from Canada who they could draw upon to talk to. It could be Thailand; we were looking at shale because we had a process which was being used on shale. The Taciak process, which was a rotisserie process, and it was developed for oil sands. I personally never felt it was suitable for oil sands because there was already the hot-water extraction process for our oil sands. But, from a conservation point of view, it has advantages over the Taciak process. But, it was ideally suited for shale. It was probably the best process there is for shale. But, Thailand they look at their shale and see whether it can be done. The process is actually used in the Stuart Shales in Australia and Brazil. Brazil has substantial shales. So, we went to the shale projects in Brazil and tried to persuade them to use the Taciak process. By that time, I say that we were the honey but also at that time, we already had a lot of technology of our own which we were promoting. So, like in Brazil, we were actively promoting the Taciak technology.

AD: Now, when was AOSTRA shut down and why?

REDFORD: Well, I think there were two main reasons why it was shut down. One, I think it really had fulfilled its primary purpose. You had now developed the technology where you could economically produce vast amounts of bitumen. The current estimate is about 270 billion barrels are available; in present economics, can be produced, what we call proven reserves. This is comparable to the Middle East, to Saudi Arabia. It's comparable to Venezuela. So, you now have achieved one

of the major objectives. You also built up a great awareness and a great body of expertise in oil sands, which was not there before, and another one of the major objectives beforehand. So, in that sense, it may have been a logical time to wind it down. I think the practical reason was that there wasn't the money available anymore, and we were running into deficits. So, you had a push and pull. You no longer had that big pull to have a resource available to take the place of the dwindling conventional reserves. And, you no longer had the money to -- and then it came at a convenient time with the leaving of one -- I can't remember the name.

AD: Well, I mean, it was really the end of the Lougheed era.

REDFORD: Lougheed had gone for some time. We were well on into the Klein period at that time. But, we lived through the Getty period. We were into the Klein period and he was, of course, very much interested in trying to balance the budget.

AD: So, basically, then what did you go on to do? Did you stay within government research establishment or what did you do after AOSTRA closed?

REDFORD: Just before we leave that, I think that there are two things I think they should've done. One is, I think it's a shame that they never continued with the information center. I know that there is all that information out there and it's just not readily available to the researchers today. That would have been a minimum cost; they could've transferred it over and it was already part of the Research Council. Or, they could've transferred over to a university, whatever. But, I think, just doing away with the information center, I don't think that was necessary, and I don't think it really saved them that much money. The other is, while we had really solved the in-situ problem, really solved a lot of the costs problems with the mining industry, a lot of the environmental problems with the mining industry, we had not really paid a lot of attention to reducing the costs in upgrading. And, I think that at the time we left, one of my big projects was NCUT, National Centre for Upgrading Technology which was moving some of the group from Ottawa out to Edmonton trying to build up a major center. And, that just kind of fell by the way side and I think that we would have been well at that stage to invest in upgrading technology. The person's name I was trying to think of was Bill Yurko.

AD: Oh, Bill Yurko, yes.

REDFORD: You see, Bill Yurko had come to the end of his term and what they did was just not appoint a new one. Then, they did not reappoint the board. Formally, AOSTRA was not wound down until a number of years later. But, that was kind of a convenient time to do it because the chairman was going.

AD: It just shows you that, I mean, visionary leadership can result in huge scientific and technological achievements, and then their implementation by industry. I mean, that you need those cycles of research and investment before you then can obtain the returns. And that, do you want to talk about the role of government in this, because you worked for government really, at an arm's length?

REDFORD: You know, there was that simile at the time of -- they had the space race and major money putting in and the major goal and objective, all directed by government, right. And, they said, "Let's have the same sort of effort when it comes to the oil sands." So, yeah, there was a vision there. There was a goal. There was an objective. And, to the credit of AOSTRA, they largely achieved that and a lot of projects failed. But, three of those failures we came up with a lot of success.

AD: Are there any anecdotes? You shared some with us but others? Eureka moments or failures?

REDFORD: One doesn't like to talk about the failures.

AD: Well, the Eureka moments?

REDFORD: I can talk about a few failures. We had a concept which was developed by Amoco. It's an in-situ recovery project -- I mean it's a combustion project. But, it involves horizontal fracturing followed by combustion above fracture pressure, and that blinds off and then you do this a number of times until you've heated up the formation, the whole formation. So, this is a concept of not going at it gradually and removing it as you would in SAGD, but heating the whole formation and then recovery. And, on very short spacing, a quarter acre I think and about 100 feet between the wells, it had worked. And, Amoco had made it work. So, they came to us and said, "Look, what we would like to do is do this on a commercial scale. But, in order to get a really good idea we have to have enough wells that there is one pattern in the middle that's enclosed. So, this is going to cost a lot of money."

So, AOSTRA went ahead as 50% partners. I think we invested $40 million in that project, which is a substantial amount of money then, it would be a lot more money now. And, we're now at commercial spacing, larger spacing. But, we also have a whole bunch of patterns so that there's one in the middle that's completely surrounded and that will give us the data that we'll have for the commercial. But, it turns out, the horizontal fractures don't stay horizontal, they stay horizontal over a short distance, and then they work themselves up; they're still horizontal but now they're at a higher level. So, they come to the well higher up but we don't have any perforations there so what's it going to do. Well, we're above fracture pressure, so we just put the pressure up higher. What happened? It just sheered the well off. But, not only that, it sheered every well off in the whole field. So, this is just a complete failure.

AD: So, the degree of pressure and then the deviation of the curve...

REDFORD: Yeah. But, you see what Dr. Bowman said, "It was a bridge too far." He said, "We're doing two things at the same time." We're going to larger spacing and we're going to a full set of field operations. We could have proved the same thing by just going to one pattern and larger spacing and it would have cost us a lot less. So, he said, "You know, this is something that we learned about field research as well as about this particular project." So, just like Montgomery, we went a bridge...

AD: ...too far. Now, you talked about Dr. Bowman on a number of occasions. Do you want to talk about: (a) his scientific knowledge, and (b) his management style? Because, I mean, both sound formidable from what you've said already. But, do you want to talk about that?

REDFORD: I actually knew Dr. Bowman long before I got to the Research Council, partly because he was at the Syncrude laboratories and even then, he was very much, "Let's work together." But, also I would meet him at conferences. He was an executive on the Canadian Society of Chemical Engineers and he became the president later on, and I was also a lead executive of the local branch of the Canadian Society of Chemical Engineers. So, we would meet and we'd have technical discussions as well.

So, it was not a surprise when he came to -- well, it was a surprise but it was a pleasant surprise when he came to take over AOSTRA. But, you were asking about his style. He's a people person. He talks very easily to people. He's a very open person, very open to ideas from people. He's not my way is the doorway. He wants to get an input from everybody. I'll tell you the other one that always impresses you with Dr. Bowman is he will always find a way. Time and time again, we were in situation where they seemed irreconcilable. And, he'd come back a day or two later and he'd say, "Well, what if we did it this way?" And, everybody was happy. He had that uncanny ability of thinking it over and thinking of something that would get through to all parties and it would be a successful project. And, of course, just his personal integrity, I think that's the big thing. Peter Lougheed couldn't have picked a better man. Pick someone else it would have been very much directed or it would have been very much susceptible outside influences. I have a lot of admiration for Clem Bowman.

AD: Now, you showed me that you got a slide tape presentation that he made. Do you want to just describe it? So, what did the wrap-up of AOSTRA involve?

REDFORD: Well, first of all Bill Yurko was the chairman of AOSTRA at that time, and his term was coming to an end. In fact, I think he had already extended one year at that time. So, they just simply did not appoint a new chairman, they did not fill any new board positions and, subsequently, wound down the board altogether. In addition to that, this was a time in which the government was cutting back markedly right across the board on people in the government. So, they had a blanket offer to people to take early retirement. And, I was one of the ones that took that. I did have the opportunity to stay on and be the undertaker for the closing down of AOSTRA but I chose not to do it. I chose to take early retirement.

AD: And then, you consulted? Is that correct?

REDFORD: After I left, I did a certain amount of consulting - a limited amount of consulting. First thing I did was write a few papers. One of them is a paper which is really -- it is one of the key papers in in-situ recovery. I was telling you about the need for getting control of the operation from surface. And, I outline that very much so in my paper. I outline the concerns. I outline what needs to be done. And, it largely has turned out as I predicted and hoped for in that paper. The paper is a

very general paper. Most of my research was on the Athabasca Deposit. And so, it's a general paper. It reviews all of the field research that has ever been done on Athabasca; sums it all up, sums up what we have found, what we have learned from it. And then goes on to say what we need to do if we're going to be successful with steam-assisted gravity drainage from surface wells. And, extended to situations where there is bottom water or a gas cap at the top. And, we have now done that and we've done it because we have got control of the pressure temperature at all of the operating conditions at the wells. And, because we have taken to heart the knowledge which was learned in the two underground-test-facility operations.

When you move from a research operation, first of all even if the old pilot, it's all very highly instrumented, both in the wells but also you have a lot of observation wells so that you can see exactly what is going on. When you got to commercial operations, there is very much a tendency to say, "Well, that was all very well and good for a pilot operation but now we're doing it commercially and what we say in the engineering community, the bean counters get a look at it." And, they say, "Oh, well you really don't need this, you really don't need that, you really can go with this cheaper well here," all these kinds of things. And, they didn't really appreciate the sophistication of the steam-assisted gravity drainage process. It was very much what we call in the industry as suck and see approach. And, the feeling of, "Oh well, all we need to do is put in some horizontal wells and operate those horizontal wells and we'll get good results." And, it's led to some disastrous failures where not just millions but hundreds of millions of dollars have been lost because of not really applying the technology that was learned in the Underground Test Facility.

Those companies that did apply it, even in various adverse situations where there was bottom water, where there was gas cap and two of those companies are run by -- or at least their principle engineers are people that work with me on the Underground Test Facility. And, they have been a major success even though they were in very adverse reservoir conditions but they've been a major success.

AD: Do you want to name some of the failures or would you rather not?

REDFORD: Well, I think it is common knowledge out there that the Long Lake project has really been very, very under-performed. It's really under-performed. And, when I look at it and I do talk about it in my courses that I give, you can see it is simply because they have not applied the knowledge correctly that we learned in the Underground Test Facility. If you looked at the Jack Fish Lake project, on the other hand, equally adverse situation but they did apply the technology and it has been a major success. I alluded earlier to the fact that steam-assisted gravity drainage is not for everything and that if it had been tried in Cold Lake, it probably would have been a real failure. Nothing begets success like success, and nothing begets failure like failure. And, if it had been tried and failed, probably we would have never tried it in Athabasca. But, because it was so successful in Athabasca, they say, "Oh, well we can try it anywhere." So, they've tried it in the Cold Lake deposit, in the Clearwater, Cold Lake deposit. In an area where there is bottom water and that's the Tucker Lake project, it's just been very, very under-performing; extremely under-performing. And, that is primarily because the Clearwater member is geologically vastly different than Athabasca. Its finest

material is at the bottom. Its coarsest material is at the top and you try to carry out a SAGD process where the permeability is way down in the "milliadarcy" range. And, it's just not going to be the same process. It's not going to have the same success.

Now, you say, "Well, no, really, the Tucker Lake problem is that there's bottom water." But, there's bottom water at Jack Fish Lake too. And, it's in the Athabasca Deposit and it's a major success. So, it's really the geological difference. One of the theses of everything I teach in my course is, number one, look at the reservoir. It's a process that works. It works in that reservoir. It doesn't work in every reservoir. And, match the process to the reservoir not the reservoir to the process. And, there's too much saying, "Oh, it is successful here, we'll try it there." But, it is successful there because it matched the reservoir.

AD: So, you mean different types of technology to deal with the variances in the geology and the nature of the deposit, where it's located, all of those things? You mentioned a course. Which course is this that you teach?

REDFORD: I just want to go a little bit further than that. The reason probably -- I mean, I come from a chemical engineering background. But, when I started in this, Dr. Carrigy, Maurice Carrigy was my mentor and he was a geologist. And, it was from him that I learned sedimentary geology and I learned the geology of the oil sands. And, as I have grown in understanding, the oil sands I've grown to understand the importance of them. I say to my students, "Look, reservoir engineering, what is the first word in that? It's 'reservoir.'" And, they say, "Oh, why do we have to learn all this geology? We're going to design wells and carry out recovery processes." I say, "You know what, it's the first word, it is reservoir. And, if you don't understand the geology you don't know what process will work in that reservoir and what will not." Now, you were asking about the course? Well, after I finished at AOSTRA, I retired, I wrote a few papers and then I did a little consulting. And, then, really got away from it entirely for, I would say, perhaps ten years, seven or eight years anyway.

Then, a company was at a project in Saskatchewan. There is an oil sands that we run into in Saskatchewan, part of the McMurray Formation runs into Saskatchewan. And, they had drilled out -- they were essentially a land company and they had drilled out this area and they said, "All right, we've got all this bitumen. We want to sell the lease," and they couldn't find any buyers. Buyers wanted to say, "Yes, you got all that bitumen. But, how much of it can you recover?" So, they wanted a recovery process and they had seen my work with Texaco. And, they wanted to carry out a project similar to Texaco. So, they called me up and asked me if I would come and consult with them. And of course, Peter Toma who had taken over the project after me came too. So, the two of us had a session with this company and thoroughly discussed the whole recovery concepts and what might work in this particular reservoir or what might not work in this particular reservoir. So, when I came out of the meeting, Dr. Toma said, "Dave, you know, you really understand this stuff. You still know this stuff." He said, "You should be teaching at the university." So, maybe a month later I got a call from the University of Alberta and was asked if I would come in and have a meeting and perhaps give a course in graduate studies. So, out of that, three years ago, I started a course in In-

Situ Recovery from the Alberta Oil Sands at the University of Alberta. It's a graduate course, one term.

AD: Well, I can't imagine a better person to do it. I mean, you have your entire career to draw on this as this interview has revealed. Now, I asked a question earlier on and I think because of an interruption you didn't get to answer it. Which was that: You've got a slide tape presentation that was done by Dr. Bowman. Can you give me an idea of when it was done and what it consists of?

REDFORD: I can't be sure when it was actually done. I would say probably in the second half of the 80s. It would have to be when Dr. Bowman was still with AOSTRA. But, probably about mid-1980 it was done. It's titled: Alberta Bitumen: Past to Present. I don't know if there was a written paper. It may have just been a talk and I suspect it was just a talk; but, I have all the slides from it and I got them through the Alberta Oil Sands Information Center which I was head of at that time. So, Helga gave me a copy. So, I propose to you that I'd see if I could get these slides onto digital format and put them on a PowerPoint and give them to Dr. Bowman and see whether he would put some writing on them and indicate who they were. Because, a lot of people indicate what the situation was or what he was trying to get across and certain thing that are put in. They're all numbered in the order in which he presented them in talks. And, they do really go back. There is one slide there of Abasand. Abasand was the first to do in-situ recovery. It was a combustion kind of a burn and turn. It was about 1926/1927. And, I remember reading a copy of his letter to one of his financiers I guess. "We've got it all solved. We'll be producing commercial bitumen in no time now."

AD: And, I think Glenbow of course, would love to have this material for its archives. So, thank you for sharing that information. Now, some final remarks I mean in terms of the future? Right now, besides the global recession and the bitumen bubble and the fact the Government of Alberta has not realized its projected revenues and it's from principally the oil sands and is in cut-back mode. But, I'm thinking of the two pipeline projects. Do you want to talk a bit about that with the extensive knowledge you have?

REDFORD: I often thought in terms of oil sands and bitumen. We think in terms of and I think perhaps the present government is an extension of that, but we think in terms of oil resources and the amount of money, royalty money or lease money that is available from these resources to Alberta, to the people of Alberta, to the Government of Alberta. But, when you think of oil sands you have to think in terms of industrial development. And, I think that is partly how Peter Lougheed looked at it. We talk about diversification of the economy. Well, when you are producing bitumen, you're not just operating a well and producing bitumen. You're operating a major mining operation. You're operating a major upgrading which is a process operation, what we call secondary industry. And, it is going to provide more for the Alberta economy, in the long run, than that development that just gave you bucks in your pocket when you took the oil out of the ground. You're going to have to work at it harder. But, in that process of working at it harder you're going to have greater economic development and greater impact on the economy of this Province than you're going to

have from that money, that free money that you got from producing the conventional crudes or the conventional gas.

So, I think in that context we're not really capitalizing on it. When we take the bitumen and sent it just outside and don't process it. We're losing half of our industry by just taking that bitumen out and sending it away for processing. On top of that, we are not really addressing the concerns that are out there. What are the concerns? Why are there so many objections to the pipelining of bitumen? And, it is a bitumen pipeline. The press always talks about crude oil pipeline. It's not, it is bitumen pipelining that we're talking about. And, what are the real concerns? Environmental: you see all the concern about greenhouse gases and there is no way you can get around it. If you take bitumen, it has higher carbon content than any of our other fuels. But, it doesn't have to be that way. If we upgraded, you get light, sweet crude; it doesn't have sulphur in it, very minimal nitrogen and the vanadium, nickel in it. It's a very, very high quality crude, sweet crude that we can pipeline very readily. And, it has the same carbon footprint as conventional crude has. "Aw, but you say. What did you have to do to get that carbon footprint down?" Well, if you use hydrogen addition upgrading and particularly if you get that hydrogen from natural gas, you have not added anything to the carbon because you've added hydrogen to upgrade it.

So, the overall footprint that you are making with bitumen is not different than the conventional crude makes and you end up getting more conventional crude. Now, is this something new? No, it's not. It's what AOSTRA studies on and it's what showed up time and time again in AOSTRA studies. It's the recommendation that AOSTRA always made to the government. We need to encourage hydrogen addition upgrading. If you look at the Husky Refinery, it's a hydrogen addition upgrader. They get more crude coming out of there than the bitumen that goes in. So, that's one aspect of it. The other is the actual pipeline. When you put bitumen in a pipeline you have to add diluent to it. So, for the same amount of bitumen running down the pipeline you reduce the capacity. So, the minute we start pipelining bitumen which we are doing now, we reduce the capacity of our pipeline system. So, we're reducing the ability of our pipeline system to carry our crude because we're diluting it with a diluent in order to carry it. And then of course, there's the other environmental aspect: bitumen is formed by water washing and bacterial action. It is very heavy. It's heavier than water.

Now, if you get as spill two things happen: it goes to the bottom of anything that's water, it's very viscous and it is like bunker seed crude. It's going to go the bottom. The other thing is it is already been subjected to biodegradation. How much biodegradation is going to take place? We get a blow out in the Gulf, it is light crude, it's dispersed, there's a lot of bacterial action taking place on it. How much bacterial action is going to take place on that bitumen? So, just in the pipelining itself we're creating a hazard. Then from a provincial point of view, this is not diversifying of our economy. I just heard on the news this morning that there is going to be a big promotion on tourism because that tourism is going to promote the Alberta economy. Lougheed had it right. You can divert the economy by processing just as he did with ethane, took the ethane off and we now have this whole petro-chemical industry here because that ethane was taken off and the processing took place here. It's the same thing with bitumen upgrading.

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AD: So, the government has to be open to scientific opinion that looks at the secondary industries that can be developed. And, I don't know whether it was you or someone else who mentioned to me that, until the government said that the conventional industry had to stop flaring because there was all that hydrogen-sulphide, sulphuric acid rain produced, the industry wasn't doing anything about it. When the regulation came about, then of course you've got the capture of that sulphur which then can be sold for fertilizers or whatever other products can be produced from it. So, that the whole notions of secondary industries, manufacturing industries coming out of bitumen, upgrading, production needs to be explored doesn't it?

REDFORD: Yes. I'm all for free enterprise. I think that free enterprise works well. But, that doesn't mean that there cannot be some limitations on it. What you were just talking about is a good example and it's happened, not just in Alberta but it also happened in Venezuela. But, it happened first in Alberta. And, you had all of this gas being produced. It was very low value. And, an individual company it may economic sense, flare the gas, produce the oil. We can sell the oil, we can't sell the gas. It took the government to say, "Look. That is not your gas. That is our gas. If you want to produce the oil, you have to do something with that gas." It wasn't any time at all, it took a few years, but they developed the technology to economically extract that gas.

We developed the gas industry and gas for sale. But also, we developed a sale for the sulphur which is one of the products that was taken out from the gas. And on top of that, we developed an engineering expertise because we were the ones that knew how to get the acid gases out of natural gas. In Venezuela, when I was there, Velasquez, who was the minister told me, "I just told the industry, you cannot flare it." Apparently, he went out on Lake Maracaibo and it was just as light as almost day with all of the flares that were burning across the lake because all of the production is on Lake Maracaibo light oil production at that time. He said, "Within a short period of time, the industry put in the compressors that were compressing that natural gas. It was either re-injecting it or it was finding some other use for that natural gas." Electrical production or something, but there was no incentive for the industry to do it.

Economically, for any one company it wasn't the right thing to do. But, for the country it was the right thing to do. And, that's what I'm saying about bitumen. The upgrading of bitumen for any one company, first of all of these small producers, they don't care. All they want to do is produce bitumen and sell it. They don't care whether it goes to upgrading or it goes to somewhere in the States, "Just give me a market for it." The larger companies are saying, "Look. I've got all these refineries down to the Gulf Coast. I need that bitumen down there so that I can use it on the Gulf Coast." But, for the people of Alberta and I think the people of Canada, we need that industry here and we do need it for environmental reasons, we need it for conservation reasons and we need it for economic reasons.

AD: Thank you. That sounds like a wonderful summative remark. Is there anything else you want to share or is that it? Thank you so much for sharing all of this experience on the research side of the oil sands and also, the Government of Alberta's role and the role of different individuals. And again, thank you.

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